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9. ABSTRACT
The ipil-ipil is a versatile, fast growing tree which can be used as forage, poultry feed, fertilizer, lumber, pulp and paper, and even as a source of alcohol, carbon, and dye. This document contains the papers and proceedings of the International Consultation in Ipil-ipil Research at the University of the Philippines. Over twenty papers are presented on such topics as: breeding, genetics, and general uses of ipil-ipil; dissemination of technology in the Asian region; research needs in varietal improvement; agronomy and farming systems; soil considerations; ipil-ipil as a reforestation crop; and charcoal production from ipil-ipil. Three areas of research are identified: production, use, and reforestation. It is recommended that research be undertaken on use of Leucaena as cover crops or shade trees and fertilizer in establishing a forest plantation and that a combination of Leucaena and selected agricultural crops for hillside farming be used to maximize land use. The paper gives information on the performance of various strains in soil rejuvenation and water conservation and on species suitability for wind and fire breaks at various elevations and climatic conditions.

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INTERNATIONAL CONSULTATION ON IPIL-IPIL RESEARCH

PAPERS AND PROCEEDINGS

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January 1978

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RESOURCE PAPERS

WORKSHOP SESSION SUMMARY REPORT

WELCOME ADDRESS

Domingo M. Lantican
Vice Chancellor
University of the Philippines at Los Baños
College, Laguna, Philippines

I wish to welcome you on this campus on behalf of the University of the Philippines at Los Baños and its constituents. We are glad that the Philippine Council for Agriculture and Resources Research and the United States National Academy of Sciences are holding this International Consultation on Ipil-ipil Research. We, in this University can assure all of you who are present here today that we share your interest in this versatile species that shows promise as one of the world's most valuable plant. Its potentials as a good source of energy, forage, nitrogen, cellulose, wood and wood derivatives and its uses for erosion control and watershed protection are very encouraging especially at this time when every means to increase production and conserve the world's natural resources are becoming more urgent

It might be of interest to you when I'll say that the first scientifically managed ipil-ipil plantation in the Philippines was established on this Campus, specifically in the Makiling Forest in 1913 by the constituents of the Bureau of Forestry and the Forest School. Soon afterwards, this plantation was the subject of many studies about the species. The value of this plant as a reforestation crop was recognized by the way it controlled the growth of imperata grass. Several years after the establishment of the plantation, a researcher of the Bureau of Forestry who was at the same time a faculty member of the School of Forestry reported how a dead creek came to life and yielded water even during the dry season. The College of Agriculture recognized the nutritive value of ipil-ipil leaves and recommended its use in animal feed formulation. The economic rotation of ipil-ipil as a source of fuel was the subject of several studies of the College of Forestry in the late 1950's. Unfortunately, much of the data were burned during the Second World War and the entire ipil-ipil plantation in Makiling was completely destroyed when the area was turned over to the Boy Scouts of the Philippines for the 10th World Boy Scouts Jamboree. All that remained now are scattered stands on this side of Makiling and new plantings on the other side, although 19 hectares of this were lost to grass fire last summer.

We are glad that interest in this species has been re-kindled and we are happy to report to you that the University of the Philippines at Los Baños is making some modest gains in this area of research and we wish to take this opportunity to express our appreciation to the PCARR, the Department of Agriculture, the Department of Natural Resources and the National Science Development Board for their valuable assistance which made all these possible. Dr. Neptale Zabala has made progress in his tree-orchard project. Dr. Emil Javier and his co-researchers have now a collection of over a hundred varieties or species of Ipil-ipil. Other researchers in soils and in plant and animal nutrition on this campus have likewise made ipil-ipil their object of study and I am confident that they will be able to contribute something to this consultation.

We are aware of similar or related projects of the Bureau of Animal Industry, the Bureau of Forest Development, the Forest Research Institute, the Forest Products Research and Industries Development Commission, and the private sector. I wish to make special mention of the efforts of Mr. Hugh Curran of Provident Tree farms who has been popularizing ipil-ipil in this country with a missionary zeal; Atty. Bobby Montemayor who has pioneered in the commercial scale production of ipil-ipil in Mindanao and Governor Leviste of Batangas who has favored ipil-ipil in his "greening" project for the Province of Batangas.

The University is honored by the presence of distinguished scientists from other countries among whom are Dr. Mark Hutton of the Australian CSIRO Division of Tropical Agronomy who bred the giant variety that is now gaining popularity in the Philippines; Dr. Jim Brewbaker, a former visiting Professor of this University and who has made substantial contribution to the breeding of ipil-ipil; Dr. Don Pluncknett, a well known tropical pasture agronomist of Hawaii and Dr. Jim Moomaw of the Asian Vegetable Research Development Centre.

I am certain that many of you deserve commendation in one way or another but time limitation does now allow me to do so. Permit me therefore to just welcome you once again and please accept my best wishes for a successful consultation.

REMARKS

Antonio Leviste
Governor
Batangas, Philippines

Frankly, I am very apprehensive having to stand here before you, having to talk about a subject I am not really very versed with and worst of all, a subject I have to talk about before the experts. I am afraid that this situation might be the same with what I experienced one time when I delivered a speech about another subject. That was when I was invited to speak about family planning (a subject I am not familiar with), at a co-education school. In the open forum, one of the Coeds asked, "Governor, will you tell me if infants have as much fun in infancy as adults do in adultery?" It was a question I could not answer; thus, if you will ask me anything about ipil-ipil, I would rather request the experts to answer it. I do wish to inform you however, to please consider that tree planting and forest conservation have always been my vocation. And recently, with my job as governor of the province of Batangas and with the Secretary of Natural Resources appointing me as the Chairman of the Regional Council for Forest Ecosystem for Southern Tagalog and even with my election to the Chairmanship of the Boy Scouts of the Philippines National Committee on Conservation, I would like to think that tree planting and forest conservation of late, have been my profession. In this connection, I would like to state that in all my living years, all 36 years of it, I have not come across of a tree species that excites me more than the "lepili." Lepili, my friends, is a term given to the species called Giant Hawaiian Ipil-Ipil K8 as agreed by Mr. Hugh Curran, Mr. Mike Berge and myself. This term has been adapted particularly in Southern Tagalog, 10 governors and 17 city mayors. This situation is similar to the K28 which Mr. Benge calls "the Bayani." We have all agreed on that and from the literature of Dr. Brewbaker's work that I have read, he stated that somehow there is a need to call it by some other names.

In the province of Batangas, for instance, when you say Ipil-ipil, farmers invariably frown because the native ipil-ipil is a shrubbery tree which is high in mimosine content and causes shedding of the animal's fur. Too much eating of it causes sterility among animals. So, it was necessary to call it by some other names. Finally, we have decided with the Governors of the Southern Tagalog region that if one would dislike something, then just do the reverse or do the opposite. So, we simply reversed ipil and came up with pili. However, it didn't sound good. Thus, we placed a prefix le to honor the former governor, my predecessor in the province of Batangas, who served for 24 years. He passed away just about the time we were propagating the giant Hawaiian ipil-ipil. And so Lepili, a term which we usually use in Southern Tagalog, stands for Sanoy Leviste Ipil-ipil. And with your permission for the brief remarks that I am about to make, I shall refer to it as such.

Indeed, not only is "lepili" an amazingly fast-growing tree. As I was telling the gentlemen earlier this morning, we could grow them as high as 20 feet in 6 months. But its versatility is even more amazing. It could be used as forage, poultry feed, fertilizer, lumber, pulp and paper, and even as a source of alcohol, carbon and dye. But I personally think that more importantly, it is amazing because it is the answer to another momentous crisis – the shortage of firewood and charcoal for fuel

I came across an article which reported that the shortage of firewood and charcoal is a more urgent crisis than the energy crisis of the industrialized world, because in the developing countries such as the Philippines, firewood gathering is the principal exterminator of trees which result to forest denudations, erosions, floodings and ultimately to food shortage. It is for this reason that we have adopted the "lepili" as the mainstay of the Batangas plan for national survival. I am happy to report to our Chairman, Secretary Leido that most of the Southern Tagalog provinces and the National Committee on Conservation of the Boy Scouts of the Philippines have adopted the same concept of the Batangas plan for national survival.

In Batangas, we have a "lepili" seed tree orchard and nursery which we are proud of, and which Michael Benge and others have helped to set-up, as well as Dr. F. Pollisco of the FORI who really get us started 2 years ago. In our orchard and nursery, we produced no less than 10,000 seedlings a day, not to mention the tens of thousands of seeds which we distribute not only within the province and the region, but also throughout the country. Even now, we receive letters from as far as Zamboanga and Aparri. It is our intention that in Batangas as well as in Region IV and the provincial councils of the Boy Scouts of the Philippines, that each would set up a lepili tree orchard. This would be put up in every schoolyard, every churchyard, every cemetery, and in every other conceivable place. In the Batangas Provincial Government for instance, I decreed last month that no employee will receive his last month's salary unless he sets up for himself a seed tree nursery consisting of 20 trees that are properly fenced, marked and identified as his own. These are some of the things we do to make certain that the people support the program.

The ultimate objective of the Batangas plan for national survival is the aerial carpet bombing of all the denuded mountains in the province, in the region and in the country.

And this, my friends, brings me to the point why I am exceedingly happy that PCARR and the U.S. National Academy of Sciences with the help of UPLB has brought about this international consultation. I would want to at least think that all these efforts we are now undertaking would be worthwhile, that we are doing the right thing, that we are using to the fullest the untapped potential of lepili in this country. And what more could an international consultation of experts like this could bring about than what are exactly expected. I would like to know for instance if our objective is to produce forage or seeds or wood which ever the case may be. How much distance do we have to plant between trees and between rows? Do one cut back depending on what we want to produce? If we must, at what age and at what height? Is it really mimosine that causes shedding of fur? And can we plant cuttings instead of seeds? These and all other questions that will redound to increased productivity of "lepili", if given the right answers will be sufficient enough to solve our problems.

In fact, there is a question and the answer of which I would like to seek before this conference is over. Is it true, as others say, that in all our earnestness to propagate it now, we will one day wake up and find a problem in our hands because once planted, these trees don't die? And then it might overcome our countryside to the prejudice of other trees? Is it true that this is a problem tree? Of course, I myself am not apprehensive. I am only apprehensive about other people's apprehensiveness. And it seems that people sometimes can't distinguish whether something is a problem or an opportunity. Why, it was only yesterday afternoon when I went to check Dr. Brewbaker at his hotel suite when I saw an elderly American at the lobby of the hotel stamping his hands on the table of the manager. And when the manager approached him, the old man said, "Mr. Manager, blast it, I've got a problem!" Then the manager said, "What seems to be your problem, sir? " The old man responded, "Well, there's a young lady utterly beautiful, starked naked lying in my bed." And the manager said, "Sir, that's not a problem in this country, that's an opportunity!" The old man said, "Opportunity, at my age? That's a problem!"

And so my friends, let me conclude by saying this: We in Batangas would like, not only to propagate the "lepili", but we would also want to put up a research center, a research center that would not just undertake a study in the next three days, like you and I, would be doing about ipil-ipil. But it is a continuing study long after Dr. Brewbaker has returned to Hawaii and the other gentlemen to Australia and wherever else. We would like to have a center to develop the untapped potential of lepili for the benefit of the Filipino people. It is for this that I particularly address myself to you and I hope you could help the Batangas Provincial Government. With the promulgation of the letter of Instruction 423 creating the Presidential Council for Forest Ecosystem Management, funded as it is with several hundreds of millions, the provincial government and the department would be more than happy to provide whatever resources we would need if the experts like yourselves would help us out. It is, to my mind, an undertaking that even myself as a public official would succeed and would be of efficient service to my country. And with your help, one hopes to succeed.

Thank you.

KEYNOTE ADDRESS

Hon. Jose J. Leido, Jr.
Secretary, Department of
Natural Resources, Philippines

A few years from now, this First International Consultation on Ipil-ipil Research will be looked upon throughout the world as another milestone in the history of natural resources management in general and of forest development in particular.

It will undescore one more of a string of salutary results stemming from our various government's reoriented and reinvigorated efforts to preserve the world's ecosystem, and at the same time, shower its benefits on all the peoples of the world.

I am equally certain that the knowledge that will be distilled from this consultation will open for us new pathways, ways and means whereby we can further exploit the boon offered by nature through the ipil-ipil tree.

The Philippine government and the department of natural resources view this consultation and similar efforts, with the fullest of appreciation. Gatherings of this complexion are among the ingredients needed to strengthen our efforts to preserve not only the forest cover, but all sectors of our natural resources.

Friends, the ipil-ipil is indeed a remarkable gift from nature. In my estimation, it ranks second to the tree of life, the coconut tree.

The many uses of the ipil-ipil however, is not of recent knowledge to Filipinos. During the Pacific war years, our guerilla soldiers boiled its inner bark in water to come up with ersatz coffee. True, it was a poor substitute but it enabled many guerillas to face the day with the same fortitude as the day before. Some of our elders in the countryside consider its sap as a cure for minor cuts and bruises and skin eruptions, although scientific research still has to provide authenticity for such a belief. Its young leaves, now already proven to be that loaded with protein, can be or have been utilized as vegetable.

I would therefore say that this consultation is a rediscovery of what the Ipil-ipil does for mankind. No doubt, more good uses can be discovered considering the advance of scientific knowledge; a knowledge which has acted as the key to unlock doors that lead to more treasure troves in the bosom of the natural resources.

To us whose daily concern is to save the forest cover from further damage, this symposium signals the growing awareness that the need to protect our forests is urgent.

This awareness, as reflected by the efforts to hold this consultation here in our country, can be humbly credited to one of the many achievements attained since we, as a people, decided to mount a national reformation for four years.

Four years time is sufficient for us to view with adequate perceptive the many achievements gained through national reformation. Perhaps most important of these achievements is the process of national economic growth. A true course has been set, unlike in the recent past when our economic growth was something like the toss of a coin.

When we speak of economic growth, we also speak of the natural resources which are the foundation of virtually all economic enterprises in our country. Impair that foundation and we hobble at our ability at winning economic progress.

Let me cite our forest resources as an example. Before the national reformation, our exploitation of this resources which is vital to our economic life, was something like Russian roulette. The click of the trigger, so to speak, meant destructive floods and landslides, serious soil erosion and other results, the sum of which was mindless waste of the forest resource.

Such a situation no longer prevails. Creation of the Department of Natural Resources by President Marcos two years ago, meant equipping our exploitation and preservation of the natural resources with a rationale whose main objective is to make this national wealth serve not only our present generations, but also those that will follow.

Thus, the government has embarked on an integrated reforestation program. It is an effort that must succeed, and succeed as quickly as possible, if we are to prevent our forest wealth from disappearing forever.

At present, our rate of forest destruction is around 80,000 hectares annually, while our rate of reforestation is only around 24,000 hectares per year.

If we do not move faster, our hopes of saving and enhancing our forest cover and the industries which evolve from this resources would be left unfulfilled. It would be a tragic legacy to the ones that will follow our present generations.

Indeed, it is noteworthy that this meeting of experts on Ipil-ipil is held at a time that the Philippine efforts on reforestation are beginning to acquire a momentum.

Just recently, President Marcos created the Presidential Council for forest ecosystem management. The Council, which is composed of no less than fourteen government agencies and civic organizations, will provide for the first five years forest cover to around 750,000 hectares of open, denuded and unproductive forest lands wherein 109,800 hectares need immediate revegetation.

This integrated reforestation and tree planting program which we call program for forest ecosystem management or profem, will also involve the planting of ornamental and fruit-bearing trees to around 114,000 hectares of school grounds, military camps and reservations and also provincial, municipal and barangay communal forests and agro-forest.

The planting of fruit-bearing and ornamental trees and other plants along 23,590 kilometers of highways and provincial and barangay roads will also be undertaken.

Another component of this program is the conversion to industrial tree plantations some 400,000 hectares of logged-over and open areas within tunker concessions let to private parties.

It is in this particular efforts and also to the revegetation of critical watersheds in the country that the ipil-ipil will play a very important role.

At this point, let me give my modest observation regarding the ipil-ipil. I regard the ipil-ipil as a personification of the Filipinos' on-going national reformation.

The rediscovery of its many good uses for humankind parallels that of the Filipino's rediscovery of himself as a result of the national reformation. This rediscovery has led him to recognize what must be his national priorities; that self-confiding self-reliance are the virtues whereby national goals are attained.

As a tree in the forest, the ipil-ipil may not rate a description as stately. But its qualities are like that of the average Filipino. These qualities are spelled out in readiness to do good for fellow human beings, out of the realization that this is the only way to achieve the just and god society desired by man since the development and maturity of his social instinct.

Our efforts to have this First International Consultation on Ipil-ipil Research be held here in our country is another expression of that social instinct. The ipil-ipil may be the subject, but the ultimate aim is the good of our nation as well as of the others being represented here today.

My congratulations to the organizers and participants.

Thank you.

1

RESOURCE PAPERS

BREEDING, GENETICS AND GENERAL USES OF IPIL-IPIL

Dr. Mark Hutton
Chief, CSIRO Division of Tropical Crops and Pastures
Millroad St., Lucia, Queensland
Australia

Breeding, genetics and general uses of Ipil-ipil. Leucaena leucocephala or Ipil-ipil is mainly (native indigenous) in the countries of Central America such as Mexico, El Salvador. It occurs in a range of forms which can be divided into:

1) Relatively short bushy varieties that are early flowering and low yielding, e.g. that materialized in Hawaii and Pacific region useful under poor soil condition such as stony hillside.
2) Tall erect varieties with restricted basal branching and that are late flowering and high yielding e.g. Guatemala 128 and K28 selected by Dr. Brewbaker. It is useful for timber.
3) Tall, late and high yielding and with strong basal branching e.g. Peru. These are the best forage types and can be grown in association with grasses like guinea, buffel *Brachiarea decumbens,* pangola.

In breeding and genetic work, it was found that the erect habit was dominant over bushy habit and that the absence of strong basal branching was dominant over its presence. Thus, it is possible to breed and select varieties for high timber yields on one hand and varieties for high levels of EAM within the reach of cattle on the other hand.

We have been successful in breeding a new variety Cunningham with up to 50 percent greater EAM production than the standard cultivar from the cross Guatemala X Peru. The desirable brancing habit of Peru was retained as well as the EAM within the reach of mature cattle. However, Cunningham has greater wood production than Peru which gives it the potential to produce large numbers of buds and leafy shoots. Also, it has been found that Cunningham has a greater ability to extract Ca from the soil than Peru which may contribute to its greater EAM production. Cattle grazing on *L. leucocephala* will give high daily weight gains of about 1 kg and the cows give high milk yields. Cow's milk has a taint which disappears on pasteurization. Prolonged grazing of cattle on almost sole diets of *Leucaena leucocephala* will cause loss of weight and loss of tail and rump hairs and general illthrift. Usually there are no effect on conception rate. The illthrift is due to the mimosine in *L. leucocephala* which varies from 13-16 percent in the leaves. The mimosine breaks down in the rumen to DHP which interferes with the thyroid activity. There is no marked differences between the varieties of *L. leucocephala* in mimosine content. Thus to obtain low mimosine types, it is necessary to cross it with the leucaena species such as *L. pulverelemta*, We have breed types with half the mimosine content of Peru from crosses between Cunningham or Peru and ecotypes of a species which appears to be *L. pulverelenta*. Obtaining a good chromosome balance and seeding ability was difficult but has now been achieved. It is hoped to produce types with 1/3 the mimosine content of Peru. Associated animal feeding experiments indicate that Leucaena types with low mimosine levels could markedly reduce the adverse effects obtained in prolonged grazing of Leucaena by beef cattle.

IPIL-IPIL BREEDING AND MANAGEMENT OF FORAGE

Dr. Emil Q. Javier
Director
Institute of Plant Breeding
UP at Los Banos
College, Laguna, Philippines

Our efforts in the Philippines have been mainly on testing adaptation and proceeding immediately to seed distribution and multiplication. In 1971 we got seed samples from Dr. Brewbaker and since that time on we got our supply from BAI. I guess that is how the BAI program in Batangas got started. I remember we brought 4,000 plastic bags of the Brewbaker materials to Batangas and the perceptive Batangas people took off from there. I'd like to point out the kinds of situation ipil-ipil is being used or utilized for forage purposes as a background for the kind of breeding program and breeding objectives that we would have to pursue. Dr. Hutton presents one type of livestock production system and which is of course the grazing system of utilization. In due course, the breeding program, would be directed to that kind of utilization of the species. Indeed in Southeast Asia like the Philippines, we have quite a big livestock production based on grazing system of utilization. There had been some efforts to introduce ipil-ipil combined with native grasses like imperata or with zone products. But at this point, we are not very sure and we have not really recommended at all the growing of ipil-ipil with grass under grazing systems in the Philippines. I think Dr. Jones will illucidate on the system of management they have evolved for ipil-ipil. Present management in our livestock farms leave much to be desired and we guess that if they allow these things to outgrow them they will have a forage right in their hands. At this point however, we are not very keen on recommending on a very large scale the utilization of ipil-ipil for grazing systems.

The second category of livestock production system where ipil-ipil is being used is the cut and carry system. Here we have 2 categories: In the first place, we have small farmer holdings as represented by the type of agriculture that the governor from Batangas had mentioned this morning. We have the systems of livestock production which in this part of the world accounts for 80-90 percent of the livestock. The ipil-ipil or the species managed is not under grazing but as a cut and carry system. The ipil-ipil seeds are grown in hedges, trenches and the branches are cut off to produce new leaves from time to time. That should be quite different from the grazing type of management that one would expect in the ranches. The second category under the cut and carry system is the mechanized forage production system that one would favor for this intensive feeds production like dairy production and likewise for commercial production of these leaves. Thus, one would envision the planting of ipil-ipil in very thick densities in rows and hills; the rows are 30-45 cm apart at very high population rates. Then the ipil-ipil is chopped every 2-4 months and the materials are sent directly to livestock or dried for leaf meal. I pointed this out because this means that the breeding program for ipil-ipil should be evaluated at a certain stage. Hopefully, it really does not matter whether you are going to use this for grazing or for mechanized forage production. I have got the feeling that they might not be exactly interchangeable. Most of our varieties for upland crops in the Philippines have been evaluated in between main crops or after rice and so on. So now, we are shifting our evaluation program for varieties in the Philippines and instead of the usual upland-open-sunlight nursery, we have an evaluation for crops after rice. This results in the stock of seeds in the soil and we have a condition of very sticky padded soil at very short maturity. At the same time, we now have evaluation systems under partial shade because more of our varieties are grown in between other crops in relay. Anyway, the idea is when we develop our programs for ipil-ipil, we should keep in mind the kinds or systems under the which the crop is to be managed and utilized. I am saying that perhaps in the evaluation part, we should keep in mind that we should have evaluation for grazing, for mechanized forage production and evaluation as forage. I am hoping they are the same but nevertheless we have to provide for that. The breeding objectives for ipil-ipil would be broadly classified into four categories. First, adaptation to environment. The new giant ipil-ipil will have to be evaluated for its performance under acid soils. One gets the feeling that the native Hawaiian type is more hardy under these very poor conditions. But certainly we now begin considering the varieties, which Dr. Hutton mentioned, that are more efficient in extracting calcium, phosphorous and that grows under low pH type of soils. Secondly, the cultural minorities of Michael Benge lived in the mountains and we are driving them further up in the mountains at 2,000-4,000 ft. If we want to use ipil-ipil under those conditions, we must have more soil-tolerance in our materials. For cultural minorities and also for reforestation, we might need more plants that are soil-tolerant. The second group of objectives would be the forage yield, I think the major components here would be the amount of basal branching that Dr. Hutton mentioned. The third category would be tolerance to pest and diseases. So far, we have been very impressed on the relative tolerance of ipil-ipil to whatever there is in the environment, though the giant ones seemed to have more of the larvae in the parts and the weevils on the seed. By and large, we don't have much alarm yet on the pest and diseases of this commodity Certainly, as we know more of this, there would be ocassion for pest and diseases hitherto not serious that are becoming more serious. Last category will be the character concentrating on the mimosine content. Of course there is now a lowering of the mimosine content. In the Philippines, we use ipil-ipil as coloring material for poultry, so there might be a need to look into the carotene and xantophyll content.

In the breeding programs for ipil-ipil, we have to consider that there is at least three major uses or conditions for ipil-ipil. Management of ipil-ipil for forage purposes, grazing systems and the mechanized forage production.

POTENTIAL ROLE OF IPIL-IPIL IN THE PRODUCTION SYSTEM

Dr. Donald Plucknett
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Honolulu, Hawaii

Cultural practices

In many countries, leucaena has spread naturally to become a dominant plant in lower rainfall lowlands. Its ability to volunteer and to become naturalized would indicate that it is an easy plant to manage. In general this is true, but there are some management concerns which need attention. Management requirements will depend heavily upon the particular use for which Leucaena is intended. For this reason, a complete set of cultural recommendations cannot be given. Special priority must be given to research on management systems for different ecological situations and specific uses.

Establishment

One drawback of Leucaena is its relatively slow seedling growth. Research is needed to find ways to accelerate its establishment and to shorten its early growth period. In general, any steps which will accelerate seedling growth and reduce early weed competition will be useful. Such steps include: good land or seedbed preparation; seed treatments; weed control; fertilization and irrigation.

Land Preparation

Land can be tilled or not tilled, depending on the situation. For forestry or extensive pastures, tillage may not be possible; therefore, use of fire or specially prepared planting sites may be required. Aerial sowing into the fresh ash of burned lands has been successfully accomplished, but some aerial sowing has not been successful. Further research is needed to ensure more predictable success with aerial sowing

For erosion control or reforestation, site preparation may consists of prepared planting holes for transplanted seedlings, or the opening of strip furrows to plant seeds.

For more intensive systems such as intensive pastures, intercropping, green manuring, etc., preparation of a good seedbed as is required for maize or other row crops, may be required. Seeds of leucaena are not large; therefore, the seedbed should be fairly fine to ensure good contact with the seed.

Seed treatment

Since hard seeds caused by a thick waxy seedcoat can be a problem, Leucaena requires scarification or special treatment to ensure good germination. Systems used have included mechanical scarification, heat treatment and acid treatments. Probably the easiest method of treatment is immersion in hot water (80°C) for 2 minutes. After treatment, seeds should be dried rapidly and stored before planting. Acid treatment which is done by dipping the seeds in concentrated sulfuric acid for 15 minutes, washing the seeds with water and drying is successful but somewhat a difficult job.

Leucaena usually requires inoculation with a specific leucaena strain of *Rhizobium* bacteria, in order to assure good nodulation of the roots and nitrogen fixation. Inoculation is especially advisable for lands in which the crop has not been grown previously. However, in areas where leucaena has been grown, the proper *Rhizobia* may be present in the soil and inoculation may not be required.

Seed pelleting may be useful to assure good establishment of the seeds. Pelleting steps include: mixing the inoculant with an adhesive solution (gum arabic - %, is suitable), coating the seeds with the adhesive/inoculant solution, and then adding a dry coating material such as lime. Pelleting may be done by tumbling the seeds in a concrete mixer or by rotating them in a small bucket or can which has been equipped to rotate with a hand crank. Seed treatments such as fungicides may be added to the pellets, but extra care must be taken to prevent the inoculant bacteria from being killed by the chemicals.

Sowing

Seeds can be drilled or broadcast sown at a depth of about 1.5 cm. Sowing rates vary widely depending upon the intended use and row spacings; for most purposes 10-20 kg per ha is probably adequate. Broadcast sowing rates should probably be about 20-25 kg/ha. Sowing rates should be worked out for local situation and needs.

Transplanting of seedlings grown in pots

In some situations, it may be desirable to germinate leucaena in small pots and transplant it directly in the field. This helps to overcome the problem of slow seedling growth. Plants have been germinated in peat pots and then transplanted in vigorous pangola grass pasture by using a tractor-drawn subsoil chisel attachment to make furrows. Such furrows or planting holes could, of course be prepared by hand.

Local potting materials such as coconut husks could be used as growth media for seedlings to be transplanted. Care should be taken to ensure that seedlings are adequately supplied with nutrients by using small amounts of fertilizer or nutrient solutions to supply at least Ca and P. *Research is needed on local requirements and used for transplanted seedlings.*

Time of planting

Sowing at the beginning of the rainy reason is most suitable. For high rainfall areas, planting should be timed to coincide with the period when leucaena seedling growth will be greatest and the weed competition is lowest. *Time of planting studies are needed for local situations.*

Plant Spacing and field design

This is an area which needs research and which is highly dependent upon the management system and the local environment. For most purposes, Leucaena is usually planted in rows. However, for forest use or erosion control on denuded lands, broadcast sowing may be used.

Row spacings vary widely, from as narrow as 0.3 m or so for mechanized forage harvesting systems, to 1-1.3 m or so in intercropping or intensive grazing systems, to as wide as 3-4 m for grazing or when intercropped with food crops or short term crops such as maize. Each system will require its own spacing and field design.

Plant spacing in the row also varies widely, from as low as 15-20 cm or so, to 1 m or more.

Weed control

Leucaena seedlings suffer greatly from weed competition for at least the first 4 to 6 months; therefore, until the leucaena canopy is developed enough to shade out weeds or until the root system has developed enough to permit the plant to compete for moisture and nutrients, weed control must be practiced. *Little is known about weed control methods in leucaena production systems: additional research therefore is needed.* Cultivation with hand tools, with animal-drawn machinery or with tractor-drawn machines is often used to control weeds between the rows.

The crop is quite tolerant to most herbicides, so chemical weed control is a distinct possibility. Certain selective grass herbicides, preemergence herbicides, and contact herbicides show most promise. *Research is needed on chemical weed control.*

Irrigation and Water requirement

Once established, leucaena can withstand several months of dry weather; indeed, this is one of its major virtues. However, to ensure rapid seedling and early growth, moisture can not be limiting. In rainfed areas, planting at or near the beginning of the rainy season is probably the best solution. Land shaping to collect rain water may be useful in low rainfall areas to assist in establishing the young crop.

Irrigation has been practiced with good results. Methods used have included furrow and sprinkler. Irrigation even in limited amounts and at infrequent intervals, is of great value in prolonging and improving crop growth in the dry season.

Some irrigation experiments have been conducted in Hawaii. Yield and growth responses to irrigation can be striking; in one experiment a single irrigation following harvest was adequate for good forage yields. It appears that it takes about 590 kg of water to produce 1 kg of dry matter, and that, in general, each 2.5 cm of irrigation water supplied during the dry season would produce about 1.7 T/ha of additional green forage. Takahashi and Ripperton (1949) estimated that the crop could be grown without irrigation in areas receiving about 1250-1500 mm of annual rainfall. Below that, yields during the dry season would be low unless irrigation was provided.

Frequency of harvest and height of cutting

Leucaena is famous for its ability to withstand repeated defoliation either through cutting or grazing. This characteristic also makes it a desirable candidate for systems where firewood or forage needs are high.

Plants can be harvested in as short as 6 months after planting and they can be cut as low as 7.5 cm without injury to the plant or reduction in yield. However, low heights of cutting may result in a high competition of the plants with the weed growth in the interrows. Higher cutting heights may be desirable for some management sytems. Besides, cutting back to leave the stumps to about 1-1.3 m height is a common practice in soilage or green manure cropping systems.

Frequency of cutting can be important. Most experiments indicate that harvesting every 3 months results in sustained high yields. During optimum growth periods, e.g. summer, shorter harvest periods of about 2.5 months may be used; but during periods of slower growth, e.g. winter, the periods between harvests can be lengthened from 3.5 to 4 months. Most systems will probably result in about 4 crops per year.

Farming Systems

Leucaena improves the soil in three ways: through nitrogen fitration, addition of humus, and action of deep roots which penetrate compacted soils. It is used to provide protectice cover for eroded or potentially erodable lands, especially in steep hill lands.

Deep root penetration enhances the soil by improving the water-holding capacity as well as bicycling nutrients from soil depths to the surface. In natural stands, an organic mulch layer from decaying leaves and stems builds up under the plants, providing a protective cover for the soil and improving soil fertility.

Drought tolerance, ability to grow on steep slopes, and permanence under natural stress conditions are special strengths of leucaena for erosion control. The plant is little injured or affected by wind or storm damage.

Planting systems for erosion control vary, including: use as an intercrop in tree or plantation crops; contoured rows or hedges across hills or along dikes or terraces; solid stands on steep difficult sites; strip-cropped hedges planted on the contour and alternated with strips of arable crops; or even establishment on ridge and hill tops, with an aim to spread naturalization on the slopes below.

POSSIBLE INTEGRATED IPIL-IPIL PRODUCTION SYSTEMS ON NATIONAL BASES

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Introduction

In recent years no single tree species has stirred considerable excitement among foresters, agriculturists and policy makers, as Ipil-ipil(*Leucaena leucocephala*) [(*Lam.) de Wit*] has done. The species has attained considerable prominence and gained a lot of attention from researchers and producers in so short a time.

This is indicated by the current thrust in Ipil-ipil production and the intensified research efforts in different parts of the world particularly in tropical countries.

For many years, however, researchers in the Philippines, especially those in forestry, have treated Ipil-ipil species as an ordinary small leguminous tree; the uses of which are limited to that of being a source of fodder for cattle and as firewood. The tree has also been planted as hedges around farms and as erosion check on slooping grounds and river banks. Recently, people have discovered more and varied uses of Ipi-ipil. Research and development efforts may yet turn out others.

The Ipil-ipil species native to the Philippines which was formally known botanically as *Leucaena glauca (L) Benth* is widely scattered on cultivated lowlands and in the vicinity of second-growth forest areas. Early experiences in growing the tree have shown that it is an excellent species for primary planting in grassy areas due to its ability to withstand competition with perennial grasses. It has a relatively rapid growth and high potential value for fuel in regions where wood is scarce.

Available literatures as early as 1914, point out that this species originated from Central America and found its way to Africa and Asia, including the Philippines. In 1910, H.M. Curran of the former Bureau of Forestry suggested the trial planting of the common Ipil-ipil variety to test its suitability as reforestation crop in the Philippines. Initial results showed that the species was not very exacting in its soil and climatic requirements and that it survived and showed excellent growth in regions of long exceedingly severe dry seasons. Rapid expansion of grass areas is a serious problem in such regions and the ability of Ipil-ipil to successfully compete with cogon grass (*Imperata spp.*) during long dry periods makes it a suitable species for reforestation. Thus, the Philippine government has been on a limited scale using Ipil-ipil for reforestation principally for erosion conrol and soil enrichment.

In the Philippines, no intensive investigation has been conducted on the production, management and utilization of Ipil-ipil although the Forest Products Research and Industries Development Commission (FORPRIDECOM) has done some initial investigations on its use as a source of charcoal and fuelwood for steam-powered plants. It was only recently that interest in Ipil-ipil rose with the introduction of fast-growing, high yielding and improved varieties from Hawaii and Australia. We are fortunate that some researchers who pioneered in the development of Ipil-ipil improved varieties, notably Dr. Brewbaker of Hawaii, are with us in this consultation. It is a tribute to Dr. Brewbaker's efforts that a new, improved Ipil-ipil has emerged with a botanical name known as *Leucaena latisiligua* [(L.) W.T. Gillis] which has been changed back to *Leucaena leucocephala* [(Lam.) de Wit]. In Hawaii, they call the species Koa Haole or Hawaiian Giant; in the Philippines we have rather creatively called it the "Giant Ipil-ipil". It was reported that under Hawaiian conditions, this variety can produce wood yield that is 100 to 200 percent more than the common tropical strains of Ipil-ipil. Ordinary strains can yield only about 35 cubic meters per hectare per year at the end of a 3-year rotation period for firewood production.

Progress of Philippine Production of Giant Ipil-ipil

Improved varieties of *Leucaena* species are proving to be more versatile than the native Philippine species. Their introduction to the country came at a time when the Philippines was beginning to feel the energy crunch and looking for products to fill up the increasing needs for animal feeds, fertilizer and pulp. With the potentialities of Ipil-ipil as a source of forage, feeds, fertilizer, charcoal, banana props, fuelwood and pulpwood materials, there promises to be handsome market for Ipil-ipil products. The Ipil-ipil production craze started when a number of individual enthusiasts and firms started growing the Giant Ipil-ipil on an experimental basis. Private individuals have been planting from one to 50 hectares of their agricultural lands largely for banana props and seed production. In Davao, about a year ago, Ipil-ipil seeds were selling from P1,000 to P1,500 per ganta. Due to the limited supply of seeds, the pricing mechanism gave the advantage to the producers. On the other hand, risk is always on the part of the buyers because the seeds are not often certified as to their origin and viability.

For fertilizer purposes, scientists at the International Rice Research Institute (IRRI) noted enthusiastically that the effect of Ipil-ipil leaves on the growth of sweet corn was "incredible and dramatic". The claim was corroborated by the Fertilizer Industry Authority which reported that field tests here and abroad "have confirmed reports that Ipil-ipil as fertilizer could dramatically improve crop growth and yield."

The Bureau of Animal Industry in Pampanga reported recently that it is planting 50 hectares with improved varieties of Ipil-ipil for animal feeds in its various breeding stations. In Batangas, Ipil-ipil serves as the most valuable cattle feed in the backyard feed lots. A head of cattle is fed 5-20 kilograms of fresh Ipil-ipil leaves daily.

The biggest Ipil-ipil plantation so far was started about a year ago by the Mabuhay Vinyl Corporation in its plantation area in Initao, Misamis Oriental, Mindanao. It has already planted more than 200 hectares of its 4,000-hectare area which it leases from the government. It expects to fully stock the area over the next two years. The company will utilize the Ipil-ipil wood mainly for charcoal production and the leaves possibly for seeds and fertilizer.

As an incentive for farmers to get involved in Ipil-ipil production, loans are being granted by the Development Bank of the Philippines to farmers in the vicinity of any

Ipil-ipil using industrial plant. To be able to plant and grow Ipil-ipil in their private lands ranging from one to four hectares, the amount of P1,000 per hectare is loaned to them. Such loan is payable after four years on the first harvest.

The response to the planting of introduced Ipil-ipil varieties has been very encouraging. However, adoption of such varieties must be backed up by local research findings. Intensive research on the production, management and utilization of Ipil-ipil for various purposes should be done first to find out the strengths and weaknesses of the species under Philippine conditions. This is the very reason why an integrated Ipil-ipil production system must be a viable working model.

A model for an Integrated Ipil-ipil Production System

In an integrated Ipil-ipil production system, the major emphasis is the coordination of relevant activities that are necessary in the production of the various end-products that would lead to an efficient and optimum use of scarce resources. The foci of attention are those lead processes that would ultimately contribute to the final realization of specific end-products needed by the consumer. The schematic diagram in Figure I illustrates such a model.

We will assume that the integrated production system is business-oriented and as such we have to look at the quality of products that would give us the maximum profit. What shall we do in the case of Ipil-ipil end-products? Let us say that our end goal is the manufacture of animal feeds out of Ipil-ipil leaves. What are the necessary inputs to produce this product which is at the bottom of the diagram? Essentially, we need the assistance of research institutions like the National Science Development Board (NSDB), Philippine Council for Agriculture and Resources Research (PCARR), University of the Philippines at Los Banos, Forest Research Institute (FORI) and Forest Products Research and Industries Development Commission (FORPRIDECOM) after receiving feedback from the "environment" that a particular product is in demand, necessitating its immediate production. The research institutions, because of their distinctive competence in developing new technology, have to examine what specific areas to investigate. Potential areas for research embracing production, utilization and end-uses of Ipil-ipil have to be identified, defined, and executed on an experimental basis taking into consideration the economic feasibilities of the process involved. After the experimental process and substantial data have been gathered, an application of results can now be tested on a pilot scheme of production management with a particular end-product in mind, e.g. feeds, charcoal, fertilizer, etc. If this stage shows a satisfactory economic picture, this final research output would then be ready to be applied by the government and the Ipil-ipil industry for a large scale production. The government can also use the research result in the formulation of production incentives which the industry can avail itself of in setting up its specific management objectives in the development of Ipil-ipil plantations for one or multiple end-products. After the product development, the production sector has to devise its marketing strategy, namely, how to reach its desired consumer in the most efficient system of delivery to ensure the greatest profit. On the other end, the consumers have to get feedback on the various production incentives so that they will be guided on how the pricing mechanisms of Ipil-ipil commodities have been arrived at.

Advantages of An Integrated Ipil-ipil Production System

We can point out that integration is the most rational approach in developing a production system for an improved variety of Ipil-ipil in any given country where the species has not been fully developed. In an integrated system, prior to actual growing of Ipil-ipil especially if it is done on a large-scale commercial plantation, the initial step is to provide inputs (results of intensive research) to production that are based on local conditions prevailing in a particular country. This may involve a considerable length of

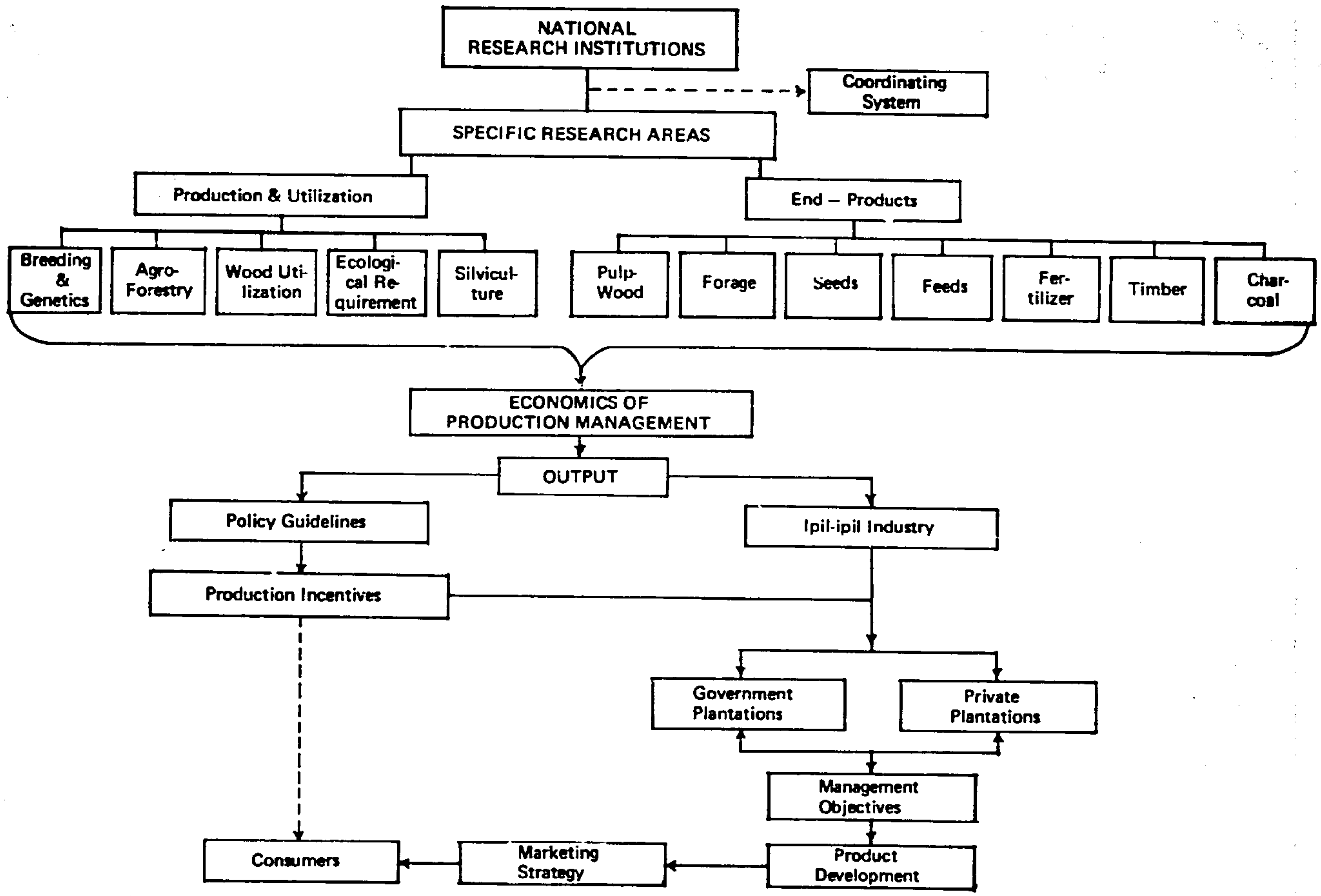

Fig. 1. Schematic Diagram of an Integrated Ipil-ipil Production System.

time and utilization of other scarce resources but this should be considered as a prerequisite to the production process. The system in its totality views production as an extension of other related processes, e.g. research activities, testing research results on a pilot basis, etc., and is always linked with market situation when the time horizon for the end-product is up for the consumption decision. It is premised on the fact that every important event that would contribute to the total system has to be coordinated well such that no relevant input for production is left out. The production system is keenly aware of the various stages that have to take place *a priori* which are all necessary conditions that would lead to the successful attainment of the final production function. In this integrated approach, the management will be able to establish systematic, organized and coordinated programs of research mechanisms for the final product.

Recommendations and Conclusion

It is recommended that an integrated approach to Ipil-ipil production be considered as a model for various countries desiring to develop the technology of improved varieties of *Leucaena* species. It is to be emphasized however that this model is being presented here for discussion with the view of refining and improving it.

It is worthy to note that the Economic and Social Commission for Asia and Pacific (ESCAP) at its 32nd Session (1976) adopted two resolutions, the first to draw up a detailed programme of work on integrated rural development and the second, to promote technical cooperation among developing countries.

It now becomes necessary for a country not only to look after the strengthening of its national capabilities and capacities but also to look for opportunities to cooperate with and help promote the welfare of other nations within the region to where it belongs.

In the Philippines, we have drafted a national integrated Ipil-ipil research program (PCARR, 1976) in the same manner that we have integrated the research phases on bamboo and high premium tree species. We hope to do the same thing with its production phase.

An integrated system of production of Ipil-ipil is proposed in this paper. If with this proposal we could motivate the participating nations into adopting a model for integrating Ipil-ipil production such as what we have presented here we shall have essentially extended to them our technical cooperation.

We foresee the countrysides of developing nations bustling with Ipil-ipil production and utilization activities. We also foresee vast cogonal, denuded or eroded forest lands and farm lots green with Ipil-ipil cover. Many rural people will be gainfully self-employed. Rural communities will have another source of income - an added milestone for rural development.

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NATIONAL INTEGRATED PROGRAM FOR IPIL-IPIL RESEARCH

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I just want to take advantage of this opportunity of being able to prick the brains of this international group of specialists because the Philippines has just put together a national integrated research program for ipil-ipil. We felt that this is a very opportune time for us to tell them what we are thinking and to prick their brains on how to further improve such a proposal.

High-yielding ipil-ipil (*Leucaena* spp.) (3 years old) when used as fuelwood would only be 18 percent of the cost of liquefied gas for the same heating level. Similarly, a study of the use of ipil-ipil as fuelwood for a 75-MW electric generating plant has revealed that unit production cost per net KWH is only P0.20 compared to P0.205 using oil to heat the same plant. Ipil-ipil is replenishable having the capacity to grow and regenerate in high contrast to oil which is forever lost once consumed. The area for possible testing sites of the different varieties of the species could be easily selected from some 370,000 hectares available for the purpose. Of this total, at least 85 percent still needs conversion into commercial plantations of fast-growing hardwoods including ipil-ipil. The areas were categorized as such by the Presidential Committee on Wood Industries Development in 1973. This projection on strategic locations, therefore, favors an integrated research on ipil-ipil.

Associated with the high cost of fertilizer due to the almost prohibitive prices of oil, Giant Ipil-ipil is considered a living factory of essential nitrogen. Compared to other legumes like mungo (mung bean) peanut, etc. with only 0.5 percent nitrogen content. Giant Ipil-ipil possesses tremendous volume of green manuring stuff to over 20 M.T. (dried leaves) per hectare per year with 4.0 percent nitrogen content. The above figure yields the equivalent of 2.5 M.T. of ammonium sulfate, 1.0 M.T. of superhosphate and 1.0 M.T. of muriate potash. With the available technology or 'Transfer System for Green Manuring', it may be feasible to improve our farming system by location-specific studies, since the system would lead to properly balanced soil fertilization within the reach of the small farmers. Towards this end is the localized application of research results especially under Philippine conditions where soil and climate have wide ranges.

Hand in hand with the establishment of large scale ipil-ipil plantations are the problems of discovering other uses of the species. Scientists from the Forest Products Research and Industries Development Commission (FORPRIDECOM) have come up with preliminary findings that pulp and paper, wallboard, particleboard and other novelties are very promising products from ipil-ipil. There is now one company in the Philippines (Nasipit Plantation) which is planting ipil-ipil to fuel the sawmills on about 31,000 hectares in Mindanao for the production of polyvinyl. The Institute of Plant Breeding (IPB) at the University of the Philippines at Los Baños is presently conducting preliminary studies for the purpose of securing benchmark information on ipil-ipil varieties under Philippine conditions.

Just recently, the general manager of Nasipit Lumber Company has indicated that his company has established an ipil-ipil plantation which is designed to fuel their sawmill if the need arises. They are quite jittery about the oil situation so just in case this comes up, they are ready to continue their sawmill operations by using ipil-ipil.

At the present, work in the Philippines indicated that there are eighteen (18) completed projects in the country which are varying in topics from utilization for wood, for feeds and the like. We have thirteen (13) on-going projects and twelve (12) project proposals in the pipeline requiring some ₱3.0 million. These are all included in the documents that we have distributed.

Program Component

The research program deals with available high yielding strains of ipil-ipil in the country and if possible, the introduction of new varieties from other countries. In general, we have six (6) proposed projects:

	Implementing Agency	*Project Leader*
Varietal Introduction, Hybridization, Selection and Seed Production Technology (Project 1)	University of the Philippines at Los Banos (UPLB) Los Banos, Laguna Forest Research Institute (FORI) Bureau of Animal Industry (BAI)	E.Q. Javier
Silviculture (Project 2)	Forest Research Institute (FORI) Los Banos, Laguna	M.V. Dalmacio
Management for Wood Production and Watershed Rehabilitation (Project 3)	Forest Research Institute Forest Products Research and Industries Development Commission (FORPRIDECOM) Los Banos, Laguna	F.D. Virtucio
Utilization for Wood Products (Project 4)	Forest Research and Industries Development Commission (FORPRIDECOM) Los Banos, Laguna	P.V. Bawagan
Management & Utilization for Forage and Soil Amerlioration (Project 5)	University of the Philippines at Los Banos (UPLB) Los Banos, Laguna	A.C. Alferez

Socio-economics (Project 6)	Forest Research Institute (FORI) and University of the Philippines at Los Banos (UPLB)	C.P. Diaz

The Forest Research Institute (FORI) shall handle silvicultural and management for wood production (including watershed rehabilitation and reforestation) research. The Forest Research and Industries Development Commission (FORPRIDECOM) shall handle all aspects of wood utilization research on the species. The Institute of Plant Breeding (IPB) of the University of the Philippines at Los Banos shall handle all studies on varietal improvement while research on management and utilization for forage and soil amelioration shall be undertaken both by the Departments of Agronomy and Animal Science of the College of Agriculture, University of the Philippines at Los Banos (UPLB). The socio-economic studies shall be jointly undertaken by FORI and UPLB.

PROJECT DESCRIPTION

Project 1 - Varietal Introduction, Hybridization, Selection and Seed Production Technology

In general, the high-yielding varieties of ipil-ipil adopt themselves to elevations ranging from 200-400 meters above sea level. Likewise, observations show that the soil pH in areas where they thrive best is confined to a limited range. With the heterogenous characteristics of Philippine soils, varying degrees of exposure and elevation of potential plantation sites and quite different climatic conditions from one locality to another, this project aims to develop through hybridization or other means, appropriate varieties for specific uses, given the locality where they are to be grown. This is one way of assurance that the species developed shall withstand resistance to possible pests and dieseases, thus leading to maximized yield per unit area. In the long run, improvement of selected strains may lead to easier seedling production and plantation establishment. Furthermore, varietal improvement of ipil-ipil is expected to usher in more specific needs of utilization. For example, developing a much higher yielding strain of lesser density for greater pulp conversion per unit volume of raw material or development of new strains with negligible mimosine content for animal feeds.

Project 2 - Silviculture

A considerable number of industrial firms are already involved in the massive planting of various varieties of ipil-ipil, on selected localities and for varied uses. The same variety is probably being planted with different methods of site preparation and much more varying degrees of cultural treatments. Also, no record so far is known whether commercial plantations on their mid-rotation periods are given stand improvement treatments for greater yield and higher quality of the harvestable crop.

This project envisions to identify promising sites and adoptive methods of site preparation for specific varieties. It will ensure high survival and faster growth with the least possible costs. An example of this is developing technology on the overall silviculture needs of a given variety if intended for lumber or veener production (it is possible that certain varieties could reach the minimum raw-size for these end-products). Studies on insect control would be included. The project shall also explore the potential of a number of ipil-ipil varieties as: cover crops or nurse-trees for fast-growing hardwoods; the most promising short-fiber hardwoods in the Philippines for pulpwood; and ipil-ipil varieties especially suited for would-be plantation sites that need soil amelioration.

Project 3 - Management for Wood Production and Watershed Rehabilitation

This project includes two(2) components, namely: (a) management for timber and pulpwood production and other uses, and (b) for watershed rehabilitation/reforestation. The first component shall include the determination of optimum rotation and/or harvest frequencies for selected strains in different localities in the country. Likewise, the first component shall derive yield prediction equations for different site qualities serving as guide for future investments in plantation scale as well as backyard-scales operations. Added to this, a weight-volume relationship, when known for any variety shall be useful in eliminating the need for tedious measurements. Thus, a greater turnover in the hauling of materials to processing mills would be generated. The second component is suited to meet the needs for critical watersheds especially for their rehabilitation with the use of specific varieties of ipil-ipil, and to be made relevant to areas confined to the source of hydro-electric power and water reservoirs for industrial and domestic use.

Project 4 - Utilization for Wood Products

At present, the wood of ipil-ipil is used as fuelwood, as a source of charcoal manufacture, and as props in banana plantations. Consequently, the leaves are also used as feed supplement for livestock. These present uses, however, do not maximize the utilization aspect of this renewable resource. In fact, the wood can also be source of pulp and paper, veneer and plywood, construction lumber, poles, picker stick and side level, particleboard, hardwood, parquet flooring materials and tannins. These possible finished products could be big dollar earners for its utilization in order to direct efforts into appropriate scales of operations. For instance, knowledge on the anatomical, physical, and chemical properties of high-yielding ipil-ipil will enlighten the industry concerning its pulping and paper-making potentials. Also, when its mechanical and related properties are known, needed information for lumber-making, veneering and plywood making will be established. Consequently, proper equipment can be designed and developed for effective processing. Hence, before any step towards maximum utilization could be made, wood properties should be studied thoroughly. These would be the bases for recommendations to future investors for processing/utilization.

Project 5 - Management and Utilization for Forage and Soil Amelioration

To realize the great potential of ipil-ipil for livestock feeds and its use for soil amendment, a broader base on its management and utilization are necessary. The project shall therefore cover some aspects on ecology which shall take into account interrelated factors that affect ipil-ipil establishment in open grasslands or rangelands. Emphasis are on soil factors and growth association of ipil-ipil with various pasture vegetation. Added to this would be cutting/defoliation management schemes that would relate to herbage yield and quality.

Similarly, the project shall work on the use of ipil-ipil for animal feeds in backyard operations; and in determining the most feasible techniques in processing ipil-ipil into leaf meal and other feed supplements for future use where the supply of other similar feeds would be scarce or when costs are prohibitive and adversely affect generation of higher income. Emphasis shall also be given to determining combinations of operations that would lead to maximum utilization of ipil-ipil for green manuring or its use for fertilizer, and in formulating suitable processing of the fertilizer for future use, especially if the amount produced is in excess of the amount required for a given area.

Project 6 - Socio-Economics

This project is directed towards feasible production and utilization techniques for specific uses of ipil-ipil. To this end, analyses to be made shall be the basis for choosing the best alternatives for profit maximization. Questions such as when and how to establish plantation or to harvest should be answered by this project when completed. Another important aspect envisioned is the determination of pricing levels through stumpage that should be fair both to producers and buyers of harvestable crops.

In addition, this project will try to analyze multi-stage costings of ipil-ipil both from wood and non-wood product aspects. The mechanics is to determine cost of production and profitability/demand of a given variety under the same locality say, if used for fuelwood or for pulpwood, for charcoal, for fertilizer or for animal feeds. Once the information is obtained, prospective growers of various strains may be guided in choosing the best business alternatives or combination of alternatives.

Table 1. Summary of program budget in US dollars*

PROJECT	YEAR 1 IDRC	GOP**	YEAR 2 IDRC	GOP	YEAR 3 IDRC	GOP	YEAR 4 IDRC	GOP	YEAR 5 IDRC	GOP	YEAR 6 IDRC	GOP	GRAND TOTAL
1	20,700	54,318	15,533	58,574	–	45,200	–	42,468	–	43,754	36,233	244,314	280,547
2	13,721	43,582	6,106	25,826	3,196	17,129	175	11,712	182	8,366	23,380	106,615	129,995
3	73,828	46,180	18,150	26,509	14,300	16,855	–	16,855	–	13,726	106,278	120,125	226,403
4	152,439	67,429	44,366	61,878	14,685	43,989	4,817	26,915	3,552	28,859	219,859	229,070	448,929
5	18,136	56,489	8,833	52,925	2,999	14,423	333	22,935	200	10,871	30,531	189,643	218,174
6	–	16,003	–	13,303	–	8,446	–	–	–	–	–	37,752	37,572
GRAND TOTAL	278,854	284,001	92,988	239,015	35,180	176,042	5,325	120,885	3,934	105,576	416,281	925,519	1,341,800

*P7.5 conversion to the dollar.
**Government of the Philippines.

DISSEMINATION OF IPIL-IPIL TECHNOLOGY IN THE ASIAN REGION

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Introduction

This brief presentation covers three main topics, namely: (1) some comments on ipil-ipil technology, (2) an outline of SEARCA's activities that may be relevant to technology dissemination and (3) some suggestions on the regional aspects of a thrust to develop and spread ipil-ipil technology in this part of the world.

Ipil-Ipil Technology

A quick review of the most recent literature on ipil-ipil reveals that considerable work has been done on this plant which offers promising benefits for the well-being of mankind. However, this international consultation and the subjects that are to be covered by the anticipated discussions are an indication that research so far pursued has only opened new doors toward the exploitation of ipil-ipil as a multi-benefactor. It is interesting to note that recent literature on ipil-ipil was written by a number of people, some of whom are here today – Dr. James Brewbaker, Dr. James Moomaw, Dr. Don Plucknet, Mr. Michael Benge and Mr. Hugh Curran, Jr.

The literature covers the agronomics, utilization and economics of ipil-ipil, but it seems that while much has been done in the area of agronomics, much has yet to be done in the areas of processing, utilization and economics. Insofar as economic studies are concerned, my impression is that there is still a dearth of information. Comparative economics in production, processing, utilization and marketing – would particularly be helpful in spreading ipil-ipil technology. When I mention comparative economics, I refer to other products which have substitutability or competitive character in relation to ipil-ipil and its product uses.

I like to think that research is different from technology. Research produces technology. It focuses on specific problems to seek solutions. But they represent like the dots in a scatter diagram and they need to be put together to form a usable line which I would like to call technology. In other words, research results need to be packaged into technology in order to be of beneficial use to people in terms of goods and services of economic importance.

It seems to me that at this stage there is some ipil-ipil technology that is available and has, in fact, been used. However, much more needs to be generated.

Hugh Curran, Jr., sometime in 1974, showed me a paper which dramatically listed the product uses of the ipil-ipil. These uses are: fertilizer, forage, feed, food, firebreakers, fencing, fuel, fiber and film. He indicated in this paper many possible product modifications. When I asked him whether empirical date were already available to make possible the packaging of the information into technology, he said that most of the statements in the paper were actually hypotheses based on the research information, and further investigations would be required.

SEARCA's Activities as a Framework

In this consultation, it seems to me that certain questions should be asked. What do we know of the ipil-ipil? What can be done with the available knowledge? What else do we need to know? How do we proceed with the packaging of research results into technology and how do we spread the technology?

Undoubtedly, there will be attempts to answer these questions during the discussions. If given the technology, how do we spread it?

SEARCA's operations offer some answers.

SEARCA is a regional organization, one of the several centers under the Southeast Asian Ministers of Education Organization (SEAMEO). It is essentially concentrating on activities that contribute to agricultural development and rural prosperity. It mainly services the SEAMEO member countries including the Philippines, Indonesia, Singapore, Malaysia, Vietnam, Cambodia, Laos and Thailand. But due to the outward pressure of science and the interest of some of SEARCA's donors, some of the projects of SEARCA involve the participation of SEAMEO member countries and, in addition, such countries as Sri Lanka, India, Pakistan, Bangladesh, Korea, Japan and Taiwan. It is likely that in the near future other countries in the Pacific would be involved in some of the new projects of SEARCA.

SEARCA's activities may be classified into three general areas: (1) manpower training under which there are two programs – the graduate program leading to the M.S. and Ph.D. degrees and the short-term training program covering some 25 areas of training, (2) research and research related activities under which there are about 20 packaged projects; and (3) technology transfer thrusts under which there are two main programs, namely: the social laboratory and the integrated fisheries community development programs.

These activities have many permutations and combinations as they mutually support and reinforce each other.

In the short-term mapower programs of SEARCA, research findings are utilized as teaching materials and a training program could be specifically designed for a specific purpose. Thus, training on the development of ipil-ipil could be incorporated in the short-term training programs of SEARCA.

One project pursued by SEARCA in the last few years was the Protein Gap Study and this particular project offers a pattern of action that may be followed in the spread of ipil-ipil technology. In the Protein Gap Study, a workshop was held in which scientists from participating countries worked out a uniform testing program for crops of high protein content. Seeds of these crops – varieties and lines which were found to be suited in the participating countries – were assembled in Los Baños for multiplication and subsequent dispersal for testing purposes. Participating countries are expected to develop national programs involving the use of varieties which have been found to be best suited to their respective environments.

Still another project which SEARCA is pursuing, in collaboration with the Business School of Harvard University, is its agribusiness commodity systems studies. Under this project, crops of economic importance are studied in various aspects, including production, processing, distribution, financing, product utilization and such other aspects that have to be considered in the development of viable commodity industries. This project could be helpful at some point in time in the future when ipil-ipil technology results in the development of specific industries.

Information on ipil-ipil technology will need to be disseminated not only for the benefit of the users of the technology but also for the benefit of scientific workers. In this respect, one of the projects of SEARCA would be valued and this is the Agricultural Information Bank for Asia or AIBA in short. AIBA is currently acting as the Asian component for the International Information System for the Agricultural Sciences and Technology (AGRIS) which is based in Rome. There is a plan to incorporate in AIBA's activities FAO's Current Agricultural Research Information System (CARIS) at least insofar as Asia is concerned. With this additional responsibility, AIBA will also act as the Asian component of the international CARIS program.

As you may know, CARIS is interested in developing directories of scientific workers, on-going and completed research programs and in monitoring research activities and disseminating research findings. One can very well see how this particular project could be of value to the spread of ipil-ipil technology in Asia.

The third area of interest of SEARCA is technology transfer. Here, SEARCA has one project in the process of being developed and this is the integrated rural development program. The spread of ipil-ipil technology could easily become part of the series of technologies that are required in integrated rural development.

Perhaps, at this point we should emphasize that SEARCA's own experience in its seven years of operation, particularly in its Social Laboratory program, has pointed up the conclusion that for a particular technology to be absorbed readily by a community, it must be accompanied by a cluster of preferably related technologies that contribute toward the improvement of the quality of life of the people. A concentration on the spread of just one technology might have a salutary effect in the beginning but it runs the risk of losing meaning after a while, merely because of the very nature of life itself. The improvement of the quality of life means the use of many and varied technologies.

Some Suggestions

Considering SEARCA's experience as a frame of reference for disseminating ipil-ipil technology in Asia, some suggestions may be in order:

1. An attempt should be made to determine the state of knowledge in ipil-ipil and to develop technologies that can now be spread to certain communities in Asia.
2. The whole area of research problems should be explored, and priorities should be determined so that a systematic attack on research problems could be made not only on a national basis, but perhaps on a regional basis, considering that some countries in the region differ in their ecological circumstances.
3. There should be a system of national programs that should include production, processing, product utilization and marketing research on ipil-ipil. These national programs should serve as the basic component of a regional system in Asia on ipil-ipil research and development.
4. The national programs should develop delivery systems for ipil-ipil technology that would enable technology users, government or private, to use technology for the production of goods and services of economic impor-

tance to the people.

5. A coordinating system should be established to see that national programs complement and reinforce each other and result in increasing research and development capability in terms of able institutions and trained manpower.

6. Such a coordinating mechanism should make use of an organization acceptable to the participating countries, preferably one with an existing geo-political framework. The extent of such coordinating may vary the institutional structure of the coordinating system but in any case the coordinating mechanism should be based on a single institution that would operate with participative involvement of the component – national programs.

RESEARCH NEEDS IN VARIETAL IMPROVEMENT OF GIANT IPIL-IPIL

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Introduction

When we think of giant ipil-ipil as the "super marvelous miracle tree", it seems as though it can grow anywhere, at anytime and at a faster rate than its common type. It's free from natural enemies and the whole plant can be utilized from roots to leaves. Thus, what is there to improve in giant ipil-ipil? Why conduct research in the varietal improvement of giant ipil-ipil?

Most of us know that giant ipil-ipil has many uses. Perhaps, it would not be too exaggerating to say that its usefulness to a person's life is "from birth to death." It is being utilized as food, feed, fertilizer, lumber, control of soil erosion, etc. The usefulness of this species makes it an important object to improve research: to develop strain which is adaptive to a wide range of environmental condition which has good form and high wood quality and resistant to pest and diseases.

Some Features of Giant Ipil-ipil

Some of the features of giant ipil-ipil which influence breeding strategy and methods are:

1) Ecological variation - The different strain of giant ipil-ipil introduced in the country could have different range of adaptability to the prevailing environmental conditions. The variation could be great among strain and even within strain. The strain planted in Makiling Forest (perhaps K8 or K28) show growth retardation of about 500 meter elevation and on more acidic soil, growth seem to be slow. This species being a legume is naturally self-fertilized, making it a true-breeding species. However, it is observed that tremendous variation in growth and form exist among trees within strain. This indicates that this species has evolved genetic mechanisms whereby it thrives in breeding with occasional out-crossing to maintain variability. This variability is of particular interest to the tree breeders.

2) Regeneration - Giant ipil-ipils are poor seeder producing few pods in one fruiting season. It, however, flowers twice a year. The production of more vegetative (leaves) parts by a tree could have out balanced the production of more seeds. Instead of producing more pods, growth metabolism is diverted to vegetative parts.

Seed variability remains quite short. Seeds have to be properly stored.

Germination capacity is very variable depending on several factors such as origin, year and timing of harvest, and pre-treatment. Morphological features of the seeds, i.e. size, thickness and number of filled seeds vary considerably causing variation both in germination percentage and germination vigour. Variation in germination capacity and vigor gives problem both in experimental procedures and in practical forestry.

The species is relatively slow starter in growth. It stays in the grass stage for about 5 months. This is critical because if it is used in reforestation projects, it could easily be suppressed by weeds unless a thorough site preparation has been made before planting.

3) Vegetative propagation - In relation to seed production, vegetative propagation of selected plus trees is a must to maintain the inherent genetic quality of the seed tree. Cuttings (trunk, stump, branches) of native ipil-ipil grow easily when planted. Fences made of cuttings are seen growing wildly. Accordingly, cuttings of giant ipil-ipils may root easily with or without hormones and grafting may be done with ease. However, these techniques had yet to be perfected.

Regeneration using cuttings may not be feasible in the production of wood for lumber and panelling but it would be most appropriate in the production of this species for feed.

4) Pest and diseases - Contrary to most belief that the giant ipil-ipils are free from natural enemies, we have observed in trees grown in Makiling Forest that there are more enemies than previously thought of. During flowering time, numerous small larvae feed on the florets. Then when the pods are immature you can find the same species of larvae feeding on the seeds. Fungus also attack the young pods and even the mature seeds. Freshly collected seeds when not sun-dried are very susceptible to fungus attack. Whether the insect and fungus' damage is of major problem, it is yet to be determined.

5) Other features - When this species is being produced solely for feed, the problem of mimosine content come into focus.. Research should be planned to correct it. The inherent variability within strain and between strain should be taken advantages in the selection of trees with low mimosine content.

Giant ipil-ipils are shade intolerant. They could not grow well under shade. When planted under partially shaded areas as in adjoining plantation, trees reach for light. This usually results to lodging.

Some trees within strain are poor natural-pruner with knotly stem. This makes the wood inferior to lumber production.

Proposals for Breeding Strategy and Action

On the light of what has been observed on the natural features of giant ipil-ipil, the following research aspects should be considered:

(1) Emphasis should be placed on exploiting ecotypic variation to secure the best possible basis for selection and breeding. Selection of provenances for testing should be fairly liberal initially, as provenance/site interactions and adaptability are only little known. Several strain have been introduced in the country and their adaptability should be well recorded. Strain/provenances trials shall be done to include investigation on altitudinal variation, micro and macro environmental differences and growth reactions. Provenance trials would give information concerning the genecology of this species which is of immediate practical value to all of us who are concerned with the mass production of this species.

(2) The great variation exhibited in growth and wood characteristics among and within strain makes selection the most approriate initial step in varietal improvement. Selection for superiority in one form or another should be the more pressing activity for us for some time to come. In the selection of plus trees, the indication of low heritability for most traits implies more trees selected preferably in plantation giving more the best performance or in provenance trials. For the same reasons, progeny testing of the select trees should be attempted in a more systematic and comprehensive manner. Recurrent selection should be made continuing until the best genotypes has been found. Traits that should be considered in selection includes: low mimosine content, high natural pruning ability, shade tolerant, good growth form (cylindrical, straight bole), prolific seeder, proportional crown-stem ratio.

(3) Breeding for resistance against pests and diseases and for desirable growth characteristics. Attempts should be made to conduct intervarietal and interspecific hybridization for improving performance. The native ipil-ipil is more resistant to pest and diseases, hardier and sturdier, prolific seeder, drought resistant, and has a wide range of adaptation in the Philippines. A cross between the native and giant ipil-ipils may produce heterotic cultivars.

(4) Establishment of seed production areas and seed orchards for the major types of giant ipil-ipil. Seed is, for many purposes, the most convenient and the most common form of package for moving genes around. It is of great importance, therefore, that seeds used for planting are those which came from a known high quality source. Trees planted in seed orchards are those selected from plantations because of their desirable growth characteristics. The first stage seed orchards consisting of phenotypic selection serve both the practical purpose of concentrating and controlling seed harvest and to provide a certain genetic improvement. The clones should be tested in progeny trials as soon as possible and roqued according to these tests. The seed orchards may also be useful for studies of clonal (individual) variation.

Attention should be paid to the many different aspects of seed orchard establishment and management, i.e. propagation practice, layout, spacing, protection, soil treatment, flowering and seed yield in order to improve on efficiency and to make forecasts of the required seed orchard establishment.

(5) Vegetative propagation is a means for obtaining quick and substantial genetic gain. This would imply investigations of cost compared with more traditional methods or techniques. Investigation to include feasibility of using radiation and chemical growth promoting media should be encouraged.

It has been observed that giant ipil-ipil produce only small quantities of seed and those spread through the months of April, July and August. In such cases, the best resort would be to obtain scion material and graft it at a new site in different climatic conditions, e.g. a distinct dry season, which could induce more regular and prolific seeding than would occur in some plantations. This has to be investigated thoroughly.

(6) Integrated with breeding are silvicultural techniques. Seed handling, nursery practice, plantation establishment and management need most urgently to be explored.

In a few words, varietal improvement research should include selection of individual plus trees possessing the desired characteristics for specific uses; vegetative propagation for the establishment of seed orchards, progeny testing of seed orchard materials; recurrent selection until such time that a superior genotype is found. Intervarietal and interspecific crosses could be attempted at this stage.

These elite trees would be the source of seeds for our massive reforestation, agro-reforestation, and tree farming activities.

AGRONOMY AND FARMING SYSTEMS FOR IPIL-IPIL UTILIZATION

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Leucaena is a plant of the lowland tropics. It thrives generally in the arid lowland tropics and therefore it is used best in this environment. It grows below 500 m of elevation in areas with rainfall ranging from 12-15 in or 500 mm up to 60 in or more. It characteristically has slow early growth- that early growth becoming slower as elevation increases up to about 1500 meters. It grows in remarkably steep slopes; and one of its great virtues is that it grows in poor soil and has a very deep root system. This deep root system reaches water and nutrients that are not available to other plants which gives it a great competitive edge.

I would like to cover several cropping systems, one of these is erosion control and cover crop use for which Leucaena has been exploited. It has been used as a cover crop or shade tree for coffee, tea, cacao, quinine, rubber and coconut. Partly, because of its deep root system, it does not generally compete with small shallow rooted plantation crops. It has been used as the nurse crop in citrus and it does supply leaf fall which provides deep litter and accumulation of both N and organic matter in the soil. As a green manure crop, it has been used in coffee and tea, and it is used generally as a soilage, i.e. in a cut and carry type of operation for corn and has been used that way in rice at least experimentally. Something like a thousand trees/ha when pruned, will yield 36 tons green matter which is equal to a thousand kilos or a ton of ammonium sulfate. The new Bayani variety, I understand, will yield 20 tons of dry matter or 2-1/2 tons of ammonium sulfate equivalent; so the giant ipil-ipil is clearly accumulating a lot of nitrogen. The soil improvement uses of Leucaena in addition to its N contribution are that the deep root system breaks up compact soil and it appears to produce N either with or without rhyzobium. Apparently, the rate and mechanism has not been studied widely as is needed. The N accumulation mechanism of Leucaena is not well understood.

Leucaena is used in reclamation and in water conservation. But certainly we have already seen today some remarkable examples of reclamation in cogon lands and steep eroded soils and other types of waste land that have been reforested. The re-vegetation of bauxite spoil banks has been studied in Hawaii and we have seen pictures of poor soils in Caribbean - it's another place where bauxite reclamation had been done with Leucaena. In the fodder and forage crop use, ipil-ipil of course has its major great virtue and this has been often discussed by a great many people. The forage is high in protein and according to reports over 3000 kg of protein can be produced in a year by cutting the green matter. This is from something like 15 tons of dry matter which has 24 percent content in the leaves. The plant sprouts freely as most species do, but the plant does not tiller and therefore it can be used as a hedge plant and will stay in place. It does not tiller like the rice plant does but it does sprout freely from the stumps. As a forage crop it is slow to establish so that its use as weed control in early stage is quite difficult. If you read the paper by Takahashi, there has been a great deal of work done on herbicide sprays. The mechanical cultivation and the difficulty in the early establishment in their system of forage production is a solid stand of cut and dried forage production using 70 centimeter rows with completely mechanized harvesting and drying. That was a very successful experiment but has never achieved commercial success, at least in Hawaii.

We should recognized that present forewood production from Leucaena comes mostly from natural standard production which is relatively low. There are some new initiatives to use it for an oil substitute and the figures on the caloric value of the wood either directly or after it is made into charcoal is remarkable at about 4000 calories/kilo of raw wood. It is improved into a level of something like 7000 calories for charcoal production and this is compared to only about 10,000 in bunker fuel oil, so you're achieving nearly the same caloric value per unit with a wood product which is very useful.

The total N production is high. It reaches the 500 k/ha figures which is really a remarkable level of production. But the efficiency in Dr. Guevarra's thesis of N utilization was only 38 percent as high as that of urea and that was partly because in this early stage, the parts of Leucaena do not rapidly decompose so it can be taken up by the corn plant. Some more studies should be done on that matter, timing of Leucaena compared with the timing of final target crop needs to be adjusted so that the grand rate of growth of the crop coincides with the release of N from the leaf. But one should expect the low efficiency of this high rates of N application if the material is simply laid down on the ground because leaching volatilization losses will decrease the availability of N to the plant. The uses in forestry of course is in reforestation.

Leucaena had been used wonderfully since 1900 at least as a shade crop not only for coffee, but also as a shade in nursery crops for some other high value species. There are statements in the literature that tea production can be increased by at least 100 percent by intercropping it with Leucaena. One great advantage of Leucaena as a nurse crop or as a shade crop for young trees is that it does not compete directly with tall forest trees. While it does produce shade for some crops, it is not tolerant of shade itself. So that when you got a taller stand, it will not reproduce underneath the forest and compete with the target species in forestry. The remarkably deep root system gives another advantage.

Finally, I just would like to mention the windbreak aspect that has been mentioned before since it is something interesting to the vegetable producers and to many areas including Taiwan where the center is located. We need very much to develop a good windbreak crop that can contribute something to the soil improvement and to the production of vegetables and Leucaena seems like a remarkable choice. It does not resist wind damage and will grow rapidly enough to be useful at a very young age. Bamboo is used widely in Taiwan and in mainland China but it is a strong competitor. It grows rapidly, it is true, and it is a useful tree crop for other purposes. But it competes for nutrients and water with other crops that it grows with.

SOIL CONSIDERATIONS IN GROWING IPIL-IPIL IN THE PHILIPPINES

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In the Philippines, ipil-ipil can be found growing or being grown on every imaginable relief and topography from narrow valleys to flood plains, dissected plateaus, rolling hills and mountains with gentle to steep slopes. The soils have very thin to very thick profiles which are either very poorly drained to well drained. Some of these soils are gravelly or stony and in some places they are associated with rock outcrops. In some of these areas, ipil-ipil appears to grow luxuriantly but in others this plant appears to be difficult to establish.

In this paper, we report our findings on some chemical properties of these soils with the purpose of relating these properties to the growing of ipil-ipil and to present some results on the effect of phosphorous and lime on dry matter production of ipil-ipil in different soils screenhouse conditions.

Some Chemical Properties of Soils Grown to Ipil-ipil

Soils used in growing ipil-ipil are generally low in fertility. To obtain more detailed information on the fertility status of these soils pH, organic matter content, "available phosphorus", cation exchange capacity and exchangeable cation nutrients such as calcium, magnesium and potassium were determined.

As shown in Table I, soil organic matter content varies with soil and decreases progressively with depth in each profile. The surface horizons of Faraon clay and the Luisiana clay found in Ilocos Norte had organic matter contents of more than 5 percent. In the other soils, the surface layers contained from about 2 to 3 percent organic matter and decreased drastically with depth. The high organic matter contents in two of the soils is attributed to lesser soil erosion and run-off occuring on their surfaces.

Cultivation is also known to accelerate the loss of organic matter in soils. The low organic matter contents indicate that these soils are deficient in available nitrogen and that they will respond to nitrogen applications. The soils except Faraon clay are moderately acidic.

The available phosphorus levels range from less than 1 ppm to about 22 ppm in Faraon clay. Except for Faraon clay, these soils are all deficient in phosphorus.

The capacity of all the soils to retain cations against leaching is quite high. The amounts of calcium in these soils except Faraon are low but the amounts of magnesium are probably adequate. While the potassium levels may appear to be quite low (except Faraon clay), response to potassium has not been obtained on these soils. It may be inferred that these soils must have a high potassium supplying capacity. However, if high yield levels are to be obtained from using these soils, potassium fertilization eventually might become necessary.

Response to lime and phosphorus

We have attempted to identify some of these soil-related factors affecting growth of ipil-ipil in experiments conducted under screenhouse conditions.

Bulk soil samples were collected from 19 sites in Luzon island. The soils were analyzed for pH, exchangeable calcium, magnesium, potassium, aluminum and phosphorus extractable with a 0.1 N NNF/0.03 N HCl solution (Bray P_2 test).

The soils were placed in clay pots at seven kilograms per pot and sown to five ipil-ipil seeds (peruvian variety). After the seeds had germinated, the seedlings were thinned to three per pot and allowed to grow for 92 days.

In Fig. 1, 2, 3 and 4, are shown the relationships of dry matter production to soil pH, exchangeable calcium and Bray P_2 extractable P, and extractable aluminum, respectively. Since the pots used in the study did not receive any fertilizer or other amendments, the plants are presumed to be subsisting on natural soil fertility. It is obvious that low soil pH, and low phosphorus and calcium levels and high levels of aluminum were limiting plant growth. To further confirm these effects, a second set of pot experiment was laid out using four soils of the 19 sites used earlier wherein phosphorus or lime and a combination of phosphorus plus lime were applied. The data are shown in Fig. 5. The application of either phosphorus or lime improved plant growth dramatically and in one of the soils (Luisiana) best growth was obtained with phosphorus and lime..

Discussion

To assure establishment and maintenance of a good stand of ipil-ipil, the fertility status of the surface as well as the lower soil horizons should be ascertained.

Among the soil properties studied, available calcium had the best correlation with dry matter yield of ipil-ipil. Dry matter yield was highest at about 52 milliequivalents of calcium per 100 gram of soil which is equivalent to 51.8 tons of calcium carbonate per hectare. This explains the universal occurrence of ipil-ipil on soils with high pH. Hill (1971) reported that in the Bahamas, ipil-ipil can grow in areas where the surface of the ground is virtually bare limestone or coral. Ipil-ipil grows fairly well on calcareous soils in the Philippines. This particular behavior of ipil-ipil sets it apart from other tropical legumes which have relatively low calcium requirement compared with temperate species (Andrew and Morris, 1961).

Application of lime to Annam, Luisiana and Alanimo clays increased dry matter yield by 3,0, 2.5, and 2.0 times, respectively, whereas on Ibaan clay, the increase was only 1.25 times. Hill (1971) obtained significant responses to added lime at 25,088 kg/ha in a strongly acid soil in Papua where green forage yield was increased 2.5 times.

Another nutrient which was shown to be influencing plant growth in these soils is phosphorus. The correlation coefficient between fluoride-extractable phosphorus and dry matter yield was lower than that obtained between exchangeable calcium and dry matter yield. One reason for this is that the pH of the soil was not adjusted and the depressing effect of pH on the availability of phosphorus cannot be discounted.

The very poor growth of ipil-ipil on untreated Annam, Alaminos and Luisiana clays could be attributed partly to soil acidity. Besides the low exchangeable calcium contents of these soils, they also had high concentrations of salt-extractable aluminum, iron, manganese and zinc. As shown by the plot of dry matter vs extractable aluminum (Fig. 4), aluminum was detrimental to the growth of ipil-ipil.

Plants that were limed and treatened with phosphorus had the highest yield of dry matter. However, the fact that addition of either lime or phosphorus gave similar yield makes it difficult to establish which factor was more influential in improving plant growth in the soils. If increase in yield is attributed to addition of lime, the beneficial effect could be due to the supply of available calcium or in raising the pH which in turn caused a concomittant decrease in soluble aluminum, iron and manganese. The increase in yield due to phosphorus is due to the very low levels of phosphorus in the soil either because of effect of pH on phosphate solubility or the very low level of the native supply of phosphorus. However, on the basis of the analysis for inorganic forms of phosphorus, the effect was due to the low availability of the native phosphorus compounds. Lime is postulated to cause the release of some of the aluminum bonded and iron-bonded forms of phosphorus. However, there are claims that lime may decrease phosphate concentration because the added phosphate may be occluded by the precipitating mass of iron and aluminum hydroxides (Murrman and Peech 1968).

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Table 1. Some chemical properties of soils in the Philippines which are being grown to ipil-ipil.

Soil (By depth, cm)	pH	Available P (ppm)	CEC	Exchangeable Cations Ca (me/100 g)	Mg	K (mg/100 g.)	Organic %
Alaminos clay (Pangasinan)							
0–20	5.25	0.8	14.92	5.43	2.51	0.18	1.98
20–51	5.25	0.9	15.84	6.04	2.71	0.11	1.13
51–81	5.15	0.9	18.24	7.65	3.88	0.08	0.85
81–112	5.15	0.7	17.84	7.85	3.88	0.06	0.72
112–154	5.15	0.4	19.80	8.06	3.88	0.24	0.63
Annam clay (Nueva Ecija)							
0–15	5.85	3.8	19.28	9.26	6.01	0.26	2.23
15–30	5.85	2.5	19.20	9.87	6.01	0.21	2.37
30–60	6.35	2.1	23.54	13.70	8.92	0.16	1.31
60–90	5.95	1.2	32.84	23.37	12.80	0.17	0.49
Bolinoen clay (Zambales)							
0–12	5.35	1.7	17.80	4.83	3.10	0.39	3.17
12–43	5.15	1.2	26.23	5.23	2.71	0.18	1.61
43–60	5.15	0.7	21.78	6.04	2.32	0.13	1.25
60–82	5.35	0.5	16.57	5.64	3.49	0.09	0.82
82–120	5.35	0.3	24.32	6.85	6.59	0.09	0.36
Faraon clay (Quezon)							
0–12	5.60	22.6	65.20	43.92	12.80	1.06	5.87
12–33	5.80	6.5	65.20	44.73	12.02	0.54	3.57
33–59	6.35	4.5	64.04	45.94	9.70	0.30	0.77
59–89	6.55	3.8	65.04	47.55	9.12	0.34	0.91
Luisiana clay (Ilocos Norte)							
0–12	5.50	1.0	26.39	4.03	9.31	0.44	5.42
12–20	5.40	0.5	25.92	4.03	8.53	0.35	4.17
20–38	5.55	0.5	30.00	4.43	10.08	0.35	3.46
38–46	5.65	0.7	30.84	5.27	11.64	0.34	3.32
Luisiana clay (Nueva Ecija)							
0–10	5.35	1.3	24.12	9.87	5.81	0.11	2.75
10–20	5.50	1.8	26.32	11.68	7.17	0.29	3.27
20–30	5.15	0.9	29.88	13.49	7.95	0.10	2.22
30–60	5.55	9.4	31.44	14.30	10.28	0.08	1.51
Adtuyon (Bukidnon)							
0–15	5.1	4.2	19.12	3.0	3.66	0.41	5.36
15–30	5.1	0.7	19.44	1.8	2.50	0.29	4.18
30–45	5.1	1.4	16.24	2.0	1.16	0.62	2.54
45–60	5.1	1.05	17.48	1.8	1.73	0.62	1.79

SCIENTIFIC KAIÑGIN MANAGEMENT SYSTEM

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Ecological problems, dwindling natural resources and the need to increase food production brought about by a growing population and subsequent disproportionate area of available/arable lands, have drawn attention to the need for re-examination of our present agricultural and forest practices. Until the mounting population explosion is checked and job opportunities outside agriculture are numerous enough to absorb the excess labor force, we must deviate from traditionalism in development and seek new revolutionary ideas in problem solving.

In a recent article published in the United Nations magazine, *CERES,* Eric Ekholm of Worldwatch Institute stated that, "Even if we find ways to raise more food to feed the growing population, we won't have enough wood to cook it with." To meet the demands of food, population and energy, new agricultural and forest systems must be devised whereby we can increase food production by more efficient use of slopelands and mountainsides. Such a system would not only offer a maximum environmental eco-system balance through integrated crop production but would also include a solution to land tenure for hillside farmers. It would also help alleviate the inherent problems credited to the swidden system of farming. No longer can we speal of re-forestation in terms of silviculture but we must find ways to increase food production by combining annual crops with perennial crops. Such a system could be termed Agro-forestation.

More often than not, we seek scapegoats to blame for denudation, the result of our un-imaginative minds. Such is the case of the "Kaingeros" or shifting, swidden agriculturists on whom we try to place part of the blame for denudation, which results in flooding, soil erosion and the like. Are we to blame these "Kaingeros" who only desire to eke out a living, or does the fault lay with us, who as technocrats, not only fail to envision alternative systems of agriculture. but also fail to creat other forms of employment. Such systems of agriculture could be based on indigenous crops and techniques to which the people can easily relate; other forms of employment could include locally based industry.

The growing concern towards the dwindling supply of natural resources, the erosive results of denudation and a deterioration of the eco-systems has led impetus to the search for and development of new plant species and varieties, as well as the re-examination and re-discovery of indigenous plant species which show promise when worked into Agro-forestation systems.

One such plant is *leucaena (Leucocephala)* commonly called Ipil-ipil or Santa Elena. *Leucaena* is a member of the greater legume family in a group that includes *Mimosa, Albezia,* and *Prospis.* It is a perennial plant which have the ability to fix nitrogen into the roots as well as accumulate nitrogen, phosphate and potash in its leaves. The leaves from one hectare of "Giant" Ipil-ipil harvested over a period of one year and applied as a green manure mulch can equal 90 bags of commercial fertilizer or 560 kg of Nitrogen, 225 Kg of Phosphate and 560 kg of potash. On test plot located at the University of the Philippines at Los Banos, the leaf weight yield of one ha of *Leucaena* was 16.5 dry m.t *Leucaena* has an amazing regenerative characteristic which permits regrowth after cutting. It virtually "defies the woodcutter." Giant Ipil-ipil offers a continuous source of fertilizer, something the kaingeros can ill afford.

The two types of Agro-forestation schemes in which *leucaena* can be worked into are:

(1) *Leucaena* can be planted for erosion control while serving as a ready source of organic fertilizer for annual crops planted in the hillsides or in the kainging areas. A variety of spacings can be made but the one presently being tested has shown promising results. This is the 1 x 1 meter spacings of *Leucaena* planted in 5-meter bands on the contour of the hillside. The *Leucaena* can be transplantador dibbled (i.e., direct seeded) just as one would plant upland rice. The field preparation would be the same as that of the upland rice or corn. Ten-meter bands of corn, rice, etc. can be planted between alternating bands of *Leucaena.* The one meter spacings between the *Leucaena* allows for the planting of grasses to help prevent sheet erosion. Cassava could also be planted between the *Leucaena* but this scheme would not be as effective in preventing erosion. The *Leucaena* should be allowed to grow for one and one half years in order to establish a good root system, thus taping a huge reservoir of nutrients. Cut at the stump height of one meter, the *Leucaena* can be harvested as a source of firewood and charcoal. It is then allowed to regrow and cut as a source of green fertilizer for annual crops. This type of planting is inexpensive. Besides, it allows grass to regrow between the stumps to help prevent sheet erosion. It allows the cattle to pass between the stumps for grazing and browsing and it allows cassava, kamoteng kahoy and other crops to be planted between the stumps. If the leaf yield is shown to be insufficient, later planting of *Leucaena* could be made between the stumps. This system would negate the necessity of kaingeros and cultural minorities to continually shift their fields. More important, because the kaingeros would no longer burn valuable timber for fertilizer of their crops, the denudation process would be decreased.

The above planting scheme will also serve to suppress two very noxious weeds namely: hagonoy (*Chromolaena odorata*) and cogon (*Imperata cylindrica*) found in pasture lands and in once – forested hillands.

(2) The second scheme would involve planting pure strands of *Leucaena* in spacings anywhere from 1 x 1 meters to 4 x 4 meters. After the first year an indigenous root crop, such as "nami" or *Dioscorea hispida,* can be interplanted. Professor Lugod of the University of the Philippines at Los Banos recorded a projected yield of domesticated "nami" grown under normal forest canopy as being 30 m.t./ha. With the fertilizer properties of *Leucaena* the per ha yield of "nami" should be appreciably

higher. Other shade tolerant crops could be substituted or rotated with "nami." In this system, one could double his production per ha by growing leucaena as a wood source and as a source of fertilizer and cover crop for a tuber crop of "nami."

The possibilities and variations of alternative systems of kaingin, swidden agriculture or Agro-forestation are many. The interplanting of *Leucaena* with abaca, bananas, coconut and coffee are but a few.

Leucaena is not a panacea for all the problems caused by denudation and shifting agriculture; but if the previously discussed eco-systems are implemented, maximum environmental protection can be gained. Perennial tree crops (to reduce erosion and run-off) coupled with annual food crops (to increase food production) as part of an Agro-forestation scheme can offer an answer to many of the problems inherent in hillside farming.

"Hunger is not the tragedy of an empty stomach but it is the tragedy of a human mind not used."

MANAGEMENT OF IPIL-IPIL FOR FORAGE

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Introduction

Ipil-ipil is widely distributed in the Philippines. It is believed to have been introduced from Mexico through the Spanish Galleon trade. However, it was not until recently that ipil-ipil has drawn the interest from many people because of its multiple uses. This was sparked from the introduction of fast-growing high yielding varieties from Hawaii. "Hawaiian Giants" has been popularized further during a seminar on June 20, 1975 in Manila by Dr. James L. Brewbaker.

Introduced Fast Growing Varieties in the Philippines

Among the fast-growing ipil-ipil that has been disseminated in the Philippines are introduction from Hawaii: K8, K67 and K22. Cultivars peru, an introduction from Australia is another fast-growing ipil-ipil which has been dispersed in the country through the National Pasture Program. The Hawaiian giants are more of a tree type while cultivar peru is more of a bushy type producing more branches at the lower part of the trunk.

Ipil-ipil as green fodder for livestock fattening

Leucaena, even before scientific data on its feed values were available, has been used by many Filipino farmers particularly in Batangas for fattening cattle in their backyard. Ipil-ipil is grown in small plots along fence lines or land bounderies. Family members cut and haul herbage to the backyard cattle shed. Before herbage are fed to the animals, they are chopped finely. Usually, about 25 kg of chopped ipil-ipil herbage are mixed with 1 kg of rice bran. Water is added to moisten the mixture. Often times, cut grasses, rice straw or corn stover are supplemented. A typical backyard cattle fattening usually takes about 4 to 6 months before animals are sold. Investment is usually low because extra family labor is utilized.

In an experiment conducted at the UPLB, herbage yield of ipil-ipil ranged from 10.6 tons to 24 tons dry matter per hectare per year with cutting frequencies of 8 to 12 weeks. This can easily support 6 to 16 steers a year assuming a 50 percent ipil-ipil fodder feeding. Ipil-ipil herbage are better given to animals as fodder (green-chops) rather than as processed leaf meal during the rainy season. The livestock manure are then collected and plowed under as fertilizer to crops.

As cited by Benge (1976), Kinch Ripperton obtained ipil-ipil green weight yield of 67 to 77.8 metric tons per herbage per year with an average of 4.6 cutting per year, a seeding rate was 40.65 kg per hectare and the row spacing was 52.2 cm apart. Fresh herbage yield would approximately be equivalent to about 21 metric tons dry matter as feed. Six to seven fattening steers can easily be supported.

Brewbaker in 1975 also mentioned that "Hawaiian Giant" Leucaena yielded about 94.26 metric tons of fresh herbage. This would be roughly equivalent to 27 metric tons dry weight yield, which can easily support 9 fatteners.

Considering that about 90 percent of Filipino farmers are small farmers, Leucaena as a major source of feed for fattening cattle will certainly boast the average family income. This is also significant because most regions have about 80 percent of the population in the rural areas. Excess family labor can easily be utilized for an ipil-ipil based backyard cattle fattening. One of the major thrusts of the National Beef Cattle Program launched about a year ago was on backyard cattle raising. Ipil-ipil fodder production program should, therefore, complement the backyard cattle raising phase of the National Beef/Carebeef program.

For larger commercial fattening, ipil-ipil planted in hedge-rows are usually harvested by a chopper with a trailer. Chopped herbage is then brought to the feedlot and given to the animals as pure or as mixture with grass herbage or sugarcane tops.

Leucaena as a Pasture Crop for Grazing

Ipil-ipil may be set in the field in pure stand or mixed with grasses. The nature of the leaves of ipil-ipil allow sunlight to filter its canopy thus allowing growth of grasses interplanted with it. In Hawaii, according to Rotar as cited in the "World Farming", Guinea grass interplanted with Leucaena will carry up to one animal per acre.

In the Philippines, however, the author does not know of any formal grazing trial on ipil-ipil that has been conducted yet. According to some BAI sources, Dr. Daniel Bulong of La Union, Philippines, who pioneered the growing of Leucaena in the Philippines for livestocks, practiced rotational grazing, letting cattle stay and graze in each paddock for three to four days.

Leucaena as feed

Leucaena forage according to Kinch and Ripperton as cited by Benge (1976) contains 275 ppm Carotene, 222 percent protein and 29 percent crude fiber. Locally, R.C. Mendoza, T.P. Altamirano and E.Q. Javier, found the herbage of cultivar peru ipil-ipil to contain 20 percent protein and yielded 10 tons to 22 tons dry matter per hectare per year in an experiment conducted at the college of Agriculture, UP at Los Banos.

Looking at its protein and carotene content, ipil-ipil therefore, is comparable to Alfalfa which contain 20 percent to 25 percent protein.

In the Philippines, some feed mills had been buying dried ipil-ipil leaves which comes from native varieties. Branches are cut and the leaves are dried under the sun. This has become a cottage industry for many families in the Central and Eastern Visayas as well as in Northern Luzon.

Effect of Defoliation on ipil-ipil

Ipil-ipil, like any other legumes, usually has slow growth rate as compared to grasses. Hence, degree and frequency of defoliation would affect the plant's productivity. Also, even though ipil-ipil is by nature deep-rooted, it should be allowed to establish before cutting or defoliation is done.

In a screenhouse experiment, the effect of the defoliation on growth and dry matter production is presented in Table 1 to Table 4. Herbage dry matter of plants cut at 15 cm stubble height was almost 3 to 4 times lower than those plants cut at 30 and 45 cm stubble height. Highest herbage yield was from uncut plants by which the leaves (main rachis plus leaflets) only were harvested.

Protein content of harbeceous stem and leaves were not affected by cutting heights as shown in Tables 2 and 3. The clipping interval was 45 days and the protein content was highest when the only leaves were harvested. The rachis of the leaves contained 22.6 percent C.P. and the leaflets contained 34.6 percent. The 45 cm cutting height tended to have lower C.P. content in its herbaceous stem. C.P. content from the leaves (including the rachis) ranged from 28 to 34.6 percent.

To have some information on some factors affecting regrowth, total non-structural carbohydrates (TNC) was determined in the roots (Table 4). Percent TNC in the roots was not markedly affected by cutting heights. Therefore, herbage production would primarily depend on the amount of buds that will form into new shoots on the stubble.

Under field conditions, Mendoza et al., employed cutting heights of .15, 1.5 and 3 meters at cutting frequencies of 8, 12 and 16 weeks. Eight weeks cutting interval produced herbage yields as much as the 12 and 16 weeks interval at any cutting heights. Herbage yield (dry weight) were 10.7, 15.8, and 23.6 tons for the .15, 1.5 and 3 meters cutting height, respectively.

These results underscore the importance of maintaining a higher stubble height to allow more buds into new branches. However, maintaining a higher stubble would only be suitable if harvesting is done annually, which is fitted for backyard cattle fattening. This is also suitable for grazing purposes to some extent, where the cattle can easily browse on the regrowth. For mechanized harvesting, however, lower stubble heights will be more appropriate.

Effects of fertilizer on growth of ipil-ipil

Contrary to the common belief that ipil-ipil would grow anywhere, it is not likely to grow well in problematic soil. Ipil-ipil would only thrive well in soils with sufficient supply of phosphorus and are not acidic. This may explain why there have been some failures in attempting to establish ipil-ipil in native grassland areas either for reforestation or for grazing purposes. Where soil is acidic, liming is necessary for good growth. Phosphorus fertilization usually promotes early seedling growth.

Researchable Problem Areas

Although "ipil-ipil craze" in the Philippines has been going on for some time, recommendations as far as its cultural management and utilization for forage is concerned have been *ad interem.* Many questions had yet to be answered and results to back up basic recommendations on its management and utilization are still meager. Indeed, there is an immediate need to conduct basic and applied researches to cope up with the still growing popularity of ipil-ipil.

Researches should embrace at least three disciplines, namely: ecology; soil fertility and legume bacteriology; and agronomic management and utilization. The following research studies have been proposed:

a) **Ecological studies of ipil-ipil: Competition and allelophatic interaction of ipil-ipil Cogon association.** Grown in association with native pastures, ipil-ipil can increase beef production significantly by improving herbage quality and yield. However, previous attempts to overseed cogonal areas with ipil-ipil were reported to be not too successful.

b) **Soil factors affecting growth and Dry Matter production of ipil-ipil.** Many people think that this crop could be grown in any soil. However, it has been found that this view is not tenable and there are environmental factors that may prevent the plant from getting established in a given site. Hence, some attempts to oversow cogonal areas have failed.

c) **Cultural Management of Ipil-ipil base cropping system.** The ability of ipil-ipil to fix significant amount of nitrogen should be exploited. Its value as a fodder for backyard cattle had been fully appreciated. With growing concern of uplifting the livelihood of the small farmers, a cropping pattern maybe evolved which would integrate ipil-ipil into the existing farming system. Herbage can be utilized as fertilizer for crops grown with it or harvested and sold as leaf meal or given to fattening animals.

d) **Herbage production of ipil-ipil mixed with improved grasses.** Because of the upright growth of ipil-ipil and the nature of its leaves, it would permit sufficient sunlight to penetrate and allow growth of grasses grown with it. Also, the grass can benefit nitrogen from ipil-ipil. Herbage quality would be better than a pure grass pasture without subsequent reduction in yield.

e) **Cutting/Defoliation Management of ipil-ipil for Herbage quality and yield.** Herbage yield of ipil-ipil will be dependent upon regrowth rate from defoliation time and stubble height. Also, the ability of plants to persist would depend upon the rate at which the plants are allowed to retain photosynthesis for root and shoot growth.

f) **Performance of backyard beef and daity on ipil-ipil base feeding system.** Although ipil-ipil has been widely used as fodder or processed feeds, there has been some conflicting reports regarding its effect on animal growth and liveweight gain. Hence, there is a need to establish some guidelines regarding its use as fodder or as feeds.

Also, there is an immediate need to investigate further its effect as feed for other animals such as goats and rabbits which are common backyard animals in the Philippines.

Table 1. Herbage dry matter per plant of ipil-ipil regrowth for a ten month period at 45-day cutting interval

Treatments	CUTTING DATES 8/4	9/16	10/24	12/9	1/20	3/2	4/15	5/27	TOTAL
					Grams/Plants				
uncut defoliated	579.00	1,967.13	1,258.57	1,106.47	743.31	693.49	1,572.62	1,218.86	9,148.45
15 cms cutting ht.	206.31	589.63	353.21	244.66	179.52	131.35	113.35	113.08	1,993.14
30 cms cutting ht.	1,227.20	1,227.20	999.62	930.00	506.28	763.65	1,299.87	1,080.30	8,034.22
45 cms cutting ht.	1,020.95	1,020.95	1,239.95	855.56	425.81	611.81	950.40	844.23	6,968.74
45 cms cutting ht. defoliated	1,647.41	1,647.41	688.86	855.74	291.15	388.63	690.75	592.20	6,832.15

Table 2. Herbage crude protein (%) of ipil-ipil stem* fifteen months from initial clipping/defoliation at six weeks interval, 1975-1976

Treatments	CUTTING DATES 2/10	3/25	5/13	6/23	8/4	9/16	12/9	1/20	4/4	TOTAL
uncut defoliated**	–	–	–	–	–	18.80	31.44	27.69	12.44	22.59
15 cms cutting ht.	16.16	13.56	11.38	17.25	18.01	11.24	29.81	29.19	16.44	18.12
30 cms cutting ht.	16.04	14.38	9.34	16.44	15.66	13.49	32.81	37.69	12.25	18.68
45 cms cutting ht.	14.78	12.06	10.06	14.38	13.98	15.30	30.69	34.94	15.25	17.94
45 cms cutting ht. defoliated	12.04	12.44	11.44	13.56	15.43	13.26	32.81	14.19	12.44	15.29

*Herbaceous portion of harvested stem

**Main rachis of the leaf

Table 3. Herbage crude protein (%) of ipil-ipil *leaves* fourteen months from initial clipping/defoliation at six weeks interval. 1975-1976

Treatment	3/25	5/13	6/23	8/4	9/16	12/9	4/4	MEAN
uncut defoliated	–	–	–	–	36.81	–	32.44	34.63
6 inches cutting ht.	15.85	22.38	28.18	43.38	28.81	32.69	37.00	29.76
12 inches cutting ht.	18.60	25.44	27.12	57.94	32.13	33.19	31.31	32.25
18 inches cutting ht.	14.35	24.83	25.12	36.94	28.94	32.31	36.56	28.44
18 inches cutting ht. defoliated	15.51	23.45	30.12	32.50	31.50	31.31	34.31	28.39

Table 4. TNC accumulation in ipil-ipil roots twelve months from initial defoliation at six cutting interval, 1975

Treatments	1/5	5/25	6/23	9/17	12/16	MEAN
			% TNC			
uncut-defoliated	17.80	–	–	22.12	28.93	22.95
6 inches cutting ht.	16.05	22.01	21.26	24.55	23.65	21.50
12 inches cutting ht.	21.36	21.92	18.80	23.91	25.00	22.20
18 inches cutting ht.	18.58	16.97	17.30	24.00	20.00	19.37
18 inches cutting ht. defoliated	18.61	–	–	23.60	25.00	22.40

THE USES AND TOXICITY OF LEUCAENA IN ANIMAL FEEDING

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I want to concetrate mainly on the toxicity of leucaena in this talk, but will briefly outline the present uses of leucaena in Australia.

Firstly, leucaena is mainly used in experimental pastures and as yet there has been little commercial development. Secondly, the leucaena is used mainly for grazing. There are no cut and carry systems and no forestry uses. We do have an interest in growing leucaena for pulp but this is at an early stage.

For grazing purposes, leucaena has many potential advantages over other species:

1. The carrying capacity of pastures is high once the leucaena is fully established. .In the sub-tropics with 1000 mm annual rainfall, we carry 3 steers/ha yearling giving 350-400 kg LWG/ha. In the hot arid area of N.W. Australia under irrigation from the Ord River Dam, we have carried 7.4 steers/ha grazing the Leucaena/pangola pastures continuously with gains/ha of 870 kg/annum. However, at this site serious problems have arisen as I describe later.

2. Leucaena has a long growing season and when planted on the better, deeper soils it stays green into the dry season longer than all other species tested.

3. Its tall habit enable it to compete with grasses, yet it is palatable enough to be controlled by cattle.

It has several disadvantages, and in a conference such as this it is important to recognize these:

1. It is seriously limited by soil factors. Acid or water-logged soils are not conducive to good growth.
2. Establishment is notoriously slow even when planted on prepared seed-

beds. It is not easy to oversow into native grasses and compared unfavorably with Stylo and Siratro in this respect.

3. Management to control growth and yet not to overgraze is more exacting than for other tropical legumes. The successful methods of management has been to graze paddocks of leucaena in conjunction with native pasture. Four paddocks of leucaena are used. The paddocks are opened in sequence to the animals which graze the surrounding area. If overused the paddocks can be closed and the grazing confined to the native grass area. This method has possibilities for improving animal production and minimizing fertilizer use to the improved leucaena area.
4. Toxicity problems. Graziers are worried about the possible toxicity problems and extension workers are hesitant to actively promote its use. The problem is undoubtedly associated with the presence of the toxic amino acid, mimosine, although other causes have been proposed. These other proposed causes - namely HCN and Selenium toxicity have not been verified. No HCN could be detected in the leucaena and selenium levels were normal at less than 1 ppm.

Mimosine and D.H.P. occurrence in the plant

The toxic amino acid mimosine is found in all cultivated forms of leucaena. Within these leucaena forms there is little variation in the content of mimosine, although very vigorous types tend to be higher than the less vigorous. High concentrations are found in the actively growing parts of the plants such as growing tips, young leaves, flowers, young pods and seeds. Older stems, roots and the empty seed pods contain low amounts usually 1.0 percent of the dry weight (see Table showing mimosine in plant parts, c/o Dr. Ray Jones). The decrease in mimosine concentration in older leaves and stems may occur by dillution as the older leaves become larger and accumulate more dry weight. This aspect has not been fully studied. In the sub-tropics the concentration of mimosine in the growing tips and young leaves is higher in summer when the plants are actively growing than in the winter season (Jones and Hagarty, unpublished results) but detailed studies of the effects of environmental and nutritional factors in determining mimosine concentration in the plant parts have not been made.

Drying of the cut forage reduces the mimosine concentration in the material. The reduction is greater if drying is prolonged in a moist atmosphere and correspondingly less if dried quickly with ample ventilation. The nature of the loss is not quite clear, but under some circumstances the breakdown product 3, 4 – dihydorxypyridine (DHP) is formed.

The Toxicity of Mimosine to Animals

a) Non-ruminants

For a long time, it has been known that leucaena feeding has adverse effects on non-ruminant animals. Hair loss is a characteristic symptom reported if consumed in appreciable quantitites by horses, pigs, rats, mice and even man. The reasons for conflicting reports of the effect of leucaena feeding have been attributed to the quantity of leucaena and especially the quantity of mimosine consumed per unit of body weight, the duration of feeding, the species concerned and the stage of development of the hair follicle (Hegarty, Schinckel and Court (1964). For example, horses readily lose hairs of the tail and mane because these are continually growing and are the first to be affected. Cessation of leucaena feeding results in normal growth of hair although in some cases this may be a somewhat different color. In some areas (specify) boars are fed leucaena to cause shedding of the coarse bristles, a practice used to increase the sale price of the animals and to invigorate them.

Although the tips, young leaves and young seeds form a regular part of the human diet in Mexico, Thailand and New Guinea supplying valuable protein, minerals and carotene, there are but few reports of hair loss or of other adverse reactions. This is rather surprising and warrants further investigation to know if the mimosine is destroyed in the gut in some way and rendered harmless by other items in the diet.

Adverse effects of mimosine on the reproductive efficiency of mice, rats, poultry and pigs follow the feeding of leucaena. In rats as little as 0.5 percent in the diet over a long period resulted in irregular and a typical oestrus cycles (Hylin and Lichton 1965). When fed to pregnant rats mimosine also caused death of the developing embryos (bindone and Lemond 1966). A similar effect was noted with pigs.

No comparable information is available on the influence of leucaena feeding on humans although it is apparent that countries where leucaena forms part of the diet still have a high birth rate.

Although the toxicity of leucaena can be reduced by adding ferrous sulfate to the diet (Matsumoto et al 1951), this practice is not adopted. The problem is usually overcome by restricting the intake of leucaena so that the level of the anti-mitotic agent mimosine is kept below a critical level.

The plant has been used experimentally for feeding fish in ponds but no adverse effects have been reported. The metabolism of mimosine in fish needs to be studied because the leaflets of leucaena could form a valuable feed for edible fish production. There are no studies to indicate whether mimosine is retained in the tissues of non-ruminant animals fed with leucaena. Equipment capable of detecting very low concentrations of mimosine is now available and so information in this important field should become available

b) Ruminants

Ruminants suffer less from apparent leucaena toxicity than the non-ruminants. This is due to the degradation of mimosine to 3, 4 - dihydroxipyridine (DHP) by micro-organisms in the rumen of animals accustomed to feeding on this material (Hegarty, Schinkel and Court 1964). This destruction of mimosine in the rumen may not occur in animals not used to eating leucaena who are introduced suddenly to large quantities of leucaena forage. The mimosine that escapes degradation is absorbed from the digestive tract and may then result in depilation as for non-ruminants. Dramatic fleece shedding occurs when sheep are fed a pure diet of leucaena. Loss of fleece occurs some 10 days after the attainment of mimosine levels above a critical value for a period of 48 hours (Reis et al 1975). Pelleting the leucaena results in faster movement through the rumen so reducing the opportunity for microbial degradation and in Australia this method has potential for the chemical shearing of sheep in a commercial scale.

c) Ruminants and DHP

It was formerly thought that DHP was a fairly harmless substance and that ruminants adapted to leucaena feeding would remain free of problems when grazing or being fed this forage. However, the occurrence of hair shedding, profuse salivation, incoordination of gait, the birth of goiterous calves and the presence of large goiters in cattle apparently well adapted to leucaena feeding threw doubt on this assumption. It is now known that goiters in cattle grazing leucaena pastures are a common, if not a characteristic, clinical sign (Jones, Blunt and Homes 1976). This is associated with low thyroxine concentrations in the blood serum (to 10 n mol/liter or less), hair loss due to these low thyroxine concentrations, low feed intake and low live-weight gains (Jones and Blunt - unpublished data 1976). DHP has now been identified as a powerful goitrogen in rats, the effects being particularly severe on low iodine diets (Hegarty, Coutt and Christie 1976). The effect on grazing cattle is cumulative and is more serious in some localities than others. The reasons are not clear but the mimosine concentration of the feed and the amount of feed eaten are thought to be implicated. When leucaena forms a relatively small part of the diet (tentatively suggested as less than 30-50%) then problems are rarely encountered and cattle thrive. No effect of leucaena feeding on conception of cattle has been reported in Australia (Hamilton *et al* 1968, R.J. Jones unpublished data) but in New Guinea heifers have been difficult to get into calf when grazing a virtually pure stand of leucaena (Holmes 1976).

It should be emphasized that no deaths resulting from leucaena feeding in the field have been reported. Also animals recover when removed to a leucaena-free pasture or are fed other materials. In this respect, it is less dangerous than the widely grown temperate legumes white clover and lucerne (alfalfa) which result in deaths due to bloat each year. It is possible, however, that a chronic reduction in feed intake is preventing maximum production in systems utilizing this plant for forage. Consequently attempts to breed low mimosine lines should be actively encouraged. This will extend the use of the plant for non ruminants and ruminants alike and should encourage the wide use of this plant for human consumption.

UTILIZATION OF IPIL-IPIL FOR ANIMAL FEEDS INDUSTRY

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The Philippine livestock and poultry industry has been using ipil-ipil leaves as a feed component for about 30 years. However, research on ipil-ipil as a feed started to be intensified only in the sixties. One of the drawbacks on the use of more ipil-ipil in poultry and swine feeding is the presence of high mimosine content in our varieties/strains. Some screening work done in the University had shown that varieties/strains contain mimosine from about 2 to 4.5 percent. Another problem is adulteration of the leaf meal. The third is the poor preparation of the leaf meals.

The large scale introduction of the varieties that are fast growing with low mimosine content such as those from Hawaii has again intensified the interest in ipil-ipil as feed in the last 5 years. In 1975 ipil-ipil caught the attention of a few provincial executives. One of them has even renamed it "Iepili" to attract attention to the variety that grows fast. "Peruvian", "giant", and "miracle tree" are terms which one would usually hear from the enthusiasts.

Table 1 shows some of the leaf meals used in animal feeding research. When properly prepared, ipil-ipil is a valuable component of animal feeds because of its high protein content. Compared with other leguminous leaf meals such as cowpea, soybean, siratro, mongo, etc., it is best in this aspect. Likewise, compared with some of the leaf meals we used as source of pigmenters, it is best (Tables 2 and 3). Furthermore, its abundance, relatively speaking, is an added advantage.

Storage of leaf meals poses a problem of space; hence, we looked into separation of chlorophylls from the carotene and xanthophyll fractions and other components of the leaf meal since one of our interests is in pigmenters. Results shown in table 4 indicate that at a lower level which is equivalent to 3 percent leaf meal, the absence of chlorophyll gave slightly less color to the egg yolks produced. However, at higher level the additional expense of separating the fractions is not warranted because pigmentation was the same.

Mimosine is not totally undesirable in poultry. Research of colleagues indicated that high levels of ipil-ipil leaf meal (15-30%) in the diet retards sexual maturity; hence, the pullet develops its body and consequently lays larger eggs.

In swine nutrition, levels of 5-10 percent in the ration is advised for good growth and development. In a depletion-repletion experiment for vitamin A and carotene of growing pigs, levels of 3-6 percent ipil-ipil leaf meal restored the levels of vitamin A and carotene in the blood besides correcting the rough hair coat and skin.

At present, ruminant nutrition takes the lead on utilization of ipil-ipil. Our results in digestion, nitrogen balance and feedlot fattening have conclusively shown the usefulness of ipil-ipil. Farmers are using ipil-ipil with simple concentrates in fattening their cattle, carabaos and goats. Although loss of hair is shown in ruminants heavily fed with ipil-ipil, growth is not retarded.

Lest it be forgotten, young ipil-ipil shoots are used as vegetable. The widespread use of the low mimosine strain may stimulate its further usefulness. But if mimosine plays a role in retarding sexual maturity, it could play the same in controlling population growth.

Table 1. Composition of leaf meals[1]

Leaf Meal	Dry Matter	Crude Protein	Ether Extract	Crude Fiber
	%	%	%	%
Ipil-ipil	89.41	24.22	4.40	13.27
Aguingay	92.25	6.21	2.42	33.69
Cassava	89.49	18.26	6.96	16.55
Kangkong	92.11	21.74	2.71	14.42

[1] Ipil-ipil (*Leucaena leucocephala*), Aguingay (*Roeteboelia exaltata*). Cassava (*Manihot esculenta*), Kangkong (*Ipomea aquatica*).

Table 2. Carotenoids from some plant sources (moisture-free basis)

Carotenoids	Ipil-ipil	Aguingay	Cassava	Kangkong
Carotene, mg/kg	518.3	201.5	327.3	293.4
Total xanthophyll mg/kg	762.4	328.1	505.2	513.8
Monohydroxy pigment mg/kg	316.2	133.7	286.4	292.7
Dihydroxy pigment mg/kg	126.9	71.5	98.2	77.1
Dihydroxy equivalent mg/kg	285.0	138.4	241.5	223.4

Dihydroxy equivalent = 1/2 MHP + DHP

Table 3. Color of egg yolk as influenced by leaf meal extract[1]

Days of Feeding	Yellow Corn	Sorghum + Ipil-ipil	Sorghum + Aguingay	Sorghum + Cassava	Sorghum + Kangkong
Depletion	<1	<1	<1	<1	<1
Repletion					
3	4.6	8.0	5.7	7.3	8.0
6	4.2	8.7	6.6	8.8	8.9
9	4.5	9.2	6.0	9.0	9.0
12	4.0	9.0	6.0	8.0	8.0

[1] Control ration of sorghum gave Roche Color Fan values of <1 in the depletion period of 21 days and in the repletion period of 30 days.

Table 4. The effect of xanthophyll and cholorophyll on egg yolk color[1]

Level of Carotenoid Extract Equivalent to:	Xanthophylls	Santhophylls + Chlorophyll
3% leaf meal	5.6	7.5
6% leaf meal	8.6	8.6

[1] Roche Color Fan values

STATUS AND POTENTIALS OF IPIL-IPIL IN ANIMAL FEEDS INDUSTRY

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Ipil-ipil leaf meal has been extensively used in the animal feed industry for the last several years. Based on the various studies conducted at the University of the Philippines at Los Baños — College of Agriculture, the feed milling industry has accepted a maximum of 5 percent ipil-ipil addition in livestock and poultry feeds. The total feeds output of the 10 leading feedmillers which are mostly in Metro Manila is approximated to be 12,000,000 bags of 50 kilos annually or a total of 600,000 metric tons of mixed feeds yearly. At 5 percent ipil-ipil utilization, the potential requirement for the 10 leading feedmills is estimated to be 30,000 metric tons annually.

The following is a sample of the actual usage of ipil-ipil in one feedmill:

IPIL-IPIL USAGE IN 1975 and 1976

YEAR	MONTH	AMOUNT OF IPIL-IPIL USED (KGS.)	AMOUNT OF FEEDS PRODUCED (KGS.)	PERCENT OF IPIL-IPIL USED TO FEEDS PRODUCED
1975	January	58,024	4,541,085	1.28
	February	41,869	3,896,600	1.07
	March	51,788	5,213,030	0.99
	April	56,308	5,836,710	0.96
	May	90,791	5,493,810	1.66
	June	77,136	4,553,810	1.69
	July	86,382	5,006,440	1.73
	August	77,803	4,193,675	1.86
	September	83,769	4,362,850	1.92
	October	90,347	4,968,220	1.82

	November	112,639	5,540,135	2.03
	December	67,668	4,794,760	1.41
	Total	894,504	58,401,125	
Average per Month		74,542	4,866,760	1.53
1976	January	74,239	5,477,505	1.36
	February	114,346	4,994,535	2.29
	March	155,830	5,285,570	2.95
	April	112,215	4,133,250	2.71
	May	139,626	5,078,040	2.75
	June	149,230	5,396,650	2.77
	TOTAL	745,486	30,365,550	
Average per Month		124,247	5,060,925	2.46

From these figures, it could be seen that only 2 percent on the average is the level of addition of ipil-ipil to the livestock and poultry feeds. The major reason for this low usage is non-availability of the ingredient. It can also be concluded that there is still a shortage of 18,000 metric tons of ipil-ipil even though an additional 3 percent more will be required.

The primary purpose of adding ipil-ipil to the feed mills is to take advantage of the high pigmenting property of the leaf meal. The desired yellow yolk and yellow skinned broilers can easily be attained even with the use of white corn if about 5 percent of a good quality ipil-ipil leaf meal is added in the diet. The addition of ipil-ipil leaf meal as a source of pigment is cheaper compared to the synthetic pigmenters which are imported. It is therefore logical to assume that the feed industry will always look for ipil-ipil as a source of pigment rather than utilize synthetic pigmenters.

The level of protein in ipil-ipil leaf meal is calculated in the neighborhood of between 20 to 24 percent. The breakdown of the various amino acids in ipil-ipil which are essential for good nutrition in livestock and poultry is as follows:

Amino Acid	**Ipil-ipil**
Alanine	1.24
Arginine	1.41
Aspartic Acid	2.35
1/2 Cystine	0.36
Glutamic Acid	2.46
Glycine	1.13
Histidine	0.60
Isoleucine	1.10
Leucine	1.98
Lysine	1.48
Methionine	0.31
Phenylalanine	1.18
Proline	1.29
Serine	1.04
Threonine	1.02
Tyrosine	0.94
Valine	1.27
Protein	22.00

The amino acid pattern in ipil-ipil protein is better than the amino acid pattern in other plant sources such as copra meal or rice bran. Its potential therefore, as a good source of protein is better than the other traditional sources of plant protein in the Philippines like copra meal. Of course, soybean oil meal which is imported in this country is much better in its amino acid composition.

The major drawbacks in the use of higher levels of ipil-ipil is the low energy value of the leaf meal and its toxic factor mimosine. On the question of mimosine, it is known that plant breeders are now able to produce strains with significantly lower mimosine content.

Another major drawback is adulteration of ipil-ipil leaf meal with acacia leaves or rice hulls or sand. This is resorted to, principally, because there is great demand for ipil-ipil leaf meal.

Summary

1. Ipil-ipil leaf meal is currently utilized at about 2 percent of the total feed produced by the major feedmills. At a maximum level of 5 percent addition, the 3 percent difference represents about 18,000 metric tons of ipil-ipil leaf meal needed by the animal feed industry.
2. The major consideration in adding ipil-ipil leaf meal is the pigmenting property of the meal for the production of yellow yolk and yellow shanks of broilers. The potential for using ipil-ipil in ruminant is not included in this discussion as ipil-ipil is utilized in greater proportion with ruminant. There is not much ruminant feeds produced by the various feed mills in the Philippines.
3. Because of the demand for ipil-ipil leaf meal, adulteration has been rampant using acacia leaves, sand and or other material.
4. The potential contribution of ipil-ipil leaf meal as a source of good quality protein is evidently seen in the balanced amino acids composition of the meal.
5. The possibility of using higher levels of ipil-ipil leaf meal will hinge on the results of the breeding work for low mimosine ipil-ipil strains. It is also probable that the breeding for low mimosine strains will result in better energy and protein utilization of the meal.

MANAGEMENT OF IPIL-IPIL FOR WOOD PRODUCTION

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Introduction

One of the prerequisites to the successful management of a tree species for wood production is a ready and stable market for its products. Ipil-ipil *Leucaena leucocephala* [(Lam.) de Wit.)] is one of such species which has been recognized to yield valuable wood products that have a ready market. It is an excellent source of fuelwood and charcoal both for domestic and industrial uses, fence and house posts, props for commercial banana plantations, pulpwood, and other valuable wood products. Considering the multi-product alternatives that ipil-ipil offers, the market seems to be potentially large and stable for successful management.

The other prerequisite is the availability and adequacy of data concerning the technical and economic aspects of wood production and utilization. With ipil-ipil, there is a need to know its silvical characteristics, silvicultural requirements, yield and optimal rotation for various end-uses, mensurational attributes, wood properties and applicable costs and returns for managed plantation.

This paper presents previous research and pertinent data on ipil-ipil particularly on the aspect of wood production, and discusses their implications on the proper management of this species. Research needs are explored in the light of existing information gaps with the overall objective of providing comprehensive and workable guidelines for the proper management of ipil-ipil plantations for wood production.

Silvical Characteristics

Ipil-ipil is a leguminous tree widely distributed in the grassland areas and second-growth forests in the Philippines. The common variety seldom attains a diameter breast height (dbh) fo 25 cms and a height of 10 meters (Steedmiller, 1911). However, the "Giant Ipil-ipil" has been reported (Benge, 1975) to have grown 13 meters high with an average dbh of 37 cms in eight years. This species grows in dense stands, showing rapid height growth during the first few years of its life especially in sprout stands. Vergara (1960) reported that the species seems to grow seasonally as it drops its leaves during the hot and dry months. This seems to be substantiated by the presence of concentric rings in ipil-ipil wood.

The distribution of ipil-ipil in the Philippines is largely artificial in the sense that not much is known about its exact climatic requirements. Steadmiller (1911) reported that ipil-ipil is usually found in areas with distinct dry season periods of 4 to 5 months and in nonseasonal areas where there is considerable rainfall every month. On the other hand, Mendoza reported that this species grows over a wide range of edaphic and atmospheric moisture conditions, ranging from 400 to 800 mm of annual rainfall. It thrives on a variety of soils but prefers deep soils well supplied with moisture (Steedmiller, 1911). However, most observations indicate that it also thrives well on alkaline soil and on rocky soils with little top soil (Mendoza).

According to some observations (Steedmiller, 1911), the altitudinal distribution of ipil-ipil seldom goes over 200 meters above sea level. Mendoza on the other hand, recommended that for optimum production under Philippine conditions, the crop should not be planted beyond an elevation of about 210 meters on the windward slopes and up to about 450 meters above sea level on the drier leeward locations. It has been further observed to thrive beyond 760 meters above sea level but found not as productive as those at lower elevations.

The species is also known to be highly intolerant and, as such, does not grow satisfactorily in mixed all-aged stands (Vergara, 1960). It is a prolific seeder and sprouts vigorously from stumps. Trees grown from sprouts, however, do not produce seeds as heavily as trees grown from seedlings do.

Silvicultural Methods

The establishment of an ipil-ipil plantation may be conducted in three ways, namely: (1) direct seeding in furrows; (2) direct seeding by broadcasting; and (3) planting seedlings on the plantation site. The first method requires plowing the area which is seldom used. The second method may be accomplished by any of the following procedures: (a) broadcasting the area without burning; (b) broadcasting in strips after burning the area; and (c) broadcasting after burning the area. An experiment conducted by Sequerra (1935) shows that burning the grass before broadcasting gives the best results.

Planting by seedlings, while giving the most satisfactory results, is also the most expensive as it requires intensive use of labor.

The silvicultural system employed in harvest cutting is the clear-felling system. This system is necessary and appropriate for the species because of its high degree of intolerance. The extreme density of ipil-ipil stands would render any other system of cutting more expensive and difficult (Vergara, 1960). Besides, the market requirements of ipil-ipil make the clear-cutting method the most practical and appropriate. In cutting down the trees, the cut should be clean and smooth leaving stumps of about 10 to 20 cms for the production of sprouts for the next rotation.

Growth, Yield and Rotation

Studies on growth and yield of ipil-ipil started as early as 1911 when Steadmiller (1911) observed that ipil-ipil seedlings attained a height of 25 cm in 3 months which subsequently reached to 3.5 meters with dbh ranging from 3 to 5 cm at the 26th month. Sprouts exhibited more rapid growth than seedlings, attaining a height of 5 meters and dbh of 5 cms in one year. Thereafter, the rate of height growth seemed negligible but the dbh increased to 10 cm at the end of 2 years. The same report says that a one-year old sprout stand yielded a stacked volume per hectare of more than 80 cu.m. of firewood,; a two-year old stand with 114 cu.m.

The length of the rotation is one of the major factors affecting the profitability of managing ipil-ipil for a given product or group of products. In 1914 Matthews made the projection that probably the most profitable rotation of ipil-ipil for firewood would be three years, based on his findings that closed-stands would average 10 cm dbh and a height of 5 to 6 meters.

Sulit in 1931, studied the financial yield of an ipil-ipil plantation and found out that the highest returns were realized at the age of 5 years. However, the study of Lalog in 1936 using the method of soil expectation value revealed that the most profitable age of ipil-ipil plantation for firewood in Mt. Makiling would be from 7 to 9 years, basing on 2 to 7 percent interest rates. In this study, the yield per hectare is stacked volume was 93 cu.m. for a 3-year old stand; 130 cu.m. for 5 years old; 193 cu.m. for 10 years old; and 220 cu.m. for a 14-year old stand. The current annual increment culminated at 3 years with 21 cu.m. per hectare between the third and fourth year after which it gradually decreased to 6 cu.m. at the end of the 14th year.

In 1936, Curran and Racelis also conducted a study on the economic rotation of ipil-ipil plantation in Mt. Makiling. The ipil-ipil stands studied ranged from 2 to 10 years old. The growth of the stands is shown in Figure 1, depicting the relationship between the stand age and volume growth in terms of current annual increment and mean annual increment. The culmination point of the mean annual increment starts at the age of 3 years which determines the economic rotation as far as volume yield is concerned. Using the annual net returns from the stands studied, the authors observed that the culmination of the mean annual returns falls on the sixth year and not on the third year. The reason for this is that the said ipil-ipil stands attained their maximum volume growth on the third year, whereas the same stands secured the highest mean annual net money returns on or about the sixth year.

Curran and Racelis also observed that the yield of ipil-ipil stands from seedlings exceeded the sprout stands. They observed that the 7-year old stands from seedlings yielded 175 cubic meters while a similar 7-year old sprout stands yielded 158 cubic meters or a difference of 17 cubic meters.

Another study on the financial rotation of ipil-ipil for firewood was conducted by Vergara in 1960. He investigated the financial rotation of ipil-ipil both for split and unsplit billets using the soil rent method. The results of his study show that the highest expectation value for the land planted with ipil-ipil, which constitutes the financial rotation, was obtained in one-year old stand for split firewood and about three years old for unsplit firewood. The difference in rotation age for these two products was probably caused by the existence of a price-age gradiant in unsplit billets while for split billets a flat price was used irrespective of age.

The yields of ipil-ipil plantation used in the above study are shown by the growth curves in Figure 2. The rotation age of one year for split firewood would have only 46 cubic meter per hectare and 104 cubic meter for unsplit firewood at the rotation age of 3 years.

Research on the utilization aspects also plays an important role in the proper management of plantation for wood production. A study conducted by Almonte in 1956 reveals that the age of ipil-ipil is a factor in pulp yield. As shown in Figure 3, the maximum pulp yield was obtained from 6-year old samples. This preliminary result on the effect of age on pulp yield justifies the more intensive and integrated studies on the utilization and management of ipil-ipil for wood.

Assessment of Research Needs

The results of various researches on ipil-ipil have been very useful and informative in the understanding of the growth and yield characteristics of this species. Substantial information may already be available not only concerning the local common variety but also on the various varieties being introduced in the Philippines. However, an assessment of the available information indicates that it is still far from adequate to be able to provide meaningful guidelines for proper management for wood production. Most of the studies conducted have very limited application because of apparent lack of correlation with other important factors or variables which may have significant effects on the optimum levels of growth, yield and rotation for various wood uses.

Some data on the optimum stocking and spacing are necessary for a given management objective. Management for fuelwood, charcoal, banana props, pulpwood and lumber may require different levels of spacing and stocking. Determination of site quality is important in management. Various site quality classes or indices for ipil-ipil have yet to be determined by research as the land productivity varies tremendously by site quality. Spacing and site affect the optimum rotation for a given product.

In conducting research for the management of ipil-ipil, particular emphasis should be given to the major products for which this species has long been used. It has long been recognized that ipil-ipil is good for firewood and charcoal because of its high heating value. There is good reason to believe that fuelwood quality and charcoal yield may vary significantly with the age of the tree; the degree of variation is, however, still unknown. What is known is that as the tree matures, the amount of heartwood, which is high in calorific value, increases. It has been observed (Curran and Racelis, 1936) that the heartwood of ipil-ipil during the seventh year and over is well developed, giving sufficiently high calorific value; whereas on the third year of its growth, it has very small percentage of heartwood. This factor should be considered in studying the yield and rotation of ipil-ipil for firewood and charcoal. Further studies on the yield and rotation should be based on both volume and quality or utility value.

Wood quality, therefore, is an important consideration in research on ipil-ipil. According to Lantican (1975) wood quality, as it is universally understood, refers to the suitability of wood for a particular end product. It is therefore necessary to know the different measures of wood quality which may be correlated with the requirements of a given product. Among the physical properties of wood, specific gravity is one of the few that is subject to precise measurements and is considered to be one of the best parameters of wood quality. It is known to be a good index of strength properties, pulp yield and quality and other physical properties which may include the heating value of the wood.

The effects of various factors such as site, spacing, and rate of growth on the specific gravity of wood should be studied. Jayne (1958) in his study of Red Pine found that spacing has a minor effect on the specific gravity of its wood while environment, as reflected in site, has a definite influence. This conclusion has been supported by similar findings of several investigators.

Rate of growth is another key factor affecting the density of wood. Several studies have shown that specific gravity has significant correlation with the rate of growth. In general, fast-growing trees would have lower specific gravity than the slow-growing trees planted on the same site. Results of many investigations (Jayne, 1958) suggest that slow rates of growth should be maintained in order to produce wood of a higher density. This biological phenomenon should be considered in growing the different varieties for wood. The variations of specific gravity as affected by age, rates of growth and site should be studied.

Other studies should include the determination of the following: (1) appropriate harvesting methods and equipment; (2) weight-volume and solid-stacked volume relationships; and (3) appropriate pulpwood volume equation and tables for the different ipil-ipil varieties.

In conclusion, as per assessment of past researches, an integrated and more comprehensive research program on ipil-ipil should be conducted, with the objective of developing a sound theoretical and practical base for efficient management of this species for wood production.

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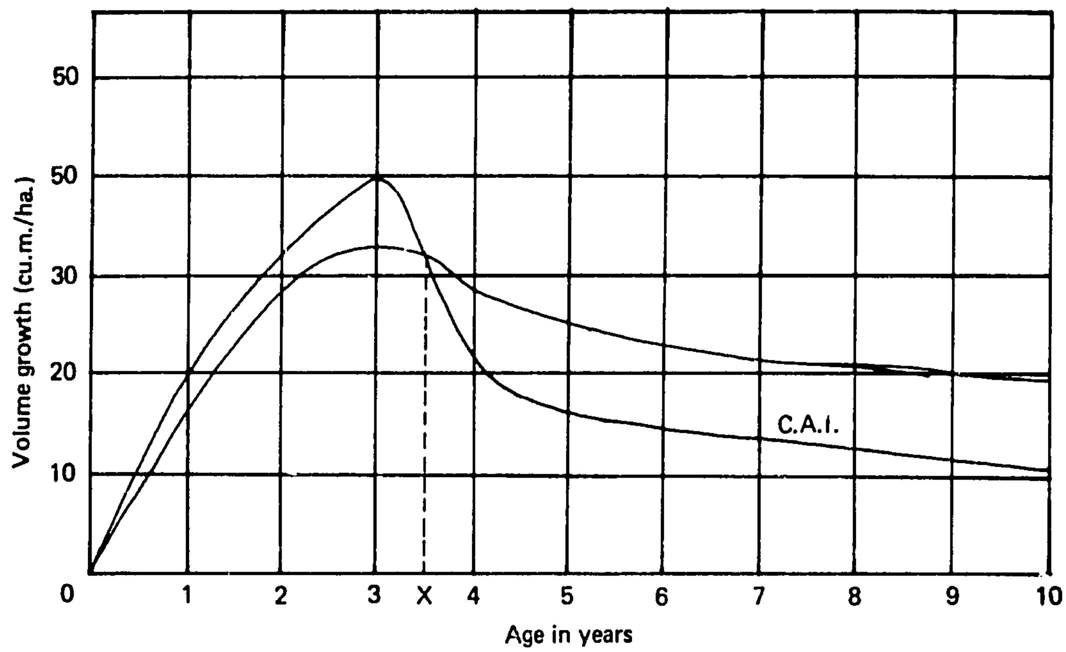

Fig. 1. Graphical representation of the current annual increment (C.A.I.) and mean annual increment (M.A.I.) of 10-year old Ipil-ipil plantation.

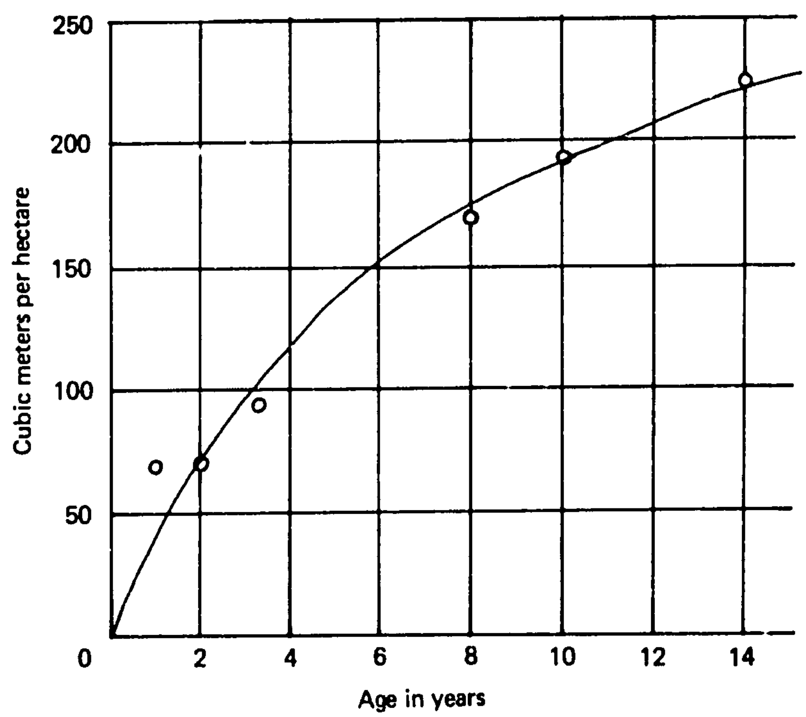

Fig. 2. Growth curve per hectare of ipil-ipil forest in Mt. Makiling area. 1958.

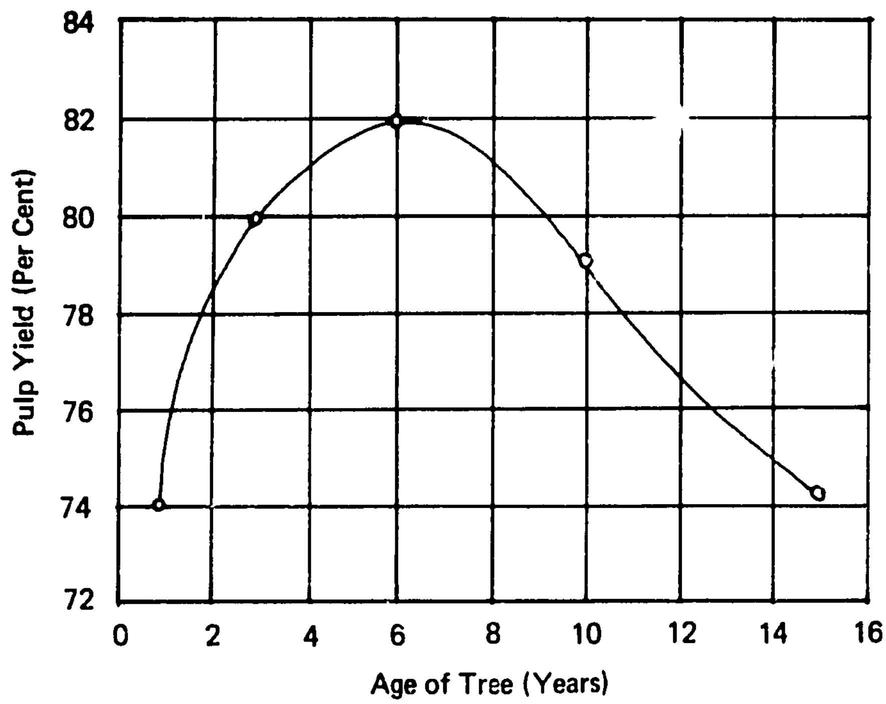

Fig. 3. The effect of age on pulp yield from ipil-ipil cooked with equal (NaOH) concentrations at equal lenghts of time.

IPIL-IPIL AS A REFORESTATION CROP

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Introduction

About one-sixth of the country's total land area or about 5 million hectares consist of grasslands, brushlands and other unproductive forest lands. To reforest these areas and restore their productiveness is the main goal of the government. Of immediate concern is the re-vegetation and rehabilitation of some 1.4 million hectares of denuded lands located in watershed areas.

Reclamation of such areas is often difficult because of adverse conditions in the planting sites. For instance, with the reported 16300 hectares mean annual reforestation, about 50 percent are for replanting (Glori, 1973, Revilla, 1976). Continuous soil erosion, leaching of nutrients, and frequent burning have transformed the soil practically sterile. Grasses, particularly Cogon (*Imperata sp.*), are the dominant vegetation. These species develop dense masses of roots and underground stems which take possession of the upper layer of soil.

For the government objectives to be attained, the species to be planted must be able to survive unfavorable growing conditions and capable of fast growth to overtop competing vegetation in a short time. It must be easy to handle and propagate and the planting materials should be readily available. Preferably, it should be economically important.

Some attributes of ipil-ipil

Of the numerous species used in reforestation, ipil-ipil could stand out one of the best. As a grassland species, it competes with cogon successfully (Amos, 1955; Mathews, 1914). It has been observed to flourish in areas that have been devoid of its top-soil, in road cuts, and even in rocky slopes where roots are penetrating deep into the cracks. This amazing ability of ipil-ipil to grow under conditions unfavorable to growth of most forest trees may be attributed to its rapid, aggressive and deep rooting characteristics which enable it to draw water and nutrients from greater depths; good nitrogen fixing properties enabling itself to thrive even in infertile soils; and tolerance to a wide range of soil and climatic conditions, permitting its establishment in most reforestation projects from sea level to about 500 m elevation or higher in all of the climatic regions of the country. The mean annual rainfall of the country is from 94 cm to 429 cm (Calooy, 1975) while ipil-ipil is reported to grow in areas with 25 cm (Brewbaker, 1975) to 400 cm rain per year (Djikman, 1950).

The economic importance of this legume is well known and more uses will be discovered. Planting materials won't be of much trouble as the species is a prolific seeder or could be propagated by stem cuttings. Its rate of growth is incredible, attaining a height of 9.5 meters and a diameter of 6 cm in 18 months (Mendoza, 1976). In other words, this legume has almost all the qualities of a good reforestation species.

Specific uses in reforestation

The various desirable traits of ipil-ipil could be harnessed to attain specific objectives like the following: :

1) Watershed cover for erosion control and water conservation

Protection of watersheds and the conservation of soil and water are the primary goals of the government in its current reforestation campaign. This legume has been found to be peculiarly fitted for these purposes. As previously stated, it can grow in barren areas such as those obtaining in most denuded watersheds. Its aggressive and deep rooting system breaks up and aerates impervious soils (Djikman, 1960), allowing greater water infiltration. Surface run-off and soil erosion are thus decreased and water quality is consequently improved.

The production of few lateral roots that grow downward at a sharp angle with the top root permits its planting at closer spacing. This, augmented by its fast rate of growth, affects the protection of the watershed much earlier.

This species like most legumes coppices readily and vigorously such that harvesting of the stem is possible without jeopardizing its protective role. More economic utilization of the land is therefore attained.

2) Pioneer and nurse crop

The adverse conditions in most planting areas do not allow the planting of many important forest trees. Ipil-ipil can be planted as a pioneer species to build up the soil and improve the conditions in order that other species may be established. Valuable organic matter is formed in the top soil with the shedding and subsequent decay of the ipil-ipil leaves. Forest species can be interplanted with the ipil-ipil. While this legume is enriching the soil, it provides shade needed in the early stage of development of the forest trees. With its few lateral roots growing deeply, least root competition is expected.

3) Ipil-ipil for fire protection

Fire has always been a major problem in reforestation burning to waste hundreds of established plantations annually. Firelines constructed each year at great costs are not very effective and short lived. Ipil-ipil planted very closely in strips of 10-20 meters wide can provide an effective, inexpensive and year round firebreak. It also serves as an efficient windbreak.

Cultural practices and needs for research

Ipil-ipil is established either by seeds, seedlings or cuttings. The latter is seldom used because of limited success.

Successful planting of ipil-ipil has been attained by sowing the seeds directly in the field. This is a preferred method by at least two plantation owners in Davao and Cebu. Seeds are drilled or dibbled in well-prepared sites and the seedlings are tended for about six months (Mendoza, 1976).

Among the important considerations in direct seeding are site preparation, time and method of seeding, rodent and insect depredation of seeds and seedlings. Site preparation ensures that the seeds get in contact with the soil and improve the condition for rapid root penetration and establishment. It reduces competition as to increase initial survival and growth of seedlings. Insect and animal population may be reduced. Thus, poor site preparation is the main reason for the failure of direct seeding in Cawag, Zambales (San Buenaventura and Asiddao, 1957) and more recently in Panay Islands. On the otherhand, Meimban (1957) got satisfactory results when site had been burned and plowed. A more practical method of site preparation is the subject of a research project now in progress in Pantabangan, Nueva Ecija. The time and method of sowing is also significant because they determine the amount of moisture available to the plant. Previous trials indicate that dibbling or drill sowing is superior to broadcasting.

Rats were likewise observed to be a problem in direct seeding. Seeds are eaten and young plants are cut. Coating the seeds with 7.5 percent (by weight) Arasan 75 WP may solve the problem. Previous experiments indicated that this concentration is effective against rodents (Dalmacio, 1974) and promote germination of ipil-ipil seeds (Dalmacio, 1976). Inclusion of rhizobia into the coating may improve the results.

The germination and production of seedlings in the nursery seem to be well established. Seeds are first treated with either hot water, hydrochloric acid or sulphuric acid, or subjected to mechanical scarification (Djikman, 1950). The hot water treatment is preferable in the field as it is readily available and economical. The seeds are soaked for 12 hours in water with an initial temperature of not more than 80°C. (Benge, 1976). Viable seeds will then immediately swell and which could now be planted individually and directly in pots, seed boxes or seed-beds as the case may be.

Newly potted seedlings are normally kept in shade for the first month and gradually exposed to full sunlight as it gets older. By the second month, they are ready for outplanting. The optimum size (morphological grade) of seedlings for outstanding to give high survival and fast initial growth, and the commensurate nursery techniques to produce it has yet to be determined. The use of bareroot seedlings or stumps for planting should also be studied. Bare-foot seedlings are much cheaper to produce and plant than potted seedlings.

Ipil-ipil is generally a slow starter (Djikman, 1950; Mercader, 1976). The seedlings also require periodic weeding especially during the first year of growing period. Judicious application of lime and fertilizer particularly phosphorus may likewise accelerate growth. For instance, in the study of Stone and Angeles (1961) in Carranglan, Nueva Ecija, this legume responsed very strongly to phosphorus and lime and not at all to potassium. Similar observations were made by Calisay (1975). In this connection, pre and post-planting cultural practices such as site preparation, weeding and fertilization should be good subjects for research. Spacing and thinning are another areas for research.

Ipil-ipil coppices readily and profusely. Three-year-old stumps in a plantation in Davao have yielded banana props five times (Mendoza, 1976), or about 7 months for each coppice to reach the desired size of not less than 3.8 cm in top diameter and 5 meters in length (Benge, 1976). For wood production, the height of stump and the number of sprouts to maintain should be determined.

Conclusion

Ipil-ipil is indeed a valuable crop for reforestation that its massive use is herein recommended. However, our knowledge on its establishment and culture is by no means complete. Anticipating its extensive use in reforestation and industrial plantations, the following areas of research are strongly recommended

1. Varieties/strains of ipil-ipil best suited in a particular reforestation area.
2. Time and method of sowing, site preparation and seed coating for direct seeding.
3. Optimum size of seedlings for field planting and commensurate nursery techniques to produce it.
4. Site preparation, weeding and fertilization
5. Spacing
6. Thinning and coppicing
7. Scheme of interplanting other forest trees or perennial agricultural crops with ipil-ipil.
8. Biology and control of insect pests attacking ipil-ipil.

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UTILIZATION OF IPIL-IPIL FOR WOOD

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Abstract

Giant ipil-ipil is apparently one of the fastest growing species with estimated mean annual increments of 24 to 312 m^3/ha/yr or 13 to 150 bone dry metric tons/ha/yr depending probably upon the site quality and the strain involved. The specific gravities, ranging from 0.50 to 0.59, are lower than those previously known for ipil-ipil. The fiber dimensions, which are typical for hardwoods, together with the relatively low extractive content, lignin content and the high holocellulose content, are favorable for its consideration as a raw material for both dissolving value of its wood is somewhat lower compared with that for common ipil-ipil, it is still considered satisfactory. Hence, it is a potential fuel for wood-burning power stations for generating electricity. Other possible uses are for lead poles for rural electrification projects, lumber, and parquet flooring.

Introduction

As far as we know, the earliest planting in the island of Luzon, at least, was in 1968 at the Canlubang Sugar Estate. Benge mentioned that the first introduction of giant ipil-ipil into the Philippines was sometime in 1964. Since 1970, the University of the Philippines at Los Banos (UPLB) has been working on giant ipil-ipil and has the largest ipil-ipil accession in the Philippines consisting of 87 strains/species of ipil-ipil from the Philippines and abroad. Plantings in the Davao area were first made by the Bureau of Forest Development and notably by Montemayor. Nasipit Lumber Co. also started on "energy forest" of giant ipil-ipil at about the same date. In Batangas province, the provincial government under Gov. Leviste has been active in the promotion of ipil-ipil.

The Forest Products Research and Industries Development Commission (FORPRIDECOM) got involved in studies on giant ipil-ipil beginning 1973 as a result of inquiries and researches requested by several wood-industry companies and private individuals. This paper concerns the work done by the various divisions of the FORPRIDECOM excluding the confidential work done for private companies.

Samples used in our studies came from private plantations and from the UPLB. In recent years, interest in giant ipil-ipil for both agricultural and forestry purposes has rapidly grown and so has the need for detailed studies on various aspects of this tree. As much as possible, efforts have been made to obtain the correct identification of the strains or species of the giant ipil-ipil used in our studies. Apparently, most of the giant ipil-ipil growing in the Philippines are strains of the species *Leucaena leucocephala* (Lam.) de Wit, to which our common ipil-ipil also belongs. Where possible, the corresponding Hawaiian accession numbers (e.g., K8, K28, etc.) for the strains/species are used.

Growth Rate

Many agreed that giant ipil-ipil is "fast growing" but so far, there has been no data available on the growth rates in terms of m^3/ha/yr or in terms of weight of wood/ha/yr. Capili states that 8-month old giant ipil-ipil trees had a diameter at breast height (DBH) of 6 cm and a height of 4.3 m, while 2.33-year old trees had a DBH of 15 cm and a height of 12.1 m. Montemayor reported that giant ipil-ipil attained up to 15 cm diameter in 2.25 years. These data refer to what is commonly called in the Davao area as the "Peruvian giant ipil-ipil" In Mindoro, a K-28 tree reached a height of 13 m and a DBH of 37 cm in 8 years.

Growth data in terms of wood volume or weight/ha/yr would be very useful to those interested in establishing plantations for the production of wood for charcoal, fuelwood, pulp and paper, lumber or other purposes. The mean annual growth increments of giant ipil-ipil are given in Table 1.

Estimated mean annual growth increments of the K-28 strain in two small areas at the Canlubang Sugar Estate, at 7 years old, were 45.5 to 45.7 m^3/ha/yr or 25.2 to 25.8 bone dry metric tons (bdt)/ha/yr for the trunk alone. If the wood in the branches of a minimum diameter of 5 cm at the small end was included, the mean annual increment was 31.6 to 37.4 bdt/ha/yr. The overall branches constituted the equivalent of 25.6 to 44.8 percent of the wood in the trunks. Hence, for fuel purposes or perhaps for pulp, the wood in the branches cannot be ignored.

In the Monterey Farms Corp. in Batangas province, 2-year old K8, K28 and K67 strains were found to have mean annual growth increments of 23.8 to 30.7 m^3/ha/yr or 12.6 to 16.3 bdt/ha/yr. Two and one-half year old K8 trees planted by the Provincial Government of Batangas had a mean annual growth increment of 48.8 m^3/ha/yr or 25.9 bdt/ha/yr.

In the Davao area, 14-month old trees at the Montemayor plantation had a mean annual increment of 57.5 m3/ha/yr or 31.0 bdt/ha/yr. Eighteen-month old trees had a mean annual increment of 123,1 m3/ha/yr or 66.5 bdt/ha/yr. In this area, these trees are commonly referred to as Peruvian ipil-ipil.

A relatively dense planting at UPLB of the 4 giant ipil-ipil strains (K 8, K 22, and K 67) had mean annual increments of 203.9 to 311.92 m3/ha/yr or 90.3 to 149. 5 bdt/ha/yr for the trunks alone at the age of 2.5 years. The growth figures exclude the wood in the 1.5 m stumps.[1]

Differences in the number of trees/ha, site quality, the strains or species involved, as well as the ages of the trees, may account for the variation in the rates of growth.

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[1]**Weight and volume determinations on tree trunks were made with the cooperation of R.C. Mendoza, Department of Agronomy, UPLB.**

Comparative growth rates for the common ipil-ipil was given by Vergara. At 2 to 3 years old, the growth rate was 34.7 to 40 m3/ha/yr, while at 7 years old it was 23.4 m^3/ha/yr. Using the specific gravity for common ipil-ipil of 0.73, the corresponding growth rate in weight is 25 to 29 bdt/ha/yr at 2 to 3 years old and 17 bdt/ha/yr at 7 years old.

While it appeared that, in some cases, notably in the Batangas samples, the common ipil-ipil seemed to have bested the giant strains/species in growth rate per unit area per yr, the stand density in Vergara's study was 100,000 trees/ha. The data in Table 1 concern estimated densities of 2,488 to 44,444 trees/ha. These are much higher than is usual for fast-growing pulp-wood plantations with less than 1000 trees/ha. The densities mentioned above for giant ipil-ipil is probably appropriate for fuelwood, charcoal, particleboard or pulpwood. Such high stand densities result in high growth rate per unit area per unit time and correspondingly lower unit production cost, but may not be conducive for growing large trees.

The DBH's mentioned in Table 1 is apparently lower than those mentioned by Brewbaker or those by Benge, Capilo or Montemayor. The K 8 strain mentioned by Brewbaker has attained a basal diameter of 21.6 cm and a height of 16.8 m in 6 years, spaced at 1.21 between trees. K 28 strain was reported to have attained a DBH of 15.2 cm and a height of 9.8 m in 2 years on unfertilized soils and with no trimming. Four-year old K 28 trees attained 15 cm diameter and 15 m height at a spacing of 1.5 x 5 m. The height figures mentioned are probably total heights.

The fast-growing pulpwoods, now growing in the Philippines, such as *Albizia falcataria, Gmelina arborea, Eucalyptus deglupta* or *Anthocephalus cadamba* have reported mean annual growth increments of 28 to 43m^3/ha/yr. Volume-wise, these figures are lower than those of the giant ipil-ipil with a similar age, the Canlubang samples. The figures for the above-mentioned pulpwood in terms of weight are only equivalent to 10.8 to 11.9 bdt/ha/yr due to their lower specific gravities, whereas the corresponding figure for the 7-year giant ipil-ipil is 25.2 to 25.8 bdt/ha/yr.

As to whether any of these fast-growing pulpwoods can ever approach the giant ipil-ipil yields, even if the former species are planted at stand densities similar to that used for giant ipil-ipil, appears uncertain for the present. Ipil-ipil has a unique deep taproot system which grows straight downwards and results in less competition of the stems with each other for plant nutrients even when planted closer than usual for other species.

Wood Properties

A. Proximate Chemical Composition

Table 2 shows the chemical composition of various samples of giant ipil-ipil. Also given are the composition of the common ipil-ipil and the average for 95 Philippine hardwoods. While the common Philippine ipil-ipil has similar holecellulose, hot-water solubles, and lignin to the average of 95 Philippine hardwoods, its pentosans and alcohol-benzene solubles are higher and its ash content is relatively lower.

The table shows the analyses for different giant ipil-ipil samples representing possibly two different strains/species with ages varying from 0.5 to 6 years old. The mean of the chemical analyses for the giant ipil-ipil trunks shows higher average holecellulose than either the common ipil-ipil or the average for the Philippine hardwoods; about the same ash content as common ipil-ipil but lower pentosan and lignin content and alcohol-benzene and hot-water solubles than either the common ipil-ipil or the average for Philippine hardwoods.

The above results indicate that, compared with the common ipil-ipil or the average for Philippine hardwoods in chemical pulping, pulp yields for giant ipil-ipil would be higher due to its high holecellulose content; lesser problems due to pitch during the pulping and paper-making process because of its relatively lower alcohol-benzene solubles; and possibly correspondingly lesser problems in the chemical recovery process of the pulp mill due to lower ash or silica. On the other hand, due to its relatively lower alcohol-benzene soluble content, giant ipil-ipil would have somewhat lesser heating value than common ipil-ipil.

A comparison of the analyses of the wood's trunk and branches of a 6-year old giant ipil-ipil is also shown. There were no differences in the pentosan and ash contents. The slight difference for holocellulose, lignin, and the alcohol-benzene and hot-water solubles are not probably significant.

B. Specific Gravity

Specific gravity data on ipil-ipil are limited. Brewbaker mentions that the specific gravity of ipil-ipil is 0.70. The common Philippine ipil-ipil has a value of 0.73. Table 3 presents the specific gravity values for giant ipil-ipil as determined by the Timber Physics and Engineering Division and by the authors. All the giant ipil-ipil trunk samples had specific gravity values of 0.50 to 0.59, lower than that of the common ipil-ipil. The branches have apparently lower specific gravity than the corresponding trunks. Sample no. 3 consists of 1 year old sprouts from 1.5 old trunks Older trees seem to have higher specific gravities. This was shown previously by watson.

Specific gravity values give a good approximation of the latent strength of comparatively unknown species. The higher the specific gravity, the higher is the strength. Thus, giant ipil-ipil is relatively lower in strength than common ipil-ipil. On the other hand, giant ipil-ipil would seem to be a better raw material for pulp than common ipil-ipil. The pulp yields and paper strength properties have an inverse relationships with the specific gravity of wood, whereas pulping chemical consumption has a direct relationship. The comparatively high density of giant ipil-ipil compared with that of *A. falcataria* (0.25) means that the former is better suited to areas subjected to strong winds, such as during typhoons, compared to the latter which easily breaks. Pulp production for a given digester capacity is about twice more for giant ipil-ipil than what is obtainable with *A. falcataria.*

C. Fiber Morphology

The fiber dimensions of the common Philippine ipil-ipil was reported by Tamolang *et al* and is included with those of giant ipil-ipil[2] in Table 4. The values are typical and are within the ranges of those obtained for various Philippine hardwoods and in other areas, as summarized by Tamolang *et al.*

The fiber dimension. of the giant ipil-ipil samples when compared with the common ipil-ipil meet some of the specifications set forth by Dadswell for an ideal pulpwood such as:

1. Higher than average fiber length for the species;
2. Cell wall thickness such that the Runek ratio (twice the cell wall – thickness/lumen diameter) is less than 1; and
3. Basic density lower than average for the species.

But this comparison may not apply when comparing giant ipil-ipil with the Philippine mahogany species.

The average fiber lenghts of the giant ipil-ipil samples are longer than that of the common ipil-ipil. The direct relationship of the fiber length or the ration of fiber length to diameter to the tearing strength fo the corresponding paper has been reviewed by Dadswell and Dinwoodie. The Runkel ratios of the various giant ipil-ipil samples are all less than 1, thus passing Runkel's criteria for good papermaking fibers.

D. Bark

The average bone-dry bark content of a 2-year old giant ipil-ipil's trunk from Davao was 29.3 kg/m^3 of wood or 0.0497 kg/kg of bone-dry wood. The trunk from

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[2]J.G. Palisoc and L.V. Villavelez, Wood Technology Division, FORPRIDECOM.

7-year old K28 logs from Canlubang averaged 43.3 kg bone-dry bark/m^3 of logs or 0.0802 kg/kg bone-dry Wood.

E. Heating Value

Heating value characterizes the suitability of wood as a fuel. The higher this value, the more desirable it is for fuel.

Common ipil-ipil has a heating value of 4640-4673 calories/kg (8352 to 8411 Btu/lb). The heating value of various ipil-ipil samples received by FORPRIDECOM ranged from 4167 to 4445 calories/kg (7500 to 8000 Btu/kg). These are still satisfactory values for fuelwood. Again, as with the other wood properties, the variations in the heating value may be due to age and varietal differences which affect the chemical composition and, in turn, the heating value.

Some Potential Uses

A. Giant Ipil-ipil for Power Generation

The recent "energy crisis" led to a feasibility study on the use of wood for generating electric power from central power stations.

Waste wood and bark have long been used as fuel for steam and electric energy production in wood-industry mills. The waste wood and bark are cheap fuels because the costs for logging, hauling and wood preparation have already been partially or fully charged to the primary products of the mills.

A survey of local wood-burning plants in the wood industry showed that 8 metric tons (green), containing about 50 percent moisture on the total weight basis, can generate 1 Mwh of energy. It was determined that 919,120 metric tons (green) (459,560 bdt) of wood would be required annually to furnish the fuel requirements of a minimum economic-size power plant of 75-Mw capacity operating at 70 percent capacity factor.

A study of the growth rates of some fast-growing woods to the conclusion that these species would require such huge areas of plantations to support 75-Mw power plant, for which they appeared less promising.

Assuming a growth rate of 50 bdt/ha/yr for giant ipil-ipil, a figure which is considered to be readily attainable, some 9100 ha of plantation could support the fuel needs of a 75-Mw plant. The ash, 0.8 percent of the wood, would amount to about 3676 bdt annually on a wood consumption of 459,560 bdt, which would be returned to the plantations, thus returning the mineral constituents to the soil and at the same time solving the waste disposal problem of the power plant.

A total of 330,063 hectares of reforestation sites have been identified as possible giant ipil-ipil plantation sites for 19 wood-fired power plants with a total generating capacity of 2175 Mw. This is not necessarily the maximum generating capacity attainable from fuelwood plantations. There is still a large area of other sites available for reforestation which have not been considered due to lack of data on the area.

It has been estimated that based on the known capability of local wood-industry firms (one of which has shown its capability at the rate of 6000 ha of plantation, annually), 5 years would suffice to develop a 9100-hectare area which would supply fuelwood on a sustained yield basis for a 75-Mw plant. The average investment per ha of plantation would be about P3000 (US $395/ha).

The discounted cash flow rate of return for a 15-year period comprising the 5-year development period and the 10-year harvesting period, taking advantage of incentives offered by both the new Forestry Reform Code and the Board of Investments and financing assistance for part of the investment requirement is 25.8 percent, which is considered an attractive return.

The corresponding investment requirement for a 75-Mw woodfired steam power plant is P265,082,000 (US $34,879,200). The production cost of energy from such a plant would be P0.18 to P0.23/Kwh (US $0.0237 to (.0303/Kwh) for wood hauling distances varying from 10 to 50 km. The corresponding cost of energy from an oil-fired power plant of the same capacity drawing high-viscosity fuel oil from a nearby petroleum refinery would be P0.20/Kwh (US $0.0263/Kwh). Fifty km is probably the maximum road-hauling distance for the wood fuel within which a wood-fired power plant could be competitive in production cost with an oil-fired plant.

B. Preservative Treatment of the Wood

Green K28 giant ipil-ipil bolts from 7-year old trees were Boultonized (boiling water-vacuum treatment with creosote) followed by the full-cell process. The 3- to-4-cm thick sapwood was easily treated with the preservative. Since this strain attained up to 13.2 m clear length at the Canlubang plantation, this is a potential material for lead poles for rural electrification.[3]

C. Parquet Flooring

Parquet wood tiles were made from the wood of 7-year old K28 logs from Canlubang. The wood had good machining properties. However, the recovery from the log was relatively lower than that obtainable from commercial hardwoods due to the presence of knots. Perhaps, this was also due to the relatively small diameter of the wood, about 20 cm.

D. Lumber

A preliminary study on lumber recovered from a selected batch of 7-year old Canlubang K28 trees yielded interesting results. Fourteen logs with an average log diameter of 20 cm and a length of 2.3 m yielded a volume of 431.13 board meters. The logs were sawn into 2.5 cm thick stock in a variety of widths at a recovery of about 241.3 bd m or about 54 percent.

E. Paper Pulp

Table 6 presents the pulping data on chips from undebarked trunks of 7-year old Canlubang K 28 and on debarked 1.5 year old K 28 trunks. The range of values for the pulping of our fast-growing pulpwoods: African tulip (*Spathodea campanulata* Beauv.), Kaatoan bangkal (*Anthocephalus chinensis* (Lam.) Rich Ex. Walp.), Moluccan sau (*Albizia falcataria* (L.) Fosberg.). and yemane (*Gmelina arborea* Roxb.) are also given (32.). Except for Moluccan sau, for which 13.3 percent of NaOH and 6.7 percent Na_2S were used, all the other species and giant ipil-ipil were pulped under the same conditions.

The giant ipil-ipil screened pulp yields, pulp screen rejects the equivalent K numbers that are within the range of those of the four pulpwoods. Chemical consumption is slightly lower than those of the other species.

Table 7 gives the results of the physical tests on pulp handsheets made from the giant ipil-ipil pulps. The ranges of the burst factor, tear factor, folding endurance and tensile strength overlap those of the fast-growing pulpwoods. The nature of the overlapping values indicates that the giant ipil-ipil pulps may be slightly superior in burst and tear strengths and slightly inferior in folding endurance and tensile strengths.[6]

F. Dissolving Pulp

Unbarked and debarked wood chips from the 7-year old Canlubang K 28 logs were subjected to water prehydrolysis to break down the pentosans. Pulping followed

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[3]F.R. Siribon, Wood Preservation, FORPRIDECOM.

the prehydrolysis step using 15 percent NaOH and 5 percent Na_2S. The maximum temperature of 170°C was attained after a 45-minute temperature rise period and was further maintained for another 45 minutes. A screened pulp yield of 41.8 percent for the debarked wood and 42.7 percent for the unbarked wood was obtained. The screen rejects were 1.4 percent for the unbarked wood and 0.4 percent for the debarked wood.

The pulp yield figures indicate that giant ipil-ipil may be a potential raw material for dissolving pulp.

Conclusions

The results on the wood properties and potential uses of giant ipil-ipil, as presented in this report, must be considered as preliminary since they are based on relatively few samples. Nevertheless, the results are encouraging and should lead to further detailed and intensive studies on various wood products including fiberboard, lumber, particleboard, dissolving pulp, tannin adhesive, novelty products, and others.

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Table 1. Estimated Mean Annual Growth Increments of Giant Ipil-ipil

Ref. NO.	Sample	Age years	DBH cm	Clear Height of trunk m	Stand density trees/ha	Volume of trunk m^3ha*	Mean Annual Increment TRUNK m^3/ha/yr*	TRUNK bdt/ha/yr**	Trunk and branches bdt/ha/yr**
1	Davao	1.2	4.9	3.0	16,667	67.1	57.3	31.0	
2	Davao	1.5	6.0	5.5	16,667	184.7	123.1	66.5	
3	Batangas K8	2	8.8	5.7	2,488	61.4	30.7	16.3	
4	Batangas K28	2	10.1	3.4	2,488	47.6	23.8	12.6	
5	Batangas K67	2	8.8	4.6	2,488	49.8	24.9	13.2	
6	Batangas K8	2.5	8.7	4.2	6,908	122.0	48.8	25.9	
7	UPLB K8	2.5	9.2	2.4	44,444	591.7	236.7	110.8	
8	UPLB K22	2.5	8.0	2.6	44,444	511.5	204.6	112.0	
9	UPLB K28	2.5	10.1	2.4	44,444	779.8	311.9	149.5	
10	UPLB K67	2.5	8.4	2.3	44,444	509.8	203.9	90.3	
11	Canlubang K28	7	13.0		3,643	318.7	45.5	25.2	31.6
12	Canlubang K28	7	16.7	7.4	2,774	320.1	45.7	25.8	37.4

* Based on volume determinations on tree samples

** Samples 1 & 2 based on density of 0.54 g/cm^3
Samples 3 – 6 based on density of 0.53g/cm^3
Samples 7 – 12 based on weight determinations on tree samples

Table 2. Proximate Chemical composition of Ipil-ipil

Ref. No.	Sample	Number of Trees	Age years	Holo-cellulose %	Pentosans %	Lignin %	Solubilities in: Alcohol-benzene %	Hot-water %	Ash %
13	Common Philippine ipil-ipil, trunk*	2	**	63.2	17.8	25.6	7.8	2.7	0.8
	Giant ipil-ipil								
14	UPLB K28, trunk	20	1.5	72.6	20.1	22.7	1.7	2.0	0.9
15	Davao, trunk	1	0.5	69.8	8.9	25.4	1.4	2.5	0.9
16	Davao, trunk	2	2.0	69.9	16.0	26.0	1.5	1.9	0.7
17	Canlubang K28, trunk	1	5.0	73.9	17.5	21.8	2.5	1.1	0.7
18	Canlubang K28, trunk*	2	6.0	71.0	13.6	23.3	2.6	2.3	0.8
19	Canlubang K28, branches of No. 18	2	6.0	72.0	13.6	22.6	2.9	1.7	0.8
	Average for trunks Nos. 14 to 18			71.4	14.9	23.8	2.0	2.0	0.8
	Comparative Analysis								
	Average for 95 Philippine hardwoods			63.6	16.4	25.7	4.2	3.0	1.5

* Average for separate analyses of 2 trees
** Unknown

Table 3. Specific Gravities of Ipil-ipil

Ref. No.	Sample	No. of trees	Age years	Specific Gravity*
13	Common Philippine Ipil-ipil	1	**	0.73
	Giant ipil-ipil			
14	UPLB K28, trunk	20	1.5	0.52
20	UPLB K28, branches of No, 2	20	1.0	0.41
21	Davao	3	3	0.50
22	Davao	3	3	0.59
18	Canlubang K28, trunks	2	6	0.52
19	Canlubang K28, branches of No. 18	2	6	0.49
12	Canlubang K28, trunk	1	7	0.54

* Equals numerically density based on over-dry weight in grams/green volume in cm3

** Unknown

Table 4. Average Fiber Dimensions and Derived Values of Giant Ipil-ipil

Ref. No.	Sample	Age years	Length (L) mm	Width (D) mm	Lumen width (l) mm	Cell wall thickness (w) mm	Slenderness ratio L/D	Flexibility ratio 1 x 100 D	Runkel ratio 2w 1	Runkel Group	Mulsteph %	Mulsteph Group
13	Common Philippine ipil-ipil	*	1.01	0.024	0.015	0.004	42	62	0.53	I	61	III
14	UPLB K28, trunk	1.5	1.04	0.026	0.016	0.005	40	62	0.62	I	62	III
20	UPLB K28, branch of No. 14 above	1.0	1.17	0.028	0.017	0.005	42	61	0.59	I	63	III
18	Canlubang K28, trunk	6	1.20	0.025	0.015	0.005	48	60	0.67	I	64	III
19	Canlubang K28, branches K28, branches of No. 18 above	6	1.09	0.024	0.014	0.005	45	58	0.71	I	67	III

* Unknown

Table 5. Heating values of some giant ipil-ipil samples

Ref. No.	Sample	No. of trees	Age years	Heating value Btu/lb	Cal/Kg.
15	Davao trunk	1	0.5	8000	4445
14	UPLB trunk	20	1.5	7700	4278
16	Davao trunk	2	2	7700	4278
17	Canlubang K28 trunk	4	5	7600	4223
18	Canlubang K28 trunk	2	6	7500	4167
19	Canlubang K28 branch of 18	2	6	8000	4445

Table 6. Pulping of Giant Ipil-ipil

Ref. No.	Sample	NaOH %	Na_2S %	Chemical Consumption Bone-dry Material %	Chemicals Charged %	Accepts %	Rejects %	Pulp Kappa Number	Yield
14	UPLB, debarked trunk, 1.5 yr. old	15	5	12.9	82.9	50.3	0.5	19.8 (14.4 K No.)	
11	Canlubang unbarked trunk, 7 yr. old	15	5	12.8	81.9	52.4	0.4	26.9 (About 18 K No.)	
	Range for 4 fast-growing pulpwoods	15*	5*	13.6-14.9	87.3-95.6	45.3-55.7	0.2-0.8	(10.9-23.9 K No.)	

Other pulping conditions:

4:1 Liquor to material ratio
90 Minutes to maximum temperature of 170 deg. C.
90 Minutes at maximum temperature

* *Used for 3 species A. falcataria used 13.3% NaOH and 6.7% Na_2S

Table 7. Properties of giant ipil-ipil pulp

Ref. No.	Sample (Species)	Time Processed (Minutes)	Freeness CSF-(cc)	Burst Factor	Tear Factor	Folds (double) (M.I.T.)	Tensile (Breaking) Length in M.)	Density g/cm,
14	Debarked trunk, UPLBL 1.5 yr old	46	350	82	81	500	9,100	0.78
12	Unbarked trunk Canlubang 7 yr old	66	350	76	86	800	10,800	0.75
	Range for above pulps	46-66	76-82	86-83	81-86	500-800	9,100 10,800	0.75 0.78
	Range for 4 fast-growing pulpwoods	22-122		66.7-80.9	68-82	750-1,275	10,400-13,000	0.77-0.85

THE ECONOMICS OF IPIL-IPIL PRODUCTION

(A proposal to develop comprehensive national and regional ipil-ipil production plans)

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Background note

I know very little about ipil-ipil and even less about the giant species/varieties. But recently, I have heard a lot about the potentials of the latter for fuel and energy generation, fertilizer, wood-based products and derivatives, forage, feeds, food firebreak, reforestation (soil cover), small poles, fence posts, etc. So, when the invitation to attend this consultation came last week, my initial reaction was to grab this opportunity to learn more about the ipil-ipil. But two things dampened my enthusiasm: the problem of fitting the consultation schedule into an air-tight schedule that has plagued me during the last few months and the thought of preparing a paper on a short notice most likely on something I know very little about. The latter became an interesting challenge and soon the first problem was overcome even at a high "price".

Scope of this short paper

With the challenge accepted, the task of writing a paper on the economics of ipil-ipil production soon became a burden, more so when the libraries on campus were found to offer little information on the subject. Fortunately, the many potential uses of giant ipil-ipil particularly its potential for fuel (in the face of the energy crisis) and for agricultural fertilizer (in the face of the food crisis and the increasing costs of chemical fertilizers), its relatively fast growth and its apparent adaptability to diverse site conditions, all these, make giant ipil-ipil quite a fascinating subject. And then, a closer look at the production problem considering the many possible uses of giant ipil-ipil, scarce land and capital resources and the urgent need to utilize these resources optimally soon points to the urgency of applying modern production theory in the case of ipil-ipil. So, in the face of the great appeal of growing ipil-ipil to private and government enterprises and the likelihood for sub-optimal nationwide ipil-ipil production if a comprehensive ipil-ipil production program is not developed and applied, I finally decided for this paper to deal on a proposal to develop comprehensive ipil-ipil production programs for the Philippines on a national as well as on the regional and production unit levels.

Past researches on the economics of ipil-ipil production

Very little research has been done on the economics of ipil-ipil production. Vergara in 1960 studied the economic rotation of ordinary ipil-ipil for fuelwood production. Francia in 1961 did a research on the comparative economic returns from kaingin lands using alternative crops of rice, coffee, banana and ordinary ipil-ipil for fuelwood. In these studies, ordinary ipil-ipil was found to be best managed on a one-year rotation for ordinary fuel-wood production and was shown to be a superior crop on kaingin lands, twice as superior to rice, coffee or banana.

The above-mentioned studies did not include the effects of site quality and accessibility on economic rotation and the varied effects of market factors on production decisions under different forestry economic situations. The results obtained in these studies, nevertheless, indicated the **profitability** of ipil-ipil production in a range of situations that approximate the conditions obtaining in the production systems studied.

The economics of giant ipil-ipil production; the need for comprehensive national and regional production planning

The economics of giant ipil-ipil production is yet to be studied. Existing literature on giant ipil-ipil indicates the great potentials of the tree species for a number of uses and all indications are that, in general, its production for some end-products is economically viable, but the specifications of the production systems under which production is optimized to meet specific objectives are still to be determined. A research project, on a national and regional levels and probably one or two case studies on a management (production) unit level, have to be conducted to determine answers to certain questions (on which production policies/guidelines will be based) including: *what kind of end products? in what quantities? utilizing what kind? how large? and which parcels of land?* and *what kind of production technology?* for the national, regional and a couple of specific giant ipil-ipil production systems. In other words, the results of the proposed research will guide national and regional production of giant ipil-ipil for various purposes. This will minimize the sub-optimal utilization of land, labor and capital resources in ipil-ipil production, avoid the occurrence of imbalances, surpluses or deficits of ipil-ipil products in different parts of the country and maximize benefit flows from the ipil-ipil industry.

Concomitant to the economic model for giant ipil-ipil production will be more realistic yield prediction for the various products under different site conditions and crop production technologies in real-world (as opposed to experimental) situations.

The research project proposal

1. The objectives

   a. To develop comprehensive giant ipil-ipil production programs for the Philippines (national, regional and production unit levels).

   b. To determine the national and regional demands for various crops of giant ipil-ipil.

   c. To determine the feasibility, viability and profitability of ipil-ipil production in various economic situations.

d. To develop yield prediction models for the various crops of ipil-ipil.
e. To determine the land, labor and capital requirements of the national and regional ipil-ipil production programs.

2. Methodology

The research methodology is likely to entail linear programming (or one of its Variations), formulation of the national, regional and management/ production unit and ipil-ipil production problems. The yield prediction models will most likely involve least squares and related methods.

3. *Duration of the research project* - 24 months
4. *Budgetary requirements* - P420,000.00
5. *Manpower requirements*

1	Project Manager
1	Assistant Project Manager
3-5	Project Advisors/Consultants
1	Research Associate, Economist/OR
3	Research Assistants
1	Clerk-typist
1	Driver

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CHARCOAL PRODUCTION FROM IPIL-IPIL

Victor Guevara
Mabuhay Vinyl Corporation

Introduction

Mabuhay Vinyl Corporation (MVC) went into tree farming of giant ipil-ipil (Leucaena leucocephala) two years ago in anticipation of the charcoal requirement for its backward integration and expansion of its vinyl chloride monomer production capability. Mabuhay is in PVC, a synthetic resin manufacture and vinyl chloride is the raw material. MVC's charcoal requirement for its carbide furnace is 60,000 tons or approximately 400,000 cu m of wood per annum. This is to make 30,000 tons a year of vinyl chloride.

The ipil-ipil trees are expected to be made into charcoal after four (4) years of growth. At this age, we envision the trees to have an average height of 6 meters and a diameter breast height (DBH) of 11 cm. This size of tree is ideal as it can be cut easily with the use of an ordinary axe by the farmer. Also, it would be easier to char or convert into charcoal.

University of the Philippines Industrial Research Center

In an effort to find more efficient means of conversion from wood to charcoal, MVC entered into a cooperative research agreement with the University of the Philippines in 1973 for the design and fabrication of wood carbonization retorts.

The UP Industrial Research Center designed, fabricated and tested two types of wood carbonization retorts for Mabuhay Vinyl Corporation namely:

(1) a direct-burn retort where part of the wood charge is burned at the top of

the retort and the air and gas-by-products directed in a down-draft flow through the charge of wood by means of mechanical blower; and

(2) an indirectly heated retort where supplementary fuel like waste oil is burned by a burner in a furnace below the retort and the hot combustion products pass through nine vertical flues which heat indirectly the wood charge inside the retort.

The first design could be operated as a continuous reactor, i.e., wood can be continuously charged at the top and charcoal can be withdrawn from below. The second retort, by its inherent design, is a batch type reactor.

The following were the findings of the U.P. Industrial Research Center:

(1) Performance of the direct-burn retort was very much better than that of the indirectly-heated retort.

(2) Percentage charcoal recovery is improved significantly by pre-drying the wood charge and operating at a lower temperature. Charcoal recovery is 18.4 percent at 30 percent moisture, upon pre-drying of wood to about 1 percent moisture, recovery went up to 32 percent.

(3) Sample analysis of charcoal discharged from Retort I using local ipil-ipil:

%Moisture	%VM (Volatile Matter)	%FC (Fixed Carbon)	%Ash
9.6	6.2	81.0	3.2
13.6	4.6	7C 4	3.7

(4) Further experiments must be done to definitely quantify the benefits of pre-drying the wood charge before carbonizing.

(5) The problem of pollution from the stack gas effluents must be solved. This could be done by burning the gas effluents in a furnace with supplementary fuel (the gas products cannot be burn by itself in the early stages of the carbonization process when the percentages of combustible are still low).

(6) To implement recommendations (3) and (4), the indirectly-heated retort can be converted into a direct-burn retort and the furnace incorporated with it can be used to burn the gas effluents. The hot (and clean) combustion products can not be used to hear the air for pre-drying the wood charge in a mechanical drier that can be integrated with the retort.

(7) Studies on tar and liquor utilization should be initiated.

Although charcoaling with the use of retorts are superior, MVC management is reluctant to adopt it for the following reasons, to wit:

(1) Handling of raw wood would be difficult. The plantation terrain is mountainous and there are no good roads within the plantation.

(2) Power is not available to run such equipment as the mechanical blowers of the retort.

(3) Capital investment for sophisticated retort is huge.

On the other hand, the use of old and crude pit method of charcoaling possessed some practical advantages to both the MVC and the small and independent tree farmer as follows:

(1) Charcoaling could be done on site where the trees are. It is easy to dig pits as you go farther out to cut the trees.

(2) The charcoal can be transported easier than the wood

(3) The cost of pit is very cheap and could well be within the reach of an or-

dinary farmer who would want to be productive and augment his income thru charcoaling.

(4) Pollution problem is not concentrated and is dispersed over a wide area.

One disadvantage of the pit method, of course, is the quality of the charcoal produced. It has a lower fixed carbon content and the charcoal recovery is less. However, Maria Cristina Chemical Industries, Inc. has been using this kind of charcoal quite successfully as a reducing agent for the manufacture of calcium carbide at the Iligan plant for the past 20 years.

Charcoal Production of Local Ipil-ipil (Leucaena leucocephala)

In Cebu, the most common method of making charcoal is by the pit method. The pit depends upon the length of wood to be burned as well as the volume to be converted into charcoal. The usual size of the pit is about 1.2 m x 1 m x .8 m on a volume capacity of 1 cu m. Normally, the wood is burned for 1 day or 24 hours and will yield 77 kilos of charcoal per cu m for local ipil-ipil (3 to 5 years old trees).

Quality of Charcoal Produced from this Method:

Fixed Carbon Content	60-65%
Ash	8-10%
Volatile	15-20%
Moisture	10-15%

Based on actual charcoaling practices in Cebu, the following observations were made by one of our consultants (Forester, Mario F. San Luis)*

(1) The burning process to convert 1 cu m of ipil-ipil wood to charcoal takes 24 hours or 1 day and the cooling process takes another 36 hours or 1-1/2 days, a total of 2-1/2 days, provided the pit is covered with barrel-flattened steel sheet and sealed with soil on top to prevent further oxidation.

(2) The charcoal from big ipil-ipil tree trunks are sturdy and heavier in weight compared with other common tree species. The charcoal from branches and trunks of the young tree easily breaks into small charcoal chips.

(3) Ipil-ipil trees are often planted in private lands in Cebu as the main source of firewood and charcoal:

   a. **forty (40) ipil-ipil trees at 2 to 4 inches in diameter and 4 meters tall which are 4 to 5 years old will make 1 cu m of wood.**
   b. **these could be raised in one (1) hectare of actual count (10,000) trees that are grown in random.**
   c. **based on 40 trees/cu m, there could be gathered 270 cu m/hectare.**

(4) Charcoal from ipil-ipil costs more (by P2.00) compared with the charcoal from other woods with the same volume.

(5) Thirteen (13) cu m of ipil-ipil wood will make one (1) MT charcoal.

Average cost of ipil-ipil charcoal in Cebu is P1.00/kilo.

With Mabuhay Vinyl going into the production and charcoaling of wood, it is hoped that it would contribute to the reforestation efforts of the government as the production of wood would be on a sustained-yield basis, improve the quality of life of our people at the Barangay level thru employment and additional income in the planting of ipil-ipil trees for wood, animal fees, fertilizer and charcoaling.

Mabuhay Vinyl Corporation has made several charcoaling experiments (Pit

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***Other charcoaling methods used in the Philippines are found in Appendix A.**

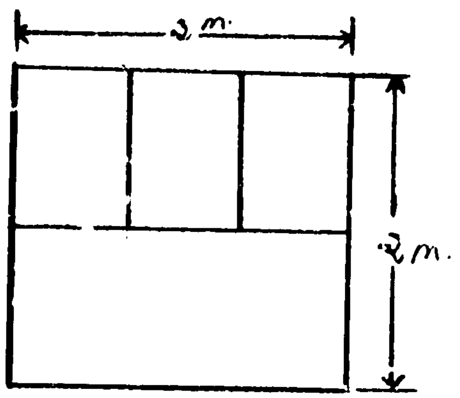
Method) using the giant ipil-ipil species. Initial results show that approximately 7 cu m of raw giant ipil-ipil wood makes 1 MT charcoal. With a specific gravity of 0.55 to 0.6, there is a charcoal recovery of 25 percent.

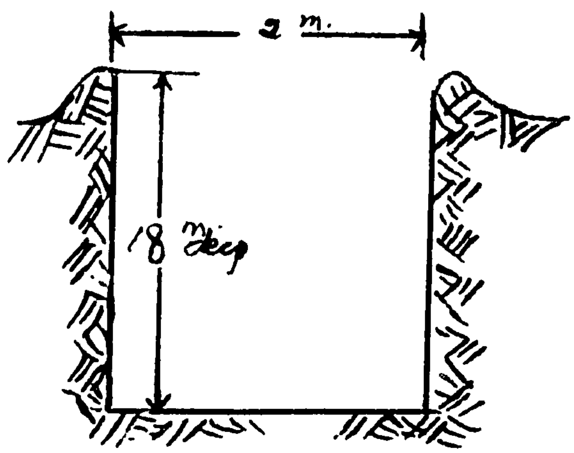
Analysis of charcoal from this experiment are:

Fixed Carbon Content	65-75%
Ash Content	5-8%
Volatile Matter	10-15%
Moisture Content	10-15%

Charcoaling Procedure

1. Pit Dimensions - 2m x 2m x 18m. Plattened sheets (from 55-gal. drums) are arranged as shown in the diagram below. (Drum covers joined by wires)





2. Charcoaling Process:

a. Spread dry firewood (1-1/2 inch diameter or smaller) on the pit's floor.

b. Spread burning ember on top of firewood.

c. Cover ember with layer of dry firewood.

d. Charge fresh wood into the pit for charcoaling; small diameter first, bigger diameter on top. For the pit described above, woods with a diameter as big as 10 inches can be charged fresh without previous drying.

e. Fill the pit with the charge so that the wood level is about 15 cm above ground level. Put flat drum covers and seal cover holes with sand or clay. However, the 15 cm gap between the cover and the ground is left open to observe the type of smoke coming out. Here, burning is regulated by closing the smoke gap to a smaller opening if burning becomes too fast.

f. "Second trip". After about 24 hours, the level of the charge shall have gone about 0.6 meter down. Put more fresh charge of wood. This is called "second trip" by the charcoalers.

g. After the "second trip", cover the pit again and leave the side gap open.

h. A "third trip" may be charged if desired.

i. When charring is completed, as indicated by the white smoke from the gap, close the smoke gap completely with sand and clay.

j. Allow 4-5 days to cool. Total cooling time is 7 days.

Charcoaling Cost

Pit Dimensions : (2m x 2m x 1.8m)
Capacity : 7 cu m wood or 1 MT charcoal/charge or 4 MT/month or 50 MT/year.

FIXED COST

	Price Per	No. of Pieces	Total Cost
Pit Holes	50	2	₱100
Bodega	150	1	150
Heavy Axe	35	1	35
Light Axe	25	1	25
Bolo	20	1	20
Spade	15	1	15
Basket for Hauling to Bodega	5	2	10
Flat Drums	25	24	600
Sub-Total			₱965
Labor:			
Cutting of wood, charcoaling, etc.	6	365	2,190
Sub-Total			2,190
Wood (ipil-ipil) (cu. m.)* (cu.m.)	20	700	14,000
		TOTAL COST	₱17,155
Cost/MT Charcoal:	₱171.55		

*Assumption Used: 7 cu m of ipil-ipil wood makes 2 MT charcoal.

APPENDIX A

Charcoal Production Methods Used in the Philippines

Methods of charcoaling commonly practised in the Philippines are: (1) pit method; (2) drum method and (3) kiln method. The (4) retort method in which the wood slabs are loaded in buggies and heated inside the very large air-tight containers by external fires is not practised in the Philippines.

1. *Pit Method*

Principle of Charcoaling. Wood must be heated to drive away the moisture and volatile so that the remaining part will be charcoaled. The easiest way is to burn some wood so that the remaining part of the charge or the core of the burning wood will char into charcoal.

Burning must be controlled and made as slow as possible. If not well regulated and burning is hurried up, the wood will be burned and will turn to ash instead of charcoal. Thus, the field will be very low.

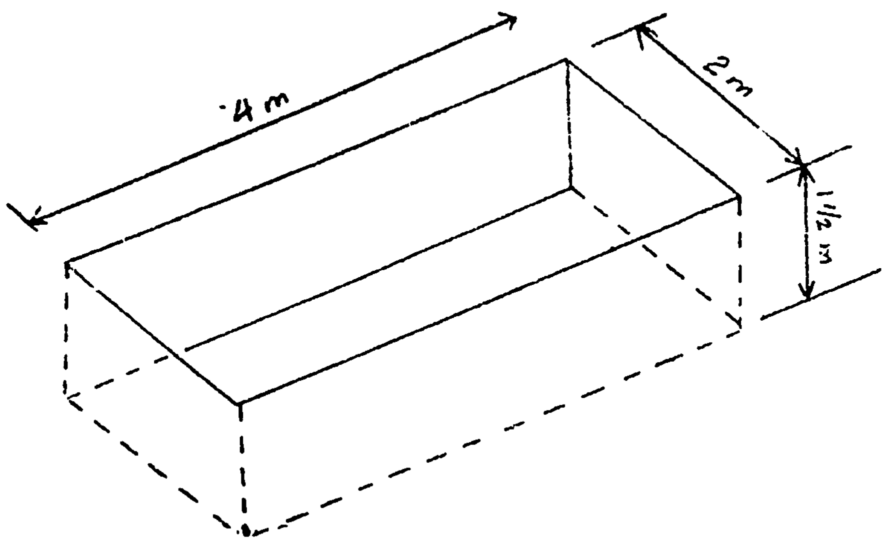
The best way to charcoal is therefore, to have a slow fire and have the smoke or burned gas circulate in the charge.

A system called "Reverse Draught" is most economical in wood and will give high charcoal yield. "Reverse Draught" system removes from the wood some of the volatiles to be burned thus assisting in the heating up of the other pieces in the charge.

"Reverse Draught" means that the air admitted into the system travels in the opposite direction of the smoke and burned the gases so that the unburned portion of wood is heated up.

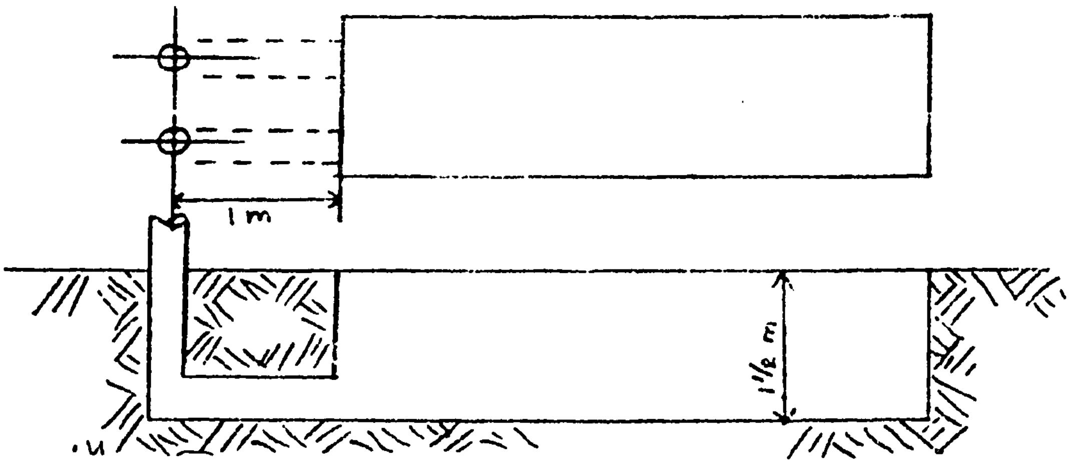
Pit Burning Using "Reverse Draught" System

a. Dig a pit measuring 4 meters long by 2 meters wide and 1-1/2 meters deep.

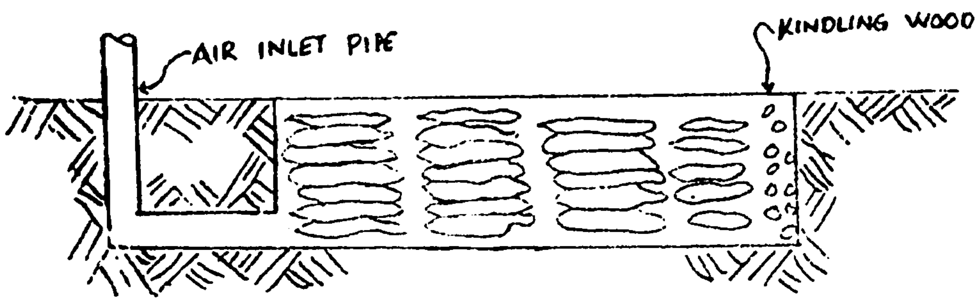


b. To prevent contamination with the earth's surface, line the pit with old galvanized iron sheets or scrap gasoline drum material.

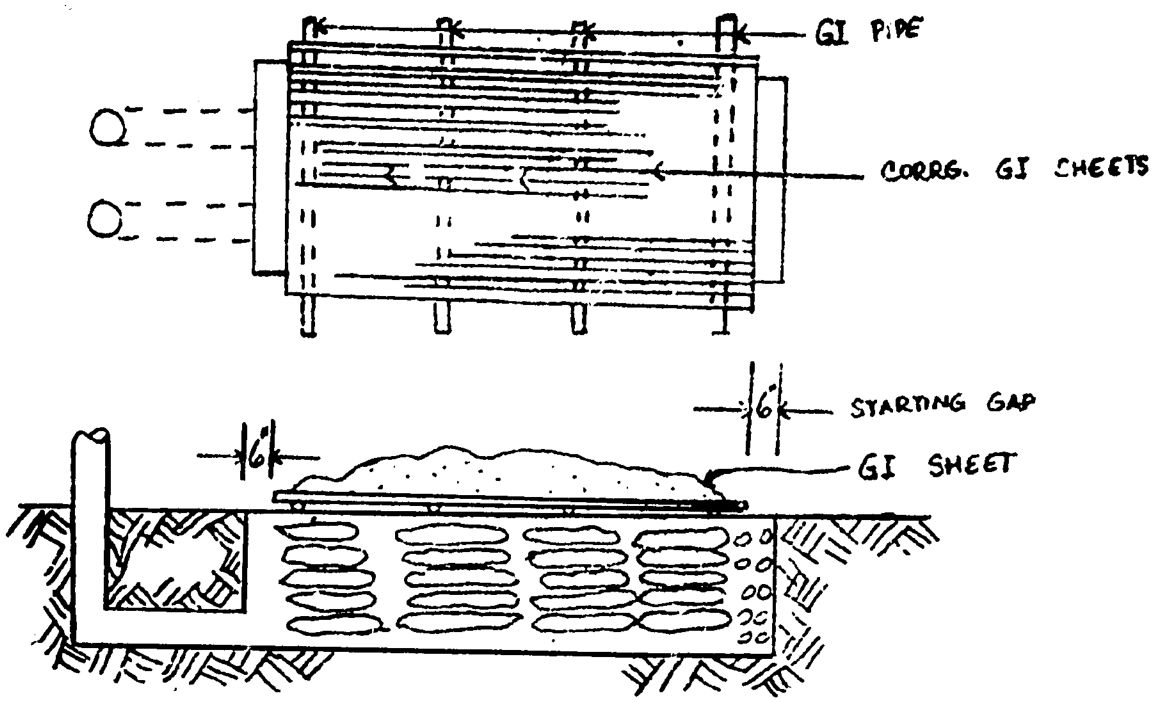
c. Make two air inlet pipes at 8 or 10 inches in diameter and install at one end of the pit. Inlet of air to the pit must be at the bottom of pit.



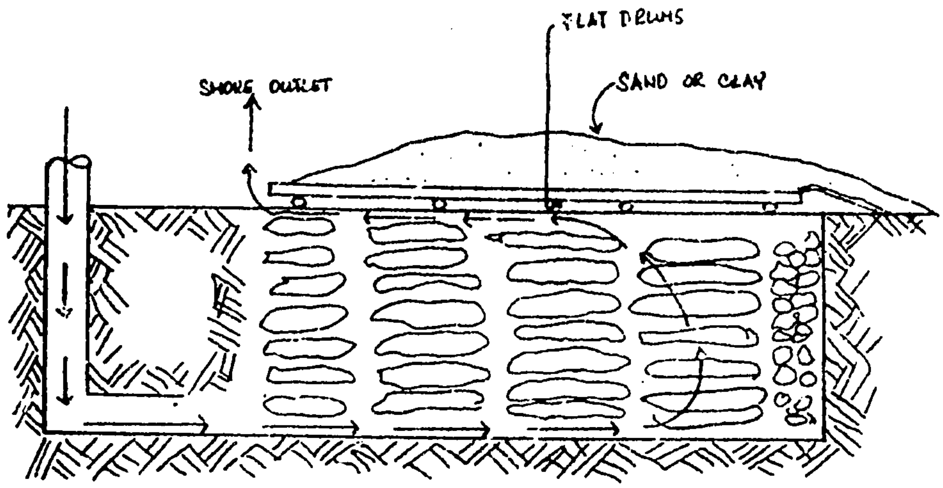
d. Only use logs of similar sizes about one meter long and use only one kind of species of wood. Remove the barks and be sure not to put partly decayed or rotten wood. Remember that barks and rotten woods will only cause uneven burning, and additional ash; thus, causing the delay of your operation. Lay a small amount of kindling wood to be used to start the fire at the opposite end of the air tubes. The wood is laid lengthwise along the kiln.



e. When the pit has been filled, place a few pieces of old galvanized iron pipes across the width which will support the corrugated galvanized iron roof. Cover the pit leaving a 6-inch (15 cm.) gap at both ends. Weigh down cover with either sand or clay.



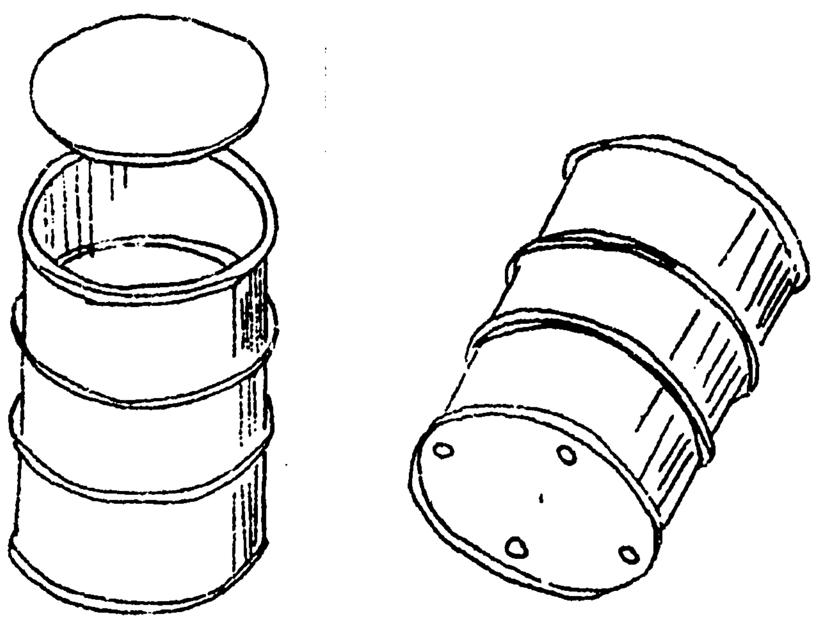
f. Light up the kindling and when the fire is well under way, cover the starting gap. Burning must be well regulated by closing the smoke gap to a smaller opening if burning will become fast. Experience will show in the color when the charge is completely charred. Then close the smoke gap completely as well as the air tubes. Pack all openings with clay or banana stalks and clay. Allow at least 24 hours to cool the charcoal.



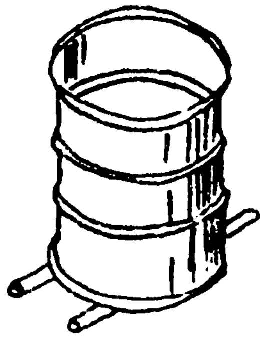
Yields. If this instructions are followed correctly, you will find that 5 tons of green wood will give one ton of charcoal. If dried wood is used and proper care is applied, 4 tons of 3-1/2 tons of wood will give one ton of charcoal. This is regardless of the species of wood.

2. *Drum Method*

a. Cut out the top of an old 55-gallon gasoline or oil drum. Save this top.
b. Punch at the bottom with a chisel, four holes equi-distant from one another. The holes should be about one inch in diameter.



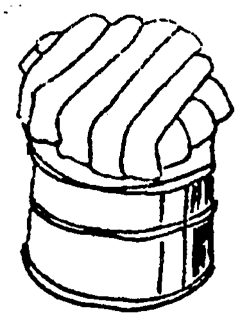
c. Place two pipes on the ground where the drum is to rest. This will allow air to enter into four holes at the bottom.

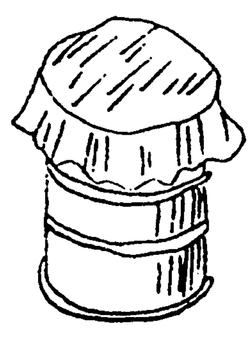


d. Burn a shovel-full of shells on the cover of the drum and when the shells are burning fiercely, throw them into the drum.

e. Throw in more fresh shells until the open flames are put out but not too much so as not to put out the fire. You will notice a good amount of white smoke coming up. The shells must be free from dirt and the husk pieces sticking must be removed. A good size of the shell is a "Quarter" size, that is, a half shell broken further in two pieces. You will then notice a shrinkage and even if you fill up the top with shells, it will come down after sometime. Continue feeding the top with shells but make sure you don't allow the open flames to burn fiercely. If burning continues to be fierce, remove the two pipes and patch around the drums with clay to restrict the entrance of air.

f. When the burning reaches the top, cover it with banana stalks or with a wet sack. Place the drum's cover and pack it down with sand or mud. Take good care for the sand or mud not to get into the charcoal.

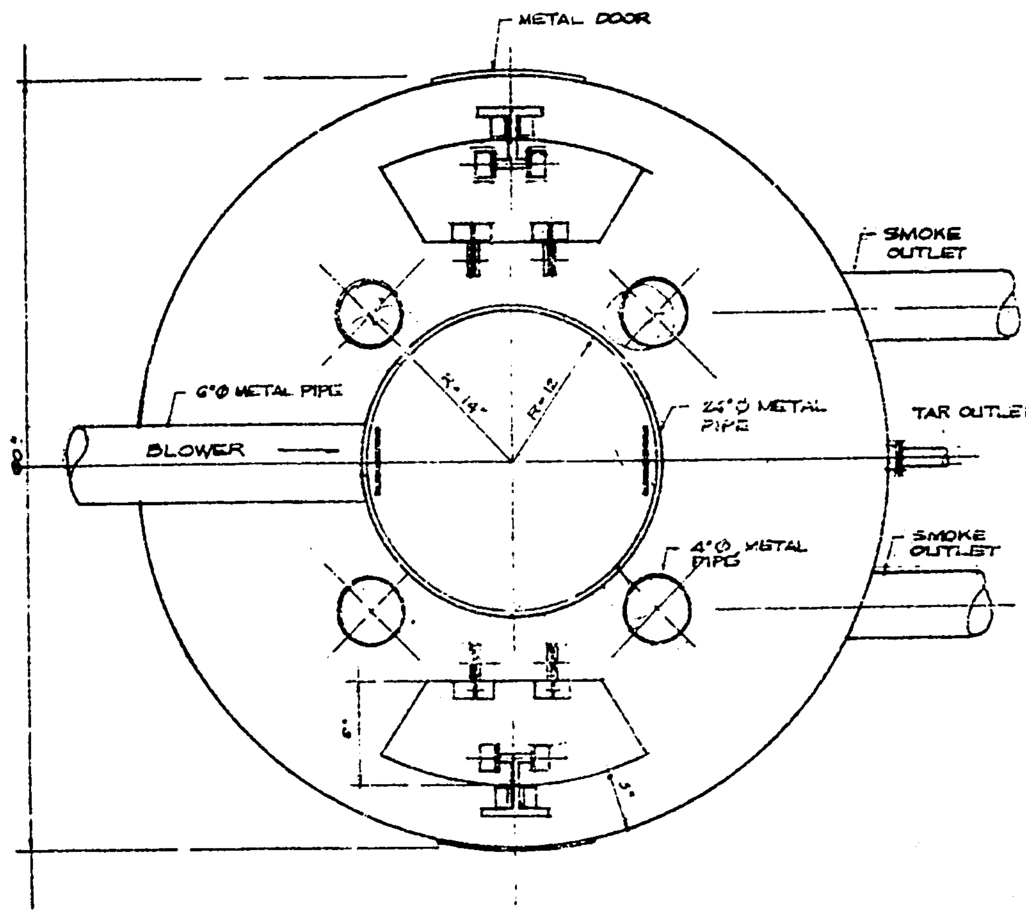




g. Leave this to cool overnight. It will take about 4 hours to burn and fill up the drum. This is done so slowly that a small boy can take care of attending 2 to 3 drums while an adult can attend to filling up ten drums. The rest of the day and night is used for cooling, so that one drum can make one burn a day. Remember, the drums could be old discarded oil drums but they must have no holes or paper thin walls, otherwise burning will not be controlled and you will waste shells. One drum when properly attended to will yield anywhere from 75 to 90 kilos.

3. *Kiln Method*

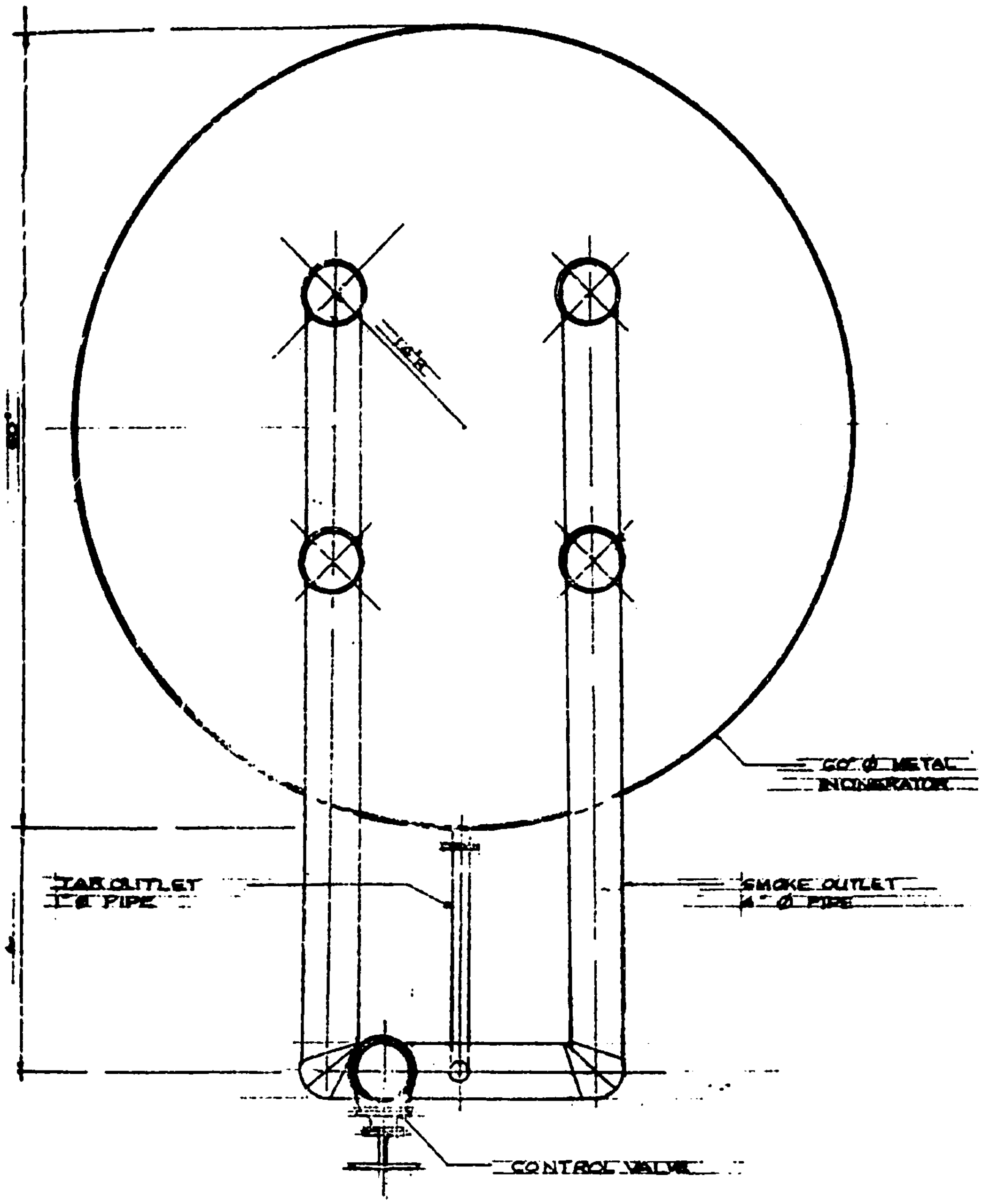
This involves the use of concrete masonry or iron kilns which are more expensive than the pit and drum methods in terms of initial investments. These kilns are designed for higher yields of better quality charcoal. To the kiln type belong the Philcoa-type kiln and the Iligan-type vertical kiln. An Iligan-type vertical kiln costs about P20,000 and delivers five metric tons of coco charcoal a day. The Philcoa-type kiln operates on a 3-day cycle, producing 1.25 metric tons per cycle. Kiln's cost is P5,000.00



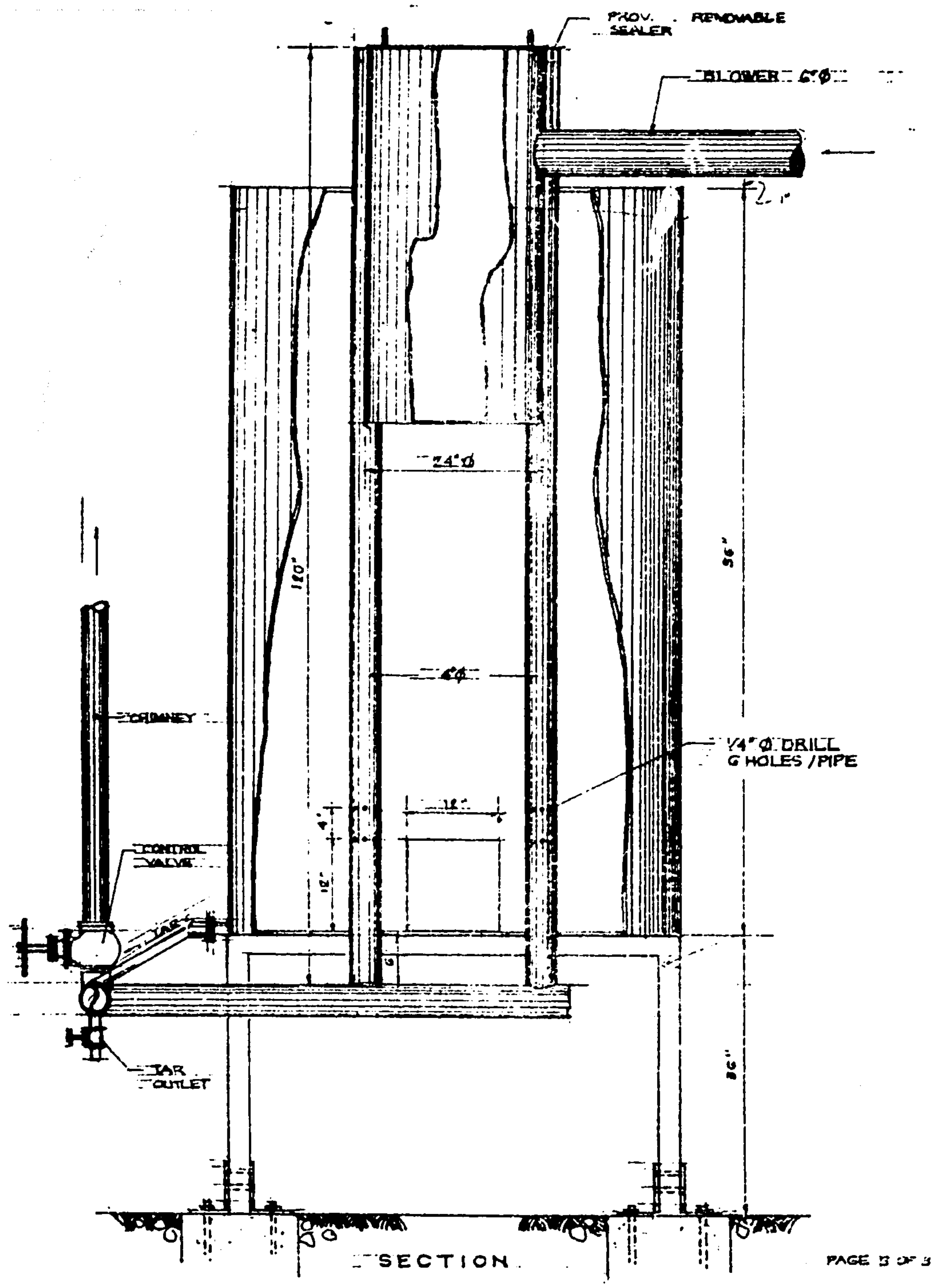
TOP VIEW

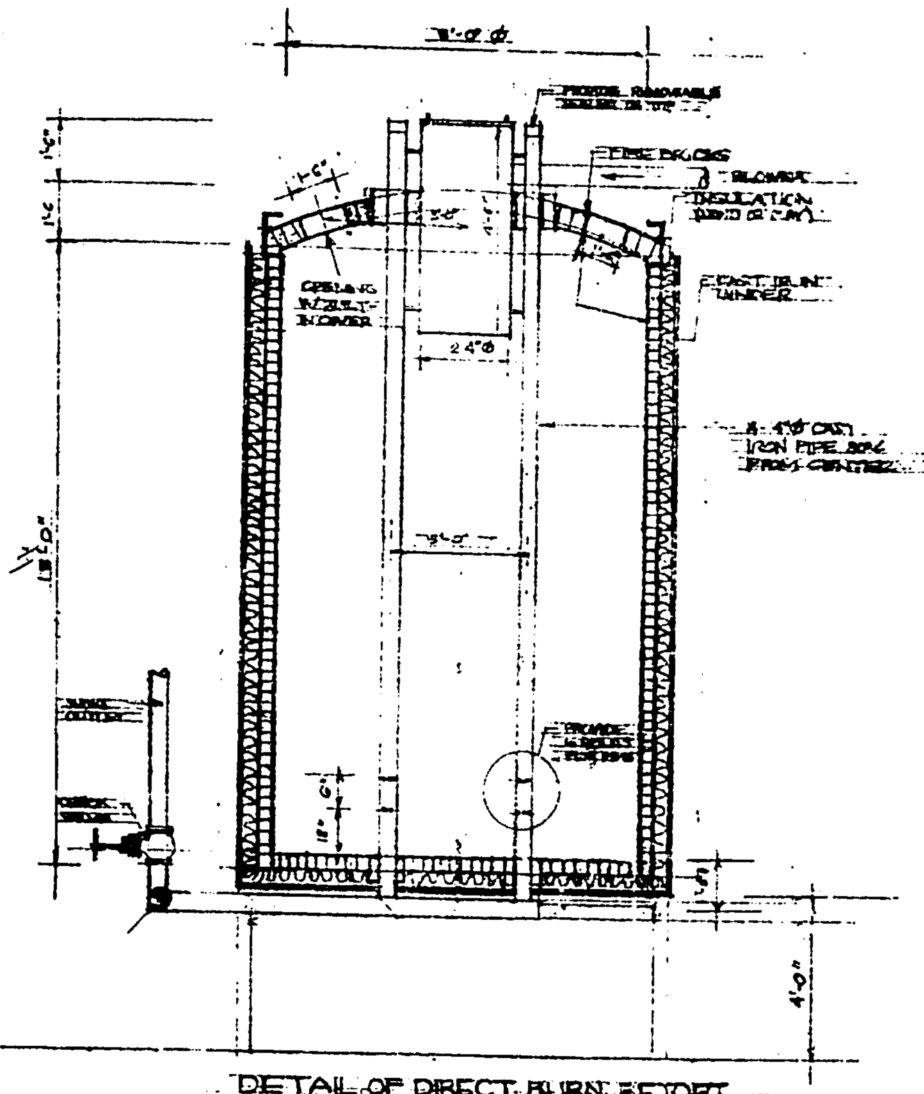
DIRECT BURN RETORT

PAGE 1 OF 3



SECTION OF BOTTOM
CONNECTION


PROV. REMOVABLE SEALER
BLOWER 6"Ø
24"Ø
4"Ø
120"
56"
36"
1/4" Ø DRILL
6 HOLES /PIPE
CHIMNEY
CONTROL VALVE
TAR OUTLET
12"
SECTION
PAGE 3 OF 3



DETAIL OF DIRECT BURN RETORT
CHARCOAL FURNACE (UNIVERSITY OF THE PHILIPPINES)

GIANT IPIL-IPIL: THE SUPER MARVELOUS MIRACLE TREE

Hugh Curran, Jr.
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Manila, Philippines

Hawaii, the Island Paradise of the Pacific, has recently surprised the world with information on new varieties of the Marvelous Miracle Tree - Ipil-ipil (Leucaena glauca now Leucaena leucucephala). This information is to the effect that ordinary ipil-ipil, inspite of many superlative qualities is but a poor cousin of a series of varieties from various parts of Central and South America, notably El Salvador. These varieties, which we shall call **giant ipil-ipil**, are reported to be at least twice as productive as the local Philippine and Hawaiian strains. Now, instead of Marvelous Tree, we have a Super-Marvelous Miracle Tree with Nine Fields for Future Fame and Fortune. These are as follows:

1. Fertilizer

If the seeds of giant ipil-ipil are thickly drilled in rows one meter apart, they may grow, in four months, a field of emerald green vegetation one to one and one-half meters high that can be harvested every two months. This field may produce up to 120 tons of green manure material per hectare per year for five years or more. Annual production may then decline and, at a certain point, replanting should take place. These 120 tons may contain up to:

1,000 kg. of Nitrogen
200 kg. of Phosphoric Acid
800 kg. of Potash

This in turn is equal to roughly:

100 sacks (50 kg.) of Ammonium Sulphate
20 sacks (50 kg.) of Super-phosphate
24 sacks (50 kg.) of Muriate of Potash

which should have a present (September 1976) market value of:

		Food Crop	Export Crop	
100 sacks Ammonium Sulphate	@P48.00	P4,800.00	@ 86.00	P 8,600.00
20 sacks Superphosphate	@ 65.00	1,300.00	@65.00	1,300.00
24 sacks Muriate spotash	@ 65.00	1,560.00	@ 65.00	1,560.00
Total		P7,660.00		P10,460.00

After cutting, the young stems and leaves can be made into compost for use in truck gardens. If the **giant ipil-ipil** is grown in five-meter strips alternating with twenty or more meter-wide strips of cultivated land, the cuttings can be spread over this cultivated land and plowed or harrowed in. Alternatively, they can be spread as a mulch on growing crops and allowed to decompose gradually on the surface, with the plant foods contained therein to be washed into the soil.

It should take only one and one-half persondays to manually cut and spread one ton of **giant ipil-ipil** leaves and stems over an adjacent narrow strip of land. With labor at ten pesos per day, this would mean fertilizer in organic form at one-fourth to one-sixth the cost of the commercial product. (120 tons at P15.00 equals P1,800.00. Fertilizer value is P7,660.00 to P10,460.00. Mechanized operations could greatly reduce this cost.)

2. Forage

If **giant ipil-ipil** seed is sown in rows one meter apart as for green manure production, it can be cut back every two months and can be fed to ruminants such as cattle, carabao, goats, etc. With 120 tons of such forage, containing more than an adequate amount of protein, 10 heads of young cattle or carabao can be fed per hectare per year. These animals might gain one-half kilo per day to produce 1800 kg of meat. At P3.00 to P5.00 per kilo of live weight, we would have P5,400 to P9,000 of meat production per hectare per year.

3. Feed

The young stem and leaves of **giant ipil-ipil** can be dried and pulverized into leaf and stem meal. 18 to 20 percent is possible with high carotene content as well. It compares favorably with temperate zone Alfalfa. 120 tons of green forage should produce at least 20 tons of dehydrated material worth P400.00 to P500.00 per ton or: P12,000 to P15,000/hectare per year.

4. Food

If the giant ipil-ipil is allowed to grow for four years at a density of 5,000 trees per hectare, some 160 cubic meters of wood may be produced. This could be 100 tons dry weight of 25 tons per hectare per year.

Treatment of the wood with dilute sulphoric acid after chipping in a wood hydrolysis plant could produce up to 50 percent by weight of sugars of which 30 percent might be glucose. This would mean 7.5 tons per hectare per year worth, P22,500.00 (P3.00/kg) at September, 1976 price.

All of the sugar can be fermented to produce Torula yeast, a 50 percent protein product fit for animal and human consumption. 20 percent of the dry weight of the wood could be so recovered or 5 tons of torula yeast per hectare per year. If it could be sold at the September, **1976** price of soybean meal (P2.50 per kg.), we would have a gross annual income of P14,000.

5. Firebreaks

Planted in wide strips (10-20 meters) thru grasslands, the **giant ipil-ipil** makes a dense stand with almost undergrowth. This stand would act as a firebreak and would permit controlled burning of pastures.

6. Fencing

Planted at one to two meter spacings, **giant ipil-ipil** makes excellent live fence posts. Strips of bamboo which have been given a wood preservative treatment could be woven into these posts to make an attractive permanent fence. Banana props and stakes for climbing crops could easily be produced at spacing of one by one meter.

7. Fuel

Giant Ipil-ipil, being a high density wood (sp. gr. 0.55 to 0.7), makes excellent firewood and charcoal. Four-year rotations should produce 160 cubic meters or 40 cu m per hectare per year. These 40 cu m should be worth P40.00 per unit at roadside or P1,600.00 per hectare per year. Seven tons of charcoal from the same wood could be worth P2,100 to P4,200 (P300.00 to P600.00 per ton).

Most interesting is the fact that the wood can be hydrolized to sugar and sugar fermented to alcohol which can be used alone or blended with gasoline to run internal combustion engines. (either diesel or gasoline). Some 160 liters could be produced from every ton of dry wood. A twenty-five ton per hectare per year yield would then mean 4,000 liters which is worth P4,000 at P1.00 per liter. Present price (1976) of Ethyl alcohol is P1.75/liter or P7,000.00 for 4,000 liters.

The wood can also be dried in the form of small blocks and be fed to a wood gas generator. The gas so produced is used to run diesel and gasoline engines. Charcoal is a slightly better but more expensive fuel for the same wood gas generator.

Both wood gas and alcohol would reduce the horsepower rating of a motor by 25 to 40 percent, so that larger engines would have to be used to give the same energy output.

8. Fibre

Giant ipil-ipil wood can be converted into paper pulp and hardboard. A 75-ton per hectare per year yield of wood means 12 tons of chemical pulp worth P15,000 or 20 tons of hardboard worth P14,000.

9. Film

Polyvinyl plastic film is made from acetylene which in turn comes from calcium carbide, which is made by reacting charcoal with lime in an electric furnace. Also, alcohol made by fermenting wood sugar can be dehydrolized to produce ethylene gas which is polymerized to make polythylene film. Both films have an immense market and good profit potentials.

Here's to a Super-Dendro-Chemical industry based on that Super-Marvelous Miracle Tree, the Giant Ipil-ipil.

ORGANIC FERTILIZER UNLIMITED

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Throughout the humid tropics, where continuous cropping of the arable lands has depleted the plant food and organic matter reserves of the soil, the desirability of restoring or increasing the fertility of these areas by the addition of organic and inorganic fertilizers has long been recognized. Unfortunately, the high costs of the materials needed have in many cases made it uneconomic to do so, with the result that far too many regions of the tropics are suffering today from poor productivity due to low levels of both plant nutrients and humus.

It has long been known that the growing of a leguminous crop in rotation with other non-leguminous crops would materially improve the yields. Furthermore, it has been recommended in many areas that a legume be grown periodically and turned under at flowering, for the sole purpose of adding to the nitrogen and organic matter reserves of the soil. These practices have been followed with excellent results in many areas, but are seldom sufficient to give maximum fertility to the soils under management.

As a whole, legumes are the best source of easily decomposable vegetable matter. This is due to their high nitrogen content, which often amounts from one-half to one percent of their green weight. This in turn means a relatively narrow carbon-nitrogen ratio, enabling the soil bacteria and fungi to quickly convert from raw plant remains to soil humus which is further broken down to release nutrients for a growing crop. It should be remembered here that the nitrogen in most legumes is obtained to a large extent thru the activity of their associated symbiotic nitrogen fixing bacteria which obtain this element from the air. In other words, the legumes are a living factory for the production of this most expensive plant foods. In many cases they may be the cheapest source of this essential plant nutrient.

Besides nitrogen, the legumes also contain large amounts of potash and calcium, varying amounts of phosphorus, as well as the minor elements. Most important is the fact that these plant nutrients are in organic form. In tropical areas with high rainfall, this is especially desirable as the elements are in a state highly resistant to leaching, but are released thru decomposition at a rate fast enough to adequately feed most commercial crops. In the case of phosphates, which in many tropical soils are quickly fixed in a relatively unavailable form, an organic source would be particularly valuable, as it is assumed that the growing plants would be able to assimulate organic phosphates before fixation had taken place thru mineralization.

Obviously, due to its associated nitrogen fixing bacteria, your legume is an excellent source of additional nitrogen for lands deficient in this element. For maximum efficiency, they would require adequate levels of potassium, calcium, phosphorus, etc., which would have to be supplied thru the soil itself or from commercial sources. Theoretically, the growing of a number of leguminous crops in succession and turning them under the right time should build up your nitrogen level to a high point. However, in practice this is never achieved, as each succeeding crop gets more of its nitrogen from supplies released in the soil by the decay of the preceeding crop. In other words, a fairly tight nitrogen cycle eventually develops which does not require very much nitrogen fixation by the associated bacteria found on the legumes.

To obtain the maximum utilization of the nitrogen fixing powers of the legume's symbiotic bacteria, another system of green manuring is indicated. This may well be called the "Transfer System" as distinguished from the conventional "Turn Under System" and would consist of growing a legume on one place of land and then transferring it to another on which the usual crop is to be grown. Such a system would be equivalent to fertilizing with a complete organic fertilizer, properly balanced, since besides nitrogen, the legume would carry all the other elements necessary for plant growths. Except for phosphates, your legume which is harvested at the right age would contain as much nitrogen and potash as ordinary barnyard manure and to a large measure could replace much, as well as large amounts of the usual inorganic commercial fertilizers, in a fertility maintenance program.

At the present time this system in many cases may be practical as well as economical in many parts of the tropics, since the advent of such machines as the field forage harvester and bulk transportation equipment which make harvesting and transfer relatively inexpensive, have reduced costs for operating such a system to a point where it will produce plant foods in many areas at a lower price per unit and then would have to be paid for inorganic carriers of the same elements. Furthermore, as has been stated previously, in areas of high rainfall and continuous warm temperatures where leading is severe and the breakdown of organic matter is rapid, the application of fertilizers in an organic state is much preferred, as the plant foods are liberated relatively slowly over the whole growing period of the crop. With commercial inorganic fertilizers, the nutrient elements are present in a water soluble and therefore reaching form in relatively high concentrations just after application. This condition would mean that much of the plant food might be lost before the crop could utilize it, as application in most cases is at sowing or when the crop is very young and therefore unable to use all of the added nutrients immediately. This would subject such plant foods to leaching or in the case of phosphates, fixation, so that a large part might not be available for the crop at its later stages of growth. Furthermore, there would be little or no danger of an unbalanced fertilization or of the plant gorging itself with too much of a certain element in case an organic source of plant food was used.

It is visualized that the strip adaptation of the "Transfer" green manure system will have great possibilities in vast areas of the tropics. Nitrogen, which is the chief limiting factor in plant growth in many regions, would be produced locally at a cost at least comparable with the commercial inorganic sources of this element. Organic matter, of tremendous value in the humid tropics, will be maintained at a high level so that the soil would have good structure, favorable tilth, excellent water and plant food holding capacities. These would be maintained at high micro and macro-biological fauna and flora which is hoped to be mainly beneficial. Continuous high yields should result; thus, though only one-third to one-half of the area might have to be kept in a green manure, this would still be economically advantageous if yields were double or more than that of the unmanured land. Where the green manure was a cut and come again perennial, of which there are a good number in the tropics, such strips would be most useful in reducing erosion and runoff. They might also serve as windbreak. This could be accomplished by allowing part of a strip or certain of the strips to grow to relatively large height and size. Later, if the windbreak is desired to be harvested and the conventional field forage harvester is unable to do so, there now exists a portable wood chipper that can handle the stems up to four inches in diameter and which could be used to convert the overmature green manure crop into a material that could be used as mulch or that could be plowed in to increase the organic matter of the soil. Such woody material would supply a longer lasting humus, that the highly callulosis stems and leaves of the immature legume, as its content of lignin would make it much more resistant to decomposition.

All in all the possibilities of the "Transfer" green manure system are fascinating and an intensive experimental program is indicated. Supplemental fertilization with commercial inorganic carriers of plant foods will no doubt be found desirable in many cases, but this can only be determined by a scientific research program.

Two recent publications of the University of Hawaii Agricultural Experiment Station have thrown some interesting light on the economic possibilities of producing low cost green manures! While these bulletins are concerned with the production and harvesting of forage crops, the information contained can easily be applied to a green manure crop. Particularly interesting are the reported annual yield of the two cut and come again forage legumes and the costs of harvesting the same. These legumes are Leucaena glauca and Desmanthus virgatus, which will produce over 20 tons of green forage per acre per year. This 20 tons will contain almost 400 pounds of nitrogen and can be harvested with a field forage harvester from one dollar to one and one-half dollars per ton. This cost of harvesting includes depreciation of equipment, fuel and oil, interest on investment and labor. Using the higher figure, we have thirty dollars as the cost of harvesting and chopping a green manure crop containing 400 pounds of nitrogen or seven and one-half cents per pound of the element. This compares with approximately seventeen and one-half cents per pound of nitrogen bought as Ammonium Sulphate at this time (1952). Of course in an area like Hawaii where land is scarce, rental values are very high and it would hardly be practical to devote any area to green manure production, as your other costs would bring the price per unit of nitrogen much higher than would have to be paid for the same element in an ordinary inorganic commercial fertilizer. However, even in Hawaii there may be certain conditions which would definitely make it worthwhile to use a green manure carrier of nitrogen, such as where it is desired to build up the organic matter of the soil as well as the nitrogen content.

As a further example of the economic possibilities of the "Transfer" system of green manuring, let us take the conditions that exist at present (1952) in the Philippine Islands. We have high prices for agricultural crops, high costs for fertilizer and decreasing production thru exploitative utilization of the soil resources of the country. With increasing population, it is becoming more and more important to restore the fertility of worn out soils, check erosion and maintain all arable lands at the highest possible production level. In the Philippines, the same green manure crops can be grown as in Hawaii and information gleaned from experimental work there can be applied to local conditions to a large extent. While costs of harvesting will naturally be greater due to more expensive equipment and fuel, the value of commercial fertilizers is also correspondingly greater so that the comparative cost will still be in favor of the nitrogen from the green manure crops. It is believed that five pesos per ton will be a fair figure for harvesting with a field forage harvester in the Philippines. Assuming a production per unit area of green manure crop which is equal to that of Hawaii, we would have 50 tons per hectare containing over 400 kilos of nitrogen. It would cost P250.00 to harvest this 400 kilos of green manure nitrogen or approximately sixty two and one-half centavos per kilo as compared with one peso and twenty centavos per kilo for nitrogen from Ammonium Sulphate at P240.00 per ton, the present price. Your pro-rated costs of establishing a cut and come again legume should not amount to more than P10.00 per year, while maintenance, mineral fertilization, land rental value, etc. should not amount to more than P140.00 per year or a total of P150.00 per annum per hectare. Adding this to the P250.00 per hectare cost of harvest, you will have P400.00 as the cost of the 400 kilos of nitrogen at P1.00 per kilo as compared to the P1.20 for the Ammonium Sulphate derived element. Add to this the value of the organic matter and other plant nutrients and you have a picture heavily weighed in favor of the "transfer" system of green manuring. When the supply of commercial nitrogen is insufficient or unobtainable, there is still further reason to fully investigate the possibilities of green manure sources of nitrogen. In the Philippines, a well organized program of research in this field should be a must.

2

WORKSHOP SESSION SUMMARY REPORT

VARIETAL INTRODUCTION, HYBRIDIZATION, SELECTION AND SEED PRODUCTION TECHNOLOGY

TASK FORCE GROUP NO. 1

Task Force Leader:	Dr. James L. Brewbaker
Task Force Members:	Dr. Mark Hutton
	Dr. Emil Q. Javier
	Dr. Guillermo Sanchez
	Dr. Noel Vietmeyer
	Dr. Neptale Zabala
Guests/Observers:	Mr. Watler Firestone
	Mr. Arthur Garcia
	Dr. E.V. Araullo
	Dr. Ireneo L. Domingo
Rapporteur:	Mr. Ernesto S. Guiang

I. DESCRIPTION OF SPECIES AND VARIETIES

Leucaena is a leguminous tree of many food, feed and fiber uses that is adapted widely throughout the tropics. It originated in Central America and was spread by the Maya & Zapotec civilizations through lowland Mexico. The state of Oaxaba, Mexico owes its name to Leucaena ("Oaxaca- the home of hauxin (leucaena"). Its original use was probably for food, the young pods and seeds being eaten. Later, it came to be used as food for domesticated animals.

With the advent in 1581 of the Spanish galleon trade to the Philippines from the West Coast of Mexico, leucaena crossed the Pacific and became a respected and widely naturalized animal-browse legume of Southeast Asia. In the 19th century, it became a favored shade tree for plantations of coffee, cacao, quinine, and rubber. It was later recognized to be more important as a source of nitrogen than as shade in these plantations. Regular pruning of the branches in plantations became a common practice, providing the equivalent of one metric ton of ammonium sulfate per hectares annually (Dijkman, 1950).

Leucaena was also used as source of wood for charcoal (Philippines); its leaves served as vegetable (Malaysia, Indonesia) and its seeds as food or ornaments. Naturalized stands of leucaena in the dry tropics became of importance for preventing erosion and restoring or stabilizing soils. The common variety, however, over-populated in native stands, leading to solid thickets that generally shut out other species and were unsightly.

Leucaena is the species *Leucaena leucocephala* (Lam) de Wit. It belongs to a Mexican genus of the family Mimosaoceae. This legume family is marked by its woodiness, its round heads of flowers, its finely divided leaves and flattened pods. Among the 20 genera of the family, the most widespread are Acacia, Albizzia, Calliandra, Entada, Enterolobium, Inga, Leucaena, Mimosa, Parkia, Piptadenia, Pitheoellobium and Prosopis. The chromosome numbers of Mimosaceae have a common base number of 13, distinguishing them from most Leguminosae and Caesalpinaceae, other groups of nitrogen fixing leguminous plants. The Mimosaceae family has attracted little research by agriculturist or botanist, although many species are used for lumber, shade and representation.

The genus includes 51 reported species, of which only ten are of unquestioned validity (Table 1). Details of the taxonomy remain to be clarified. Seven of these species apparently originated in Mexico. Although data are limited, it appears that most of these species can be intercrossed (González, Brewbaker and Hamill, 1967).

The species *L. diversifolia, L. pulverulenta, L. esculenta* and *L. leucocephala* can grow to tall trees, exceeding 15 m, and are of some use for shade and browse in Latin America and the Caribbean islands. The remaining species are low shrubs generally under 5 m in height. Leaflet size varies greatly in Leucaena from the extremely small leaflets of *L. pulverulenta* to massive leaflets of *L. macrophylla* (Table 1), and they range widely in habitat throughout the American continents.

All leucaenas are non-thorny, high in leaf protein, and generally attractive as seedlings to grazing animals. Many are indanger of extinction.

Leucaena is the best known species of the genus *L. leucocephala* (Lam.) *de Wit*, formerly known as *L. glauca* or *L. latisiliqua*. "Guaje" and "huaxin" are common names in Latin America for this species. Many other common names are used around the world, including ipil-ipil (Philippines), koa hoale (Hawaii), tang-a-tang, leedtree, white popinac. As a common name, "leucaena" is preferred internationally.

Leucaena leucocephala originated in the midlands of southern Mexico, Guatemala and El Salvador. In this region, the native leucaena is often a tall tree, to 20 m in height, and has been called the "Salvador type." Lowland Maya and Zapotec Indians grew and utilized leucaena, which is widely established in the Yucatan peninsula and Oaxaca. The major strain of leucaena surviving in these areas is a rapidly – flowering, highly seedly shrub that has come to be called the "Hawaiian type." The plant reproduces with a minimal amount of annual rainfall, down to 40 cm in Hawaii, where it covers Honolulus landmark, Diamon Head. It is probable that this strain was favored by Maya and Oaxacan people as a source of young pods and seeds that are eaten and made into dried food supplements in Mexico today. The arboreal forms of *Leucaena*, which may have been the earliest evolved, were left behind by man in the native forests of Central American midlands and remained unexploited until the 1960's.

The giant leucaenas were discovered in Central America in 1910 and given the name "*Leucaena salvadorensis*." They are now known to be arboreal forms of *Leucaena leucocephala*, the "Salvador type." The giant leucaenas are distinguished from common types by much larger stems, to a diameter of 25 cm in 5 years, and by larger leaves, pods and seeds (Figures 5). They mature in 6 years to about 18 m, twice the height of the "Hawaiian type" (Figure 5). One of the outstanding giants is the K8 strain from Hawaii, obtained by the U.S. Department of Agriculture in 1959 as "*L. esculenta*" from Guerrero state, apparently from the Zacatecas ejido. K8 is one among several "giant" types that have looked particularly attractive both for forage and fuel production in Hawaii, others being K28, and K67 (Brewbaker 1975, Brewbaker et al 1972). Another series of strains selected in Australia have the large leaflets, pods and seeds, but branch out at a lower height (Hutton and Gray, 1959). They have been referred to as "Peruvian," and are favored for pasture and forage purposes.

Table 1. The 10 major species of the genus Leucaena.

Species	Locale First Reported	Tree Height	Leaflet Length	Pod Length
		—m.—	—mm.—	—cm.—
L.. leucocephala (Lam.) de Wit	1783 C. America	5-20	10	15-20
L. diversifolia (Schelecht) Benth	1842 Vera Cruz	10	5	10
L. pulverulenta (Schelecht) Benth	1842 Vera Cruz	15	5	15
L. trichodes Benth	1842 S. America	10	10	15
L. macrophylla Benth	1844 Guerrero	5	60	20
L. retusa Benth	1852 Texas	5	20	25
L. esculenta (Mcc. & Sesse) Benth	1875 Mexico	15	5	25
L. lanceolata Watson	1886 Chihuahua	5	20	15
L. shannoni Donn. Smith	1914 Salvador	10	20	15
collinsii Britton & Rose	1928 Chiapas	5	10	15

II. BREEDING AND IMPROVEMENT

Selection, breeding and improvement work is in progress in several centers in the world including University of Hawaii, CSIRO Division of Tropical Crops and Pastures Australia. Work on varietal evaluation is also being done at the University of the Philippines at Los Banos, in Mexico and Altamarino, MARDI in Malaysia etc. As a result of the selection and breeding work which has been done, several new varieties have been released for commercial use in recent years such as K 8, K 28, K 67 and K 340 from the University of Hawaii and CV Peru by CSIRO. More recently a new variety, Cunningham, has been bred by CSIRO.

Leucaena leucocephala is generally adapted to summer rainfall regimes of as low as about 500 mm up to 2500 mm or more. In equatorial regions, it grows well up to about 800 m above which its growth is restricted by low temperature. Between the tropics of Capricorn and Cancer, it grows best at the lower altitudes. It thrives on soils close to neutral on reaction and also alkaline soils with pH up to 8.5.

It is not well adapted to acid soils. Selection and breeding for tolerance to low pH and associated factors including high Al and Mn, low Ca, and high H on concentration needs to be a major breeding objective if its use is to be encouraged on the extensive areas of acid tropical soils including latosols. In conjunction with such programmes, it would be necessary to correct the mineral deficiencies often associated with acid tropical soils, the most important of which are P.S., Ca, Mo. and Zn. However, there is the opportunity of selecting for better uptake of some of these minerals. Normally, *L. leucocephala* does best on well drained soils but it would be an advantage to select for tolerance to seasonal water logged conditions which are common in the tropics. Salt tolerance would also be advantageous under some conditions such as on coastal areas.

L. leucocephala is noted for its drought tolerance but selection for this character could increase its use in drier marginal areas. Its growth is often restricted when it is grown at higher altitudes and with its increasing use for re-afforestation at higher elevation. There is a distinct need to select or breed varieties with cold tolerance. This may involve hybridization with other Leucaena species such as *L. pulverulenta* and *L. diversifolia* which grow at high altitudes. Shade tolerance would also be an advantage especially in varieties selected for re-afforestation.

L. leucocephala varieties can be classified into:

(1) that bushy varieties which are early flowering and low yielding eg. common types in Hawaii and the Pacific region

2) Tall, late, erect varieties with high yield and restricted basal branching, eg Guatemala and K 8 and K 28

3) Tall and late, with strong basal branching and high EDM yields, eg. Peace

The erect habit was dominant over bushy habit and the absence of strong basal branching was dominant over its presence. Thus, it is possible to select and breed varieties for high wood yields on one hand and for high levels of EDM on the other hand.

The bushy non-photo-periodic, early maturing and heavy seeding types are valuable for forage and afforestation in difficult situation such as poor thin soils and story hillsides. For timber production, selection of taller growing types with restricted branching and seed production need to be selected for a range of soils and climates. This could involve selection for photo-sensitivity. In addition for specific purposes like paper pulp manufacture, reported varietal differences give scope for selecting and breeding better processing types with high holocellulose and low alcohol-benzene solubles and silica.

For pasture and forage, selection of types with high EDM is needed. Research has shown that EDM yield can be increased by breeding varieties which retain multi-branched habit but which have greater wood production. The capacity to produce high EDM yields is also valuable for leaf-meal and green manuring. Leaf meal could be a valuable source of food for fish in the rapidly developing aquaculture systems.

Herbage quality in pasture species is a function of intake and digestibility but in *L. leucocephala* intake in cattle and other rumenants can be restricted by its high mimosine content which averages 4-5 percent in the material eaten. The reduced intake is usually manifested after prolonged feeding on a diet consisting mainly of *L. leucocephala.* Associated with the reduced intake are loss of weight, loss of tail and rump hairs and general illthrift, although conception is not usually affected. The mimosine breaks down in the rumen di-hydroxypyridine which interferes with thyroid activity. Most of L. leucocephala varieties that are tested up to the present have a high mimosine content, so to breed low-mimosine types, it is necessary to intercross with other Leucaena species such as *L. pulverulenta.* Hybrids with L. pulverulenta have produced segregates with low mimosine levels. Feeding experiments with these low mimosine lines did not reduce intake in goats.

The effects of mimosine are more severe in monogastric animals like poultry, pigs and horse. In the Philippines, it has been found in feed formulations for these animals that the *L. leucocephala* leaf meal should not exceed 5 percent. In addition *L.*

leucocephala leaf meal is a prime source of carotene and also of pigment for intensifying the yellow color of egg yolk.

L. leucocephala varieties are deficient both in iodine and sodium and the lacks of iodine intensifies the effect of mimosine in rumenants because of the involvement of the thyroid glands. Lack of sodium can adversely affect animal production but is usually offset by the provision of salt licks.

The seedlings of *L. leucocephala* are establish slowly in the field and this is a disadvantage in large scale afforestation and pasture development. Pelleting with rhizobium, lime, phosphorous and molybdenum (where it is deficent) mitigates to a degree the problem of slow establishment. There is a need to understand better the factors affecting seedling establishment and to determine whether it is worthwhile to select for rapid seedling growth and/or nodulation.

There have been few reports of serious disease problems in *L. leucocephala.* Damping-off occurs in seed beds but can be controlled by soil sterilization and suitable fungicides. The giant types are more susceptible to attacks by pod and seed insects. This difference should be investigated as a basis for selection. Nematodes can be a problem on some soils and it may be necessary to seek sources of resistance.

III. SEED PRODUCTION AND HANDLING

A. Management For Seed Production

Siembra y densidad de siembra

La, densidad de siembra para la produccion de semillae de la variedad Peruana y K 8 es de 6-8 Kg de semilla, por Ha aproximadamente, con una separacion entre plantas de 1.0 m.

Es necessario mantener al cultivo, limpio de malas hierbas desde la siembra, con el fin de promover, un desarollo uniforme, asi como tambien suplementar un nivel adecuado de nutrientes para generar un rapida desarollo del cultivo.

Estas variedades una vez alcanzada una, altura superior a 1.70 m iniciaran la floracion, sin embargo la mayor produccion de semillas de estas se ha registrado durante la epoca de secas, en la mayoria de los casos.

La cosecha se, hace cuando las semillas estan, maduras, antes de guelas vainas se habean y tiren las semillas al suelo. Las vainas con semillas verdes, pero muy turgentes (de mayor tamano que cuando secas) deben ser tambien cosechadas. Las vainas deben secarse directamente als sol y cuando esten completamente secas la semilla se puede separar de estas por medio de golpes con baras, posteriormente las semillas, pueden ser limpiadas haciendolas pasar a teavez de arneros o telas de atambre haciendolas pasar a teavez de arneros o telas de atambre con diferentes diametros.

Una vez culminado cada, ciclo de produccion de semillas esta especie ha adquirido una altura bastante considerable en la majoria de los casos, siendo necessario podarlos para facilitar la cosecha. La altura, de corte que mejores resultados reporta para este fin es: de 0.80 ma 1.0 m (1) sin embargo cada 2 a 3 años es necesario podar los a una altura de 10 a 20 cm.

B. Seed handling and storage

The seeds of ipil-ipil are in pods which open a few weeks after turning dark in color. Collection of the pods should be made before they open so that the seeds would not be on the ground.

To extract the seeds from the pods, the pods are spread on a dry, hard, and well ventilated surface such as a concrete floor canvass, etc. After drying the pods are stirred to release the seeds from the pods. Variations of this method may be employed.

One convenient variation for example, is to spread the pods on an elevated wire screen with mesh wide enough to allow the seeds to pass through. A canvass is spread underneath the screen. As the pods are dried and opened, the seeds fall into the canvass.

Before storage, the seeds should be dried thoroughly either by air drying with the aid of dessicants, or with temperature controlled chambers. Since Leucaena seeds are often infected with seed insects and some fungi, they should be treated with insecticide such as malathion or metoxychlor or with a fungicide.

Seeds lose 50 percent viability in 4 to 5 months if not stored properly. Seed moisture content should be down to ––– percent before putting in sealed drums or other containers and kept in refrigeration at temperature about 10°C. Seeds stored in this way have been known to remain viable for over a decade.

Ipil-ipil seeds are hard-coated and the hardness of the seedcoat increases the length of storage. Treatment is needed before sowing to obtain high and uniform germination. Some methods used are mechanical scarification of the seed coat, acid treatment and tap or hot water soaking. All these methods work to hasten entrance of water through the coat. Mechanical scarification may be accomplished by using a drum with the wall lined with said paper and attached to a shaker or rotator. Immersing the seed in ordinary tap water may soften the seed-coat in a day or two. A faster method is to soak the seed in water heated to 75°C – 80°C for 2-4 minutes or by pouring the seed in water heated to boiling point, left to cool off, and the water is decanted off. Concentrated sulfuric and hydrochloric acids have been used successfully. The water treatments are preferrable since injuries to the seed are less likely to occur.

Research

The present methods of harvesting ipil-ipil fruits, seed extraction and drying are laborious, expensive and inefficient. There is a need to develop techniques that are not only more efficient, but would also allow handling of large quantities of seeds.

The optimum moisture content and temperature under which seed should be stored to prolong its viability should be determined.

C. Vegetative propagation and grafting

The use of vegetative parts for reproduction has the advantage of shortening the period of planting to foliage or fuelwood harvesting. It has the additional advantage of reducing the troublesome weeding problem associated with slower growing plants started from seed. However, growth is quite slow and poor using stem and branch cutting. Stump planting, that is planting the plant with stem and roots but without crown, would give satisfactory establishment. Stumps with a diameter of 10 cm and length up to four meters are used.

For the purpose of seed production, grafting of scions from superior genotype which are established in seed orchards would be a quick means of obtaining genetic improvement. This vegetative propagation method, however, has yet to be perfected. Critical considerations should be given in the selection of scions, age and size of the stock, time of grafting and techniques in grafting.

IV. RESEARCH AND DEVELOPMENT NEEDS

Scheme for the control of Ipil-ipil reproduction material (varietal certification)

Rationale: Increase demand for reproductive materials of *Leucaena* species is expected as there is tremendous interest in growing this species in tropical and sub-tropical countries. Apprehension is allayed on unscrupulous seed merchants who would sell adulterated and uncertified seeds. On this respect, control on the movement of reproductive material of Leucaena species must be initiated.

Object: To encourage the production and use of seeds, parts of plants and plants that have been collected, transported, processed, raised and distributed in a manner that ensures their trueness to name.

a) source-identified reproductive material, which represent a minimum standard
b) selected reproductive material
c) reproductive material from untested seed orchards, which give promise of seed of improved quality
d) tested reproductive material which is genetically improved.

Requirements:

1. Create "Seed Authority Group."
   Composition: Forest tree breeder; forage crop breeder, and technologist;
2. Adopt rules and directions of the scheme
   a) Categories or reproductive material
   b) Delinient regions of ———————
   c) List of approved basic material
   d) Approval of basic material
   e) Regulations governing the production of all reproductive material
   f) Inspections, sealing and labelling
   g) Method of operation of the scheme

FARMING SYSTEMS

TASK FORCE GROUP NO. 2

Task Force Leader:	Dr. James C. Moomaw
Task Froce Members:	Dr. Donald Plucknett Dr. Santiago N. Tilo Dr. Benjamin C. Mahilum Guillermo Sanchez Bro. Alois Golberger Dr. Walter L. Firestone
Rapporteur:	Ms. Beatriz P. del Rosario

I. DISTRIBUCION Y ORIGEN DE LA LEUCAENA

La leucaena es un genero que tubo su origen en Mexico y Cent o America, de donde se distribuyo al resto del mundo.

En la vertiente del Golfo de Mexico se encuentran identificadas las especies. *L pulverulenta, L diversifolia* y *L lanceolata.* En la costa del oceano pacifico en Mexico selocalizan: *L callinsii, L. pulverulenta, L. lanceolata, L retusa, L. diversifolia, L esculenta, L. macrophylla y L. macrophylla, Trichodes Trichodes.*

La Leucaena **leucocephala** es la especie del genero Leucaera, masamplianmente difundida, se ha reportado en toda America y se encuentra naturalizada en casi Todo el mundo tropical.

Ecology

La *Leucaena leucocephala* se encuentra anpliamente distribuida en todo el tropico. La precipitacion y la altitud sobre el rivel del mar son los principales factores que afectan su distribucion. Esta especie es oprovechado en areas con una precipitacion de 20 a 120 pulgadas (1, 2, 3) su distribucion y cantidad de lluvia esta relacionada en forma directa con la **produccion.**

Es posible detectar esta especie en altitudes un poco renor de 1500 metros sobre el rivel del mar, sin embargo la taza de crecimiento es menor a medida que la altura sobre el nivel del mar aumenta.

No es muy especifica en sus reguerimentos de suelo ocurre en suelos rocosos, arcillosos y areas expuestas, sin embargo su taza de crecimiento es menor en suelos acidos, donde la fertilizacion con Calcio y Fasfoco resulta economica, aplicandolos en forma separada.

A pesar de que la Leucaena se desarrolla en una gran diversidad de suelos y condiciones ecologicas, su mayor desarrollo y mas rapido crecimiento ocurren suelos arcillasos, profundos, alcalinos con buen suplemento de nutrientes y humedad.

Crece bien con insolacion directa, tolera sombra parcial o ligera y muere con sombra sebera o total.

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II. SOILS, PLANT NUTRITION, FERTILIZATION AND CULTURAL PRACTICES

A. Soil Requirement

Topography and Soil Features

The Leucaena species are known to inhabit a wide range of topography and soil types with all sorts of soil features. In this varied habitat, these plants also exhibit varying degrees of growth and development, Hill (1971) states that Leucaena flourishes on alkaline soils and even those with thin top soil and rocky feature. In the Philippines, Farinas (1951) reported that *leucocephala* grows on any terrain and type of soil provided that the annual rainfall does not exceed 1651 mm. Takahashi and Ripperton (1949) observed that in Hawaii this leguminous plant thrives on crevices of rocks and in all well-drained soil types and series. Oakes (1968) noted that best development and most rapid growth of *Leucaena* occur in deep and fertile soils and in low-lying areas where runoff deposits abundant nutrients from the highlands. In Bangkok it has been observed that some strains of Leucaena grow along canals and on saturated grey soils (Brewbaker, 1976).

Depth of the Solum. On characteristics of Leucaena is its well developed and deep tap root, Dijkman (1950) reported that the main root of one-year old seedlings reached two meters deep while those of five-year old trees reached five or more meters. Plucknett (1976) showed slides indicating deep root penetration of *leucocephala* tap roots in volcanic ash soils in Hawaii. Along road-cuts in the Philippines, the common leucocephala shows tap roots as deep as four meters. Brewbaker (1976) indicated that *leucocephala* tap roots reach down as deep as the water table. Gary (1968) stated that *leucocephala* roots even break seemingly impervious layers of soil in the subhorizons.

The foregoing findings indicate that *Leucaena* favors a deep loose soil for full development and vigor. Its capacity to grow on thin top soil as reported by Hill (1971) is an index that the roots of this legume have also the capability of spreading out laterally when the topsoil is thin and rests on an impervious sublayer.

Leucaena's ability to develop a deep tap when the soleum permits is a boon to soil fertility management. Gary (1968) considers *leucocephala* an excellent aid-plant for recycling soil nutrients e.g. the root absorbs soil nutrients from deep down in the soil profile and deposit them on the soil surface through leaf fall.

Soil Texture. The rooting habit of *Leucaena* seems to indicate that full development of its root system is attainable only in light-textured soils. In heavy clays, it can be deduced that *Leucaena* roots will not be as large and as deep as those in light soils. When this happens, then its vegetative growth may not also be as well developed as it should be (Oakas, 1968)).

Soil Chemical Properties. Takahashi and Ripperton (1949) considered neutral to slightly alkaline soils as best suited to *leucocephala.* Hill (1971) and Tilo (1976) contend that *leucocephala* has low tolerance for acidic soils e.g. its early growth is more severely affected in acidic soils than in alakaline ones. These authors attribute this phenomenon to either lack of P or Ca or both in acidic soils. Tilo (1976) and Plucknett (1976) averred that both P and Ca are required by *leucocephala* in relatively large quantities.

CEC. No data are as yet available showing the relationship between rate of growth and development of *Leucaena* and CEC of the soil. However, like many other crops, *Leucaena* stands to benefit from a high CEC of soils especially in the tropics where fertilizer requirements for crops are high. A high CEC enables the soil to retain relatively larger quantities of fertilizer nutrients which can sustain crop growth better and larger.

Exchangeable bases. Tilo (1976) showed a typical positive response curve indicating the relationship between exchangeable bases and the dry matter production of "giant" *leucocephala.* He also provided evidence showing a typical negative response curve of *leucocephala* dry matter production as influenced by exchangeable Al. This is an indication of the tremendous effect of pH on *leucocephala* growth. Whether this is a pH effect *per se* or a Ca effect requires further study.

Available P. The observation made by several workers (Tilo 1976; Brewbaker; 1976; and Hill 1971) whereby the slowness of growth start of *leucocephala* is aggravated by high soil acidity is an indication that P is a critical element in the normal development of this crop. This has been substantiated by the findings of Tilo and his coworkers (Tilo, 1976) where dramatic growth responses of giant *leucocephala* to P application on acidic soils were obtained. Thus, soils with substantial quantities of available P are conducive to vigorous growth of *leucocephala.*

Important Micronutrients. The term "important micronutrients" refers to those micronutrients which are needed by *Leucaena* not only for growth but also for special physiological processes such as those involved in modulation. These micronutrients with adequate amounts of available B and Mo soils are therefore suitable for good growth of *Leucaena.*

B. Mineral Nutrition

The mineral nutrition of *leucocephala* is little understood and this is true for most of the tropical legumes. Information is required on foliar symptoms of mineral nutrient deficiencies, chemical decomposition and adaptability to soil type and environment. *Leucaena* presumably needs the same essential soil macro and micronutrients which are required by other plants. These are the six macro- and seven micronutrients. As a forage crop, *Leucaena* must also have substantial amounts of I and Co which are needed by animals.

Nitrogen. Ordinarily, N fertilizers are not applied to *Leucaena.* However, in areas extremely deficient in N, small amounts of fertilizer N are applied as a boaster. This boaster N may be applied in the order of 5 to 10 ppm. Like any other legume, *Leucaena* produce module where Rhizobium fixes atmospheric N. Dijkman (1950) considers inoculation a worthwhile venture in Leucocephala culture. Gary (1968) and Hill (1971) mentioned the specificity of rhizobial strains for *Leucocephala*. Only strains from fast-growing legumes are found effective for giant *Leucocephala*.

Phosphorus. P seems to be a critical element in the nutrition of giant *Leucocephala* (Tilo, 1976). To date, however, no data are available establishing the critical levels of P for *Leucaena*. It is hoped that interest in P nutrition for this crop shall be generated so that in the near future conclusive evidence for critical levels of P in *Leucaena* shall be available.

Potassium. The status of potassium nutrition in giant *Leucocephala* is not yet well defined at present. Takahashi and Ripperton (1949) experimented K fertilization of common *Leucocephala* in a Hawaiian soil supposedly deficient in K. No response was obtained. It was probable that the soil analysis showing K deficiency in the said soil was based on available K in the surface soil and not in the whole soleum. Since *Leucocephala* is a deep-rooted plant, then the plants of Takahashi and Ripperton (1949) must have absorbed whatever available K from the subsoil below the sampled top layer. It is therefore, hoped that further studies on K nutrition of *Leucocephala* shall be made.

Other Macronutrients. Data in nutrition studies of *Leucaena* involving the other macronutrients are nil. Perhaps interest in this field shall be kindled so that nutrition of this crop can be better understood.

Micronutrients. Micronutrients nutrition of *Leucaena* is at present an unexplored area. Hopefully, future studies will enable us to understand micronutrient nutrition of *Leucaena*.

Soil Sampling as a Diagnostic Tool in Determining Nutritional Requirements of Leucaena. In view of the deep rooting habit of *Leucaena,* said sampling for available nutrients should include the whole soleum. Better still, the profile down to R should be sampled at depth increments of 15 to 30 cm.

C. Fertilization

Ipil-ipil appears to tolerate a wide range of soil pH but would grow better in a soil with a higher pH than a low one.

Nitrogen. Being a legume, ipil-ipil is presumed to be able to satisfy its nitrogen needs from symbiotic nitrogen fixation. Thus, normally, the application of fertilizer nitrogen is not practiced although small amounts are suggested. In place of nitrogen application, the seeds are inoculated with a compatible strain of root module bacterium (*Rhizobium sp.*). In many places, inoculation is not even resorted to and still the plants are able to grow luxuriantly.

Phosphorus. The phosphorus needs of the plant may be supplied almost entirely by the soil or supplemented by fertilizer phosphorus. In many acid soils such as those which occur in the tropics, phosphorus availability is very low and therefore fertilization with phosphorus becomes necessary. It has been shown in Queensland that nitrogen fixation in ipil-ipil is markedly dependent on the supply of phosphorus.

Potassium. There is very little known about fertilization of ipil-ipil with potassium, but on the basis of the potassium content in the forage, the plant is a heavy user of potassium. This would mean that in the soils where ipil-ipil is grown, sufficient potassium is made available from the soil.

Calcium. Australian scientists have reported that ipil-ipil is able to grow on soils with very low calcium levels in Queensland but in other places growth appears to be impaired by low levels of calcium. It is possible that the ability of ipil-ipil to grow under low levels of calcium is a varietal adaptation. Workers in Queensland who grew ipil-ipil in pots at pH 5.5 with calcium levels of 5 and 40 ppm observed more vigorous growth at the higher level.

Magnesium. There are a few reports for magnesium fertilization with tropical legumes but there seems to have been no published report of ipil-ipil. Anbrew (1962) remarked that magnesium is rarely deficient in the field, particularly in tropical areas, although deficiency may occur through mismanagement.

Sulfur. It is reported that symptoms of sulfur deficiency resemble those of nitrogen. Although the use of superphosphate prevents early detection of sulfur deficiencies, they are commonly reported in Australia, New Zealand and Africa. In New Guinea, ipil-ipil has been found to be highly sensitive to sulfur deficiency. Application of sulfur produced rapid responses.

Molybdenum Molybdenum deficiency has been recorded on a range of soils, but it is usually associated with acid soil conditions. The paucity of published results of molybdenum responses in tropical regions does not imply that this element is deficient in these soils. Dr. Brewbaker mentioned of molybdenum deficiency in certain soils of Hawaii. On an acid soil in Costa Rica, Esquivel (1965) observed an increased weight and number of nodules by supplementing molybdenum and boron to fertilizer which is mixed with lime.

Zinc. Dr. Sanches has reported that where certain forage grasses have difficulty in getting established, ipil-ipil has been shown to establish normally. In this soil, zinc deficiency was established to be the cause of poor growth of forage grasses but this low level of zinc is tolerated by ipil-ipil.

D. Cultural practices

In many countries, leucaena has spread naturally to become a dominant plant in lower rainfall lowlands. Its ability to volunteer and to become naturalized would indicate that it is an easy plant to manage. In general this is true, but there are some management concerns which need attention. Management requirements will depend heavily upon the particular use for which Leucaena is intended. For this reason, a complete set of cultural recommendation cannot be given. Special priority must be given to research on management for different ecological situations and specific uses.

Establishment. One drawback of Leucaena is its relatively slow seedling growth. Research is needed to find ways to accelerate its establishment and to shorten its early growth period. In general, any steps which will accelerate seedling growth and reduce early weed competition will be useful. Such steps include: good land or seedbed preparation; seed treatments; weed control; fertilization and irrigation.

Land preparation. Land can be tilled or not tilled, depending on the situation. For forestry or extensive pasture, tillage may not be possible; therefore, use of fire or specially prepared planting sites may be required. Aerial sowing into the fresh ash of burned lands has been successfully accomplished, but some aerial sowing has not been successful. Further research is needed to ensure more predictable success with aerial sowing.

For erosion control or reforestation, site preparation may consist of prepared planting holes for transplanted seedlings, or opening of strip furrows to plant seeds.

For more intensive systems such as intensive pastures, intercropping, green manuring, etc., preparation of a good seedbed, such as is required for maize or other row crops, may be required. Seeds of leucaena are not large; therefore, the seedbed should be fairly to ensure good contact with the seed.

Seed treatment.

Because hard seed caused by a thick waxy seedcoat can be a problem, Leucaena requires scarification or special treatment to ensure good germination. Systems used have included mechanical scarification, heat treatment and acid treatments. Probably the easiest method of treatment is immersion in hot water (80°C) for 2 minutes. After treatment, seeds should be dried rapidly and stored before planting. Acid treatment- dipping seeds in concentrated sulfuric acid for 15 minutes, washing with water, and drying — is succesful but somewhat difficult.

Leucaena usually requires inoculation with a specific leucaena strain of *Rhizobium* bacteria, in order to assure good nodulation of the roots and nitrogen fixation. Inoculation is especially advisable for lands which have not grown the crop previously; in areas where leucaana has been grown, the proper *Rhizobia* may be present in the soil and inoculation may not be required.

Seed pelleting may be useful to assure good establishment from seed. Pelleting steps include: mixing the inoculant with an adhesive (gum arabic — % is suitable), coating the seeds with the adhesive/inoculant solution, and then adding a dry coating material such as lime. Pelleting may be done by tumbling the seeds in a concrete mixer or by rotating them in a small bucket or can which has been equipped to rotate with a hand crank. Seed treatments such as fungicides may be added to the pellets, but care must be taken that the inoculant bacteria are not killed by such chemicals.

Sowing. Seeds can be drilled or broadcast sown at a depth of about 1.5 cm. Sowing rates vary widely depending upon intended use and row spacings; for most purposes 10-20 per ha is probably adequate. Broadcast sowing rates should probably be about 20-25 kg/ha. Sowing rates would be worked out for local situation and needs.

Transplantation of seedlings grown in pots. In some situation it may be desirable to germinate leucaena in small pots and transplant directly in the field. This helps to overcome the problem of slow seedling growth. Plants have been germinated in peat pots and then transplanted in vigorous pangola grass pasture by using a tractor-drawn subsoil chisel attachment to make furrows. Such furrows or planting holes could, of course be prepared by hand.

Local potting materials such as coconut husks could be used as growth media for seedlings to be transplanted. Care should be taken to ensure that seedlings are adequately supplied with nutrients by using small amounts of fertilizer or nutrient solutions to supply at least Ca and P. *Research is needed on local requirements and uses for transplanted seedlings.*

Time of planting. Sowing at the beginning of the rainy season is most suitable. For high rainfall areas, planting should be timed to coincide with the period when leucaena seedling growth will be greatest and weed competition is lowest. *Time of planting studies are needed for local situations.*

Plant Spacing and field design. *This is an area which needs research* and which is highly dependent upon the management system and the local environment. For most purposes, Leucaena is usually planted in rows. However, for forest use or erosion control on denuded lands, broadcast sowing may be used.

Row spacings vary widely, from as narrow as 0.3 m or so for mechanized forage harvesting systems, to 1-1.3 m or so in intercropping or intensive grazing systems, to as wide as 3-4 m for grazing or when intercropped with food crops or short term crops such as maize. Each system will require its own spacing and field design.

Plant spacing in the row also varies widely, from as low as 15-20 cm or so, to 1 m or more.

Weed control. Leucaena seedlings suffer greatly from weed competition for at least the first 4 to 6 months; therefore, until the leucaena canopy is developed enough to shade out weeds or the root system has developed enough to permit the plant to compete for moisture and nutrients, weed control must be practiced. *Not enough is known about weed control methods in leucanea production systems: and research is needed.* Cultivation with hand tools animal-drawn machinery or tractor-drawn machines is often used to control weeds between the rows.

The crop is quite tolerant of most herbicides, so chemical weed control is a distinct possibility. Certain selective grass herbicides, preemergence herbicides, and contact show most promise. *Research is needed on chemical weed control.*

Irrigation and Water requirement. Once established, leucaena can withstand several months of dry weather; indeed, this is one of its major virtues. However, to ensure rapid seedling and early growth, moisture should not be limited. In rainfed areas. planting at or near the beginning of the rainy season is probably the best solution. Land shaping to collect rain water may be useful in low rainfed areas to assist in establishing the young crop.

Irrigation has been practiced with good results. Methods used have included furrow and sprinkler. Irrigation even in limited amounts and at infrequent intervals, is of great value in prolonging and improving crop's growth in the dry season.

Some irrigation experiments have been conducted in Hawaii. Yield and growth responses to irrigation can be striking; in one experiment a single irrigation following harvest was adequate for good forage yields. It appears that it takes about 599 kg of water to produce 1 kg of dry matter, and that, in general, each 2.5 cm of irrigation water supplied during the dry season would produce about 1.71/ha of additional green forage. Takahashi and Ripperton (1949) estimated that the crop could be grown without irrigation in areas receiving about 1250-1500 mm of annual rainfall. Below that, yields during the dry season would be low unless irrigation was provided.

Frequency of harvest and height of cutting. Leucaena is famous for its ability to withstand repeated defoliation either cutting or grazing. This characteristic also makes it desirable candidate for svstems where firewood of foraqe needs are high.

Plants can be harvested in as short as 6 months after planting. Plants can be cut as low as 7.5 cm without injury to the plant or reduction in yield. Low heights of cutting result in plants which compete favorably with rank weed growth in the interrows. Higher cutting heights may be desirable for some management systems, and cutting back to leave stumps about 1-1.3 m height is common practice in soilage or green manure cropping systems.

Frequency of cutting can be important. Most experiments indicate that harvesting every 3 months results in sustained high yields. During optimum growth periods, e.g. summer, shorter harvest periods of about 2.5 months may be used; curing periods of slower growth, e.g. winter, periods between harvests can be lengthened 3.5 to 4 months. Most systems will probably result in about 4 crops per year.

III. SYSTEMS FOR SPECIAL USES

A. Erosion Control

The use of Leucaena for erosion control in the various high rainfed areas of the tropical areas of the world has shown considerable promise. Leucaena improves the soil in three ways: through nitrogen filtration, addition of legumes and action of deep roots which penetrate compacted soils. It is used to provide protection cover for eroded or potentially erodable lands, especially in steep hill lands.

Deep root penetration enhances the soil by improving the water holding capacity as well as bicycling nutrients from soil depths to the surface. In natural stands, an organic mulch layer from decaying leaves and stems builds up under the plants, providing a protective cover for the soil and improving soil fertility.

Drought tolerance, ability to grow on steep slopes and permanence under natural stress conditions are special strengths of leucaena for erosion control. The plant is little injured or affected by wind or storm damage.

Planting systems for erosion control vary, including: use as an intercrops in tree or plantation crops; contoured rows or hedges across hills or along dikes or terraces; solid stands on steep difficult sites; strip-cropped hedges planted on the contour and alternated with strips of available crops; or even establishment on ridge and hill tops, with an aim to spread naturalization on the slopes below.

B. Organic fertilizer

Leucaena has been grown as a soil improvement crop in plantations since the late 19th century. The basis for this use is the remarkably high production of organic material containing large amounts of nitrogen in several cultivars of the crop.

In Hawaii (Takahashi and Ripperton, 1949) yields of 60 t/ha of fresh whole forage were produced annually by cutting four times per year. The newer introductions to some location have produced over 100 t/ha (Brewbaker, 1975; Brewbaker, Plucknett and Gonzales, 1972). These green materials contain about 28 percent dry matter and 1 percent nitrogen on the average. In the Philippines, Mendoza et al (n.d.) produced 310 to 800 kg N/ha/yr depending on cutting height. If we use a conservative figure, the harvest of Leucaena for its nitrogen may yield 400 to 500 kg N/ha/yr and this material will probably contain 200 kg P_2O_5 /ha and 450 kg K_2O/ha. Significant amounts of Ca and other nutrients will also be added to the soil.

An additional advantage of this system is the addition of organic matter in large amounts. The physical properties-especially water holding capacity and cation exchange capacity will be greatly enhanced with this system.

Two systems for growing "fertilizer" crops are practiced (Djikmon, 1959): first, growing a high N crop on crop land for a long period of complete crop cycle before plowing in or cutting the crop and second, harvesting and carrying green leaf material for plowing into the soil from a border or more distant planting. Leucaena may be used in either way but, of course, in terms of labor it must be balanced against the loss of crop area for production.

Experiments designed specifically to test nitrogen production by Leucaena and its utilization by corn, Guevarra produced 500 to 600 k N/ha/yr. The Leucaena was cut at 1 m height at 3-month intervals (Guevarra, 1975). When two corn crops were grown per year and fertilized with Leucaena leaf intercropped with the corn, yields of about 3.5 t/ha were obtained with each crop. Corn intercropped with Leucaena yielded 23 percent more than when not intercropped, but the efficiency of Leucaena N was only 38 percent of urea fertilizer N in producing the corn crop. Leucaena applied late in the corn crop cycle (at tasseling) was not utilized. Transfer of the legume N to an associated crop is known to be mainly from bacterial decomposition of plant parts. Many losses on the process.

inspite of the losses in the process or organic matter decomposition and the space and time requirements for growing nitrogen in association with crops, there may be many situations in remote area or where fertilizer prices are high that Leucaena N can greatly increase crop yields at low cost.

Effects of intercropped Leucaena on grain yields of corn (H610) planted at three spacings. Second crop of corn. Hawaii, 1975 (after Guevarra, 1976)

		Dry Matter Yield	
Leucaena Treatments	Leucaena-N applied	Field Area Basis Grain	Corn Area Basis Grain
	kg/ha	kg/ha	kg/ha
Applied at planting time and seedling stage			
1 row	95	2.97	6.61
2 rows	146	2.20	6.61
Applied at planting time and tasseling stage			
1 row	107	2.73	5.47
2 rows	179	2.16	6.50

C. Systematic Kaingin

Leucaena or ipil-ipil is surely one of the best species which can be utilized in improving our present way of farming (which is also called Kaingin) in the mountainous areas.

After burning the second growth forest, ipil-ipil is planted or directly sown in rows 5 to 6 meters apart depending on the gradient of the slope. Afterwards any agricultural crop can be planted between the rows of ipil-ipil. Corn and sweet potatoes are mostly used by the minority groups in the mountains. The rows of ipil-ipil are cut back in intervals depending on the growth of the ipil-ipil and the soil conditions. The branches and leaves are used as green manure and mulching material.

For a systematic Kaingin management, ipil-ipil should also be used as a major source of green forage for animals like cows and goats, since most of the areas where Kaingin is going on are steep, often too steep for planting corn, rice and other food crops. Weed is another problem if corn and rice are planted. Since these slopes cannot be plowed, weeding has to be done by hand which is time consuming and laborious.

The very destructive Kaingin management can easily be changed and improved to a scientific Kaingin management which not only prevents soil erosion but will enrich the soil with most of the nutrients. Actually, we have quite an amount of technical knowledge on using ipil-ipil to improve our Kaingin management or to give substitute to the kaingin farmers. Inspite of this, we hardly made any progress because we were overlooking the social factor: the people. We also have to give to the people, who will implement this knowledge, some kind of incentives:

1) a land classification will have to be made
2) the status of the land will have to be classified.

People who only occupy and do not own the land have not much interest to develop or improve the land and their farming system. More research on the social and political aspect will have to be made.

The gap between scientists and kaingin farmers is too wide. Research findings on the use of ipil-ipil for an improved and soil building kaingin farming have to be translated into languages which the hillside farmers can understand. Applied research on the hillside will have to be made. Once the farmers are ready to improve their kaingin farming, all the necessary input and market facilities must be at the easy reach of those farmers.

At present we do not have complete recommendations and research findings on ipil-ipil and its use for a systematic kaingin farming but enough for the initial starter. If this knowledge would be brought out of the libraries and laboratories to the level of the hillside farmers, we could have more progress.

D. Reforestation

Leucaena, a plant that possesses certain salient characteristics which make it particularly useful in and desirable for reforestation and land reclamation. Its widespread adaptation to a wide range of soils and rainfall belts, ease of establishments, rapidity of growth and compatability with a wide range of forest species makes it particularly useful in reforestation. Its gregarious growth habit, producing seeds in copious amounts capable of sustained longevity of viability, render the plant invaluable as a nurse crop in reforestation. The multiple benefits derived from its use as a nurse plant contribute to its economic value as a reforestation crop. The erosion control and soil improvement capabilities, along with its serving as an excellent and cheap source of green manure and fuel, all contribute to its usefulness in reforestation. The species occurs characteristically in grasslands and second-growth forests but does not ordinarily form a component of mixed stands. In addition to the usefulness of Leucaena to reforestation is its tolerance to diseases and pests, extremes in atmospheric and edaphic moisture, inclement weather and fire and adaptation to particularly difficult hatitats. The plants thrive in full sun and parital shade and are capable of repeated drastic pruning when necessary to alleviate for water and essential plant foods. The top soil is deepened and enriched by this legume and the ground cover along with its extensive root system aids in preventing erosion. Forest species planted between established stands of *L. leucocephala* have more moisture available than when planted in pure grass stands. In addition to providing shade, the presence of L. leucocephala would stimulate the planted forest trees to attain height rapidly, thus reducing the potential danger from fires.

As a planted nurse crop, it competes successfully with tall brunchgrasses for plant food and sunlight in becoming established, provided the area is kept free of fire. The gregarious and rapid growth of the plants and particularly their prolific ratooning capability, producing dense stands which shade young tree seedlings, is beneficial in discouraging weed growth.

The plant does have limitations as a nurse and shade crop. It is not particularly suited for the moderately acid soil requirements of tea, nor does it thrive at elevations above 3,500 to 4,00 feet.

Land preparation is recommended where it is established by seeding as a nurse crop in reforestation and as a firebreak in grassy areas. Seedbed preparation is usually practiced when the crop is established by seeding for: cover, erosion control, forage, green manure, hedge, shade and windbreak.

When the plant is used for land reclamation or for reforestation, usually less land preparation is required to establish the crop, thus reducing costs. The crop is usually established by seeding or ridges, allowing natural spread down the slopes. Seeding is usually done at the onset or during the wet season after the area has been burned, provided grasslands are involved. The seeding rate varies between 2 and 10 liters per acre, dependent upon whether planted, broadcasted or in row

E. Shade, cover cropping, windbreaks and miscellaneous uses.

An important characteristic of Leucaena is its multiple use in agricultural and forest-related production systems. It is frequently planted in situations where it is primarily a shade or nurse crop for plantation crops but it is also used as a green manure, cover crop, firewood, and food crop. Poles may also be cut to prop banana bunches or for use in light construction. It may be browsed and is also ornamental.

Before 1900, Leucaena was used as a shade tree for plantations of coffee, tea, rubber, cacao, quinine and fruit. It can be managed to fit nearly any shade requirement (Oakes, 1968). Its characteristics include large crown spread but light canopy, deep root system, immunity to diseases and insect of the companion crop, withstand heavy pruning, minimum maintenance requirements.

A valuable attribute of Leucaena is its ability to withstand shaping, cutting and trimming to suit most desired uses. Hence, it can be maintained at a very low height as a soilage crop or green manure crops; as a low to medium shrub in grazing or cut-and-haul forage systems; as a small tree in borders or hedges in soil conservation programs, in windbreaks, etc.; or as large trees in forests plantings. It can be grazed, chopped, logged, topped or cut at will and still survive even in shallow, difficult soils. Its hardiness and ability to survive has resulted in an impressively wide array of uses in agriculture and forestry in the tropics.

Leucaena has few natural enemies and almost no serious pests. The most serious insect pests in Hawaii are the black twig borer (*Lylosandrus compactus*). Also, the pantropical seed weevil. There are no major diseases, although the roots can harbor some soil fungi that are active on plantation crops.

It may become a weed in some applications owing to its copious seed production and is not adapted to the cool high elevation tea production areas. The plant does not thrive on strongly acid soils but is said to indicate alkaline soils. Its response may be to available calcium or phosphorus in these soils, however.

Leucaena is a valuable cover plant in many situations, including plantation tree crops. Its deep root system apparently does not compete much in intercropping systems with other crop for nutrients and moisture; and for that reason it has been interplanted with perennial crop such as coffee, cinchona, cacao, tea, rubber, oil palm, coconuts, and fiber crops. In very dry periods, if it does begin to compete with main crops for moisture, it can be drastically pruned and the logging can be used as green manure or for animal feed.

The plant is used as a windbreak and to prevent wind erosion in areas with light soils. It is used around vegetable gardens for its organic N production in addition to the wind protection especially at low elevation sites.

Leucaena is planted in grasslands where reforestation is desired but also to serve as a shade tree for cattle and to provide a firebreak since it will shade out the grasses beneath the canopy in a few years time. The plant frequently remains green during dry seasons of the year owing to its deep tap root system.

Leucaena seed contains a galactomannan in relatively large amounts. This highly viscous gum is used as a thickening agent and emulsion stabilizer at very low concentrations (Morimoto and Uuran, 1962).

Seeds of the plants are also used to make ornaments of a wide variety such as necklaces, bracelets, leis, etc.

The poles are used for garden stakes, pickets and tools. It is used as a living fence in some areas. The flowers are worked by bees and the bark produces a brown or red dye which is used for wool, cotton, fish lines, etc.

The bark, roots and seeds are used in home remedies of unknown effectivity. It is used as a contraceptive and to produce abortion. It is used as an emmenagogue and emollient after roasting the seeds.

In addition to its use for erosion control, Leucaena grows on some unusually poor soils and can expand land utilization in many marginal situations. The plant grows on steep, rocky soils in dry lowland climates where few other crops do well. In some cases, the deep root system will penetrate to ground water where shallow-rooted crops will not persists or will remain green after other crops have ceased growth

IV. RESEARCH NEEDS

1. Plant nutrition studies to resolve the questions of adoptation to low pH soils. The question is related to the observed response to applied P and to

the accumulation of Ca in the leaf and leaf litter. Response and requirement for Mo is also in question. Foliar symptoms or deficiency need identification: S, Cu, Zm on some soils maybe deficient.

2. Critical levels of macro and micro nutrients.
3. Physiological understanding of the remarkable production of organic N by the plant. Some of the highest recorded N yields are observed without apparent nodulation of the roots of Leucaena.
4. Field testing leucaena as conventional grass for erosion control in watersheds – on small test areas (1000-1500 ha).
5. Applied research on establishment of kaingin systems involving leucaena.
6. Economic evaluation of organic N production and utilization – green manure as mineral fertilizer.
7. Management systems for local conditions: time of planting relative to rains, sowing rates, spacing.
8. Speeding early seedling growth and related weed control for establishment – minimum tillage, aerial sowing, transplanting techniques.

MANAGEMENT AND UTILIZATION FOR FORAGE AND SOIL AMELIORATION

TASK FORCE GROUP NO. 3

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MANAGEMENT AND UTILIZATION FOR FORAGE AND SOIL AMELIORATION

I. ESTABLISHMENT

Soil and Elevation

Leucaenagrows on almost any type of soil but most observation indicate that it thrives best on well-drained soils with pH 5.2 to 8.5. It can grow on rocky and heavy black cracking clay soils but cannot tolerate water-logged conditions.

Leucaena has been observed to thrive in places up to 750 m but is more productive at lower elevations.

Land Preparation

When cultivation is feasible, it is desirable to have the land for Leucaena planting thoroughly prepared. This is particularly advisable when Leucaena is planted by direct seeding. This is being done to prevent the growing Leucaena seedlings from early weed competitions.

In hilly areas, it is recommended that Leucaena be planted as seedlings. This is done by digging holes where potted Leucaena plants are dropped and covered with soil. For growing plants, the area should be trimmed to prevent the young seedlings from being shaded out and give them a good start.

Seed Treatment

Freshly harvested seeds of leucaena are hard and they soften slowly in storage. Therefore, it is necessary to scarify the seeds before imbihition and subsequent germination can occur. Several ways to scarify the seeds have been developed but the methods most readily adopted in practice are modifications of the hot water seed treatment (Gray, 1962). Seeds soaked for 3-4 minutes in hot water maintained at 80°C then removed to cold water will usually give germination values of 90 percent or more.

Another modification involves placing the seeds in a mesh bag in an equal volume of water at boiling point and stirring for 3 minutes (the length of an average pop record on a transistor radio). Seeds are then cooled immediately in water and dried in the sun before planting. Alternatively, the seeds can be soaked in water until they sprout and then planted in seed beds or plastic bags filled with soil.

Although treated seeds store well in these situations, it is advisable to treat seed when required since unscarified seed has a longer storage life.

Inoculation

Leucaena is highly specific in its nodulation requirements, and nodulates effectively with fast growing Rhizobium strains. It is therefore advisable to innoculate seeds before planting in areas where leucaena does not grow naturally. A high quality peat innoculum should be used, using a sticker of gum arabic, cellofas or methofas. For seed beds, the inoculum can be watered in after germination has occured. Innoculation is especially important where leucaena is to be planted on acid soils. In these situations the non-acid producing *Rhizobium* strain CB 81 should be used, and if the seed is not planted immediately it should be lime pelleted. Even then it should be stored in refrigerator and planted within one week. Innoculation cannot overcome the need for nutrients and other than nitrogen, so it is essential to fertilize with these nutrients on soils deficient in P, S, Ca, Mo and K if maximum nitrogen fixation and legume growth is to be achieved.

Sowing

Shallow planting is essential for good establishment. Seeds planted below 4 cm often have emergence problems. The use of about 5-7 kg seed/ha is recommended in Australia for row sowing 2-3 m apart. In many countries, the seeds are planted individually in soil filled plastic bags or peat cups, while in New Guinea and Malawi seeded planting followed by transplanting to the field (stamping) is practiced. For the latter method, the tops and roots are trimmed leaving a rather rare stump of finger thickness. The failure rate is low and the method considered more reliable than direct sowing in the field.

Few seedbed problems have been encountered in the tropics. In the sub-tropics, damping-off of seedlings can occur in cool wet conditions. This may be overcome by sowing at a warmer time of the year or by the use of a suitable fungicide. Seedlings are generally tolerant of pests and diseases but may be preferentially eaten by domestic animals and hares. In Australia and New Guinea, the young plants are avidly eaten by kangaroos and walabies. Steps to exclude these pests are necessary for successful establishment.

Care of Young Plants

Growth of Leucaena is ensured by preventing the young plants from weed competitions until it reached a height of one (1) meter. From germination it is desirable to weed regularly and keep the field entirely free from weeds. Domestic animals should not have access to the young Leucaena plants. Once Leucaena had grown taller, it is in a commanding position and domination of other plant species need not be feared.

Fertilization and liming

In many situations, Leucaena responds well to lime and phosphorus applications, particularly in acidic and non-fertile soils. Applications of lime and phosphorus at planting boost growth and establishment of newly planted Leucaena.

If the pH of the soil is below 5.0, lime needs to be applied to bring the pH up. This is done first before any attempt to apply phosphorus fertilizer is made. Acidic soil renders the phosphorus not available for plant use. Applying 2 to 4 tons of lime per hectare will bring the pH to about 5:5 from a pH of 5-0.

Phosphorus is usually needed in soils to encourage the growth of Leucaena. Phosphate fertilizer may be sidedressed at the rate of 15-30 kg P per hectare. In some cases, response of Leucaena to molybdenum and sulfur had been observed.

II. MANAGEMENT FOR YIELD MAXIMIZATION

For Soilage

In an experiment conducted at the U.P. College of Agriculture, Philippines, herbage yield produced ranged from 10 to 24 metric tons dry weight per hectare per year. This! can easily support 6 to 16 steers a year assuming 50 percent |ipil-ipil foddeı feeding. In Hawaii it was shown that herbage yield (fresh) ranged from 67 to 95 metric tons a year. At this yield level, about 12 to 18 steers at 50 percent ipil-ipil feeding. Because of the high herbage yield potential of this crop which can be fed to animals as fodder when processed into leaf meal, it will play a vital role in uplifting the life of many small farmers.

Stand density

To mixture yield, one must have the proper plant density fitted for the purpose at which ipil-ipil is grown. For forage, about 100,000 to 130,000 plants per hectare are needed. About 4 to 5 kilos of seeds will be planted 5 cm apart with the rows and 2 meters between rows. It maybe planted 75 cm between rows but the former spacing would allow easy cultivation and easy harvesting. Weeds should be suppressed until the plants are about a meter high. Addition of about 50 kg P_2O_5 would enhanced early stand establishment.

Period of establishment

Preservative cutting of the plants would reduce herbage yield and retard root development. The initial cutting should not be done until the lease trunk has attained at least 3 cm or one seed production cycle has been completed by the plant.

Harvesting, frequency and height of cutting

Harvesting of ipil-ipil herbage should be done periodically so as to have a high proportion of edible stem. However it should not be too frequent so as to allow the plant sufficient rest period between cutting intervals. Since the parts of the plants that are harvested are the photosynthesizing organ, it should be allowed to replenish whatever food reserves in the stem has been used for new tissue formation. Experiments have shown that 2 to 3 months are ample time between cuttings.

The amount of the stubble that should be retained by the hedgerows varies according to the methods of harvesting. While retaining high stubble would favor higher herbage yields, it is only permissible for manual harvesting. Stuble height of 30 cm to 45 cm would be high enough for manual harvesting using a forage chopper.

For Pasture

When intended for grazing, ipil-ipil is better implemented with grasses such as Guinea grass. The nature of the ipil-ipil leaves allows plenty of sunlight to filter to the ground. In Hawaii, it was shown that an acre of Guinea ipil-ipil pasture can easily support one animal. This is equivalent to about 5 animals per two hectares. For grazing purposes, shorter bushy type varieties rather than the tree types should be used

Grazing

Grazing should not start, until the plants are one meter high. At this state, the plants should have at least established, yet, are grazable being about at eye level of the cattle. Because of its high palatability, ipil-ipil pasture can easily be overgrazed. Continuous overgrazing will impair subsequent herbage production from regrowths. Undergrazing, on the other hand, will promote tall woody stems which cannot be grazed by cattle. Hence, careful management is necessary. In some cases, there is a need to occasionally top overgrown ipil-ipil stem to about 3 to 4 feet above the ground.

Rejuvenation

Sometimes the plants do not produce succulent herbaceous stem because of continuous overgrazing. If this happens, the stand can return back to productive state by cutting back the trunk and resting the pasture. Grazing again be done only after the plants have completed one productive cycle. Care should be taken to ensure that fertilizer nutrient are not limiting yield.

III. NUTRITIONAL PROPERTIES OF FORAGE

Young Leucaena forage is valuable source of crude protein, vitamins and minerals. A typical analysis of leafy forage is shown below:

Nutrient Composition*

	Per cent
Dry Matter	89.4
Crude Protein	24.2
Ether Extract	4.4
Crude Fiber	13.3
Ash	10.8
Calcium	1.98
Phosphorus	0.27
Digestible Protein	19.7
Total Digestible Nutrients	57.3
Gross Energy, K cal/kg.	3995

*Source: Castillo, L.S. and A.L. Gerpacio, 1976

Leaves have lower crude fiber than the stem fraction, the stem fraction having twice as high as the leaves and therefore of lower value for non-ruminants.

The leaf meal is especially valuable because of its amino acids composition which is superior to many other plant protein sources such as copra meal or rice bran. The amino acid composition determined in the Philippines for locally grown leaf meal are given below.

Amino Acid	Per Cent*	Per Cent**	Available**
Alanine	1.24	–	–
Arginine	1.41	1.25	0.62
Aspartic acid	2.35	–	–
1/2 Cystime	0.36	0.27	–

Glutamic Acid	2.46	–	–
Glycine	1.13	–	–
Histidine	0.60	0.52	0.20
Isoleucine	1.10	2.30	1.09
Leucine	1.98	1.93	1.15
Lysine	1.48	1.50	–
Methionine	0.31	0.38	0.23
Phenylalanine	1.18	1.37	–
Proline	1.29	–	–
Serine	1.04	–	–
Threonine	1.02	1.12	–
Tyrosine	0.94	0.97	–
Valine	1.27	1.32	0.84
Tryptophan	–	–	0.27

*Labadan, M.M, 1976.
**Castillo, L.S. and A.L. Gerpacio, 1976.

For poultry feeding, Leucaena leaf meal is a very good source of pigment for egg yolk and shanks and breasts of broilers. For layers fed with white corn or sorghum, 4-6 percent of good quality ipil-ipil leaf meal will impart the desirable color in egg yolk. For broilers, a level of 3 percent will impart yellow color to the shanks and breasts.

Five percent of the leaf meal is usually recommended for poultry, swine and rabbit diets. The carotenoids content of such leaf meal is shown below:

Carotenoids of Leaf Meal

Carotine, mg/kg	518.3
Total xanthophyll, mg/kg	762.4
Monohydroxy pigment mg/kg	316.2
Dihydroxy pigment, mg/kg	126.9
Dihydroxy equivalent* mg/kg	285.0

*Dihydroxy equivalent = ½ MHP + DHP

In an experiment where chicks and pigs were depleted of vitamin A and carotene, favorable response in terms of growth and appearance when these animals were supplemented with 4.5 to 6.0 percent ipil-ipil leaf meal. (Costales, et at, 1964).

On one study, 5 native cows suspected to be suffering from avitaminosis A as indicated by low plasma vitamin A (75 I.U./100 ml), feeding with concentrate mash containing 10 percent ipil-ipil leaf meal plus ad libitum amount of mixed grasses raised the plasma level to 2177 u/100 ml in the fourth week of feeding. Furthermore, this was a general improvement of the physical conditions of the animals (Momongan et al).

Storage of leaf meal

In connection with the storage of leaf meal, one of the problems encountered is the loss of carotene which amounted to about 50 percent in 10 days of storage. Castillo, et al (1963) reported that the carotene decreased from 731 mg/kg to 367 mg/kg. The addition of anti oxidant significantly minimized this loss. However, storage in partial vacuum or inert gas such as carbon dioxide or nitrogen did not give any beneficial effect.

Estrogens

Estrogen content of legumes were determined in one study (Aglibut and Castillo, 1963). Of the 14 tested, ipil-ipil showed the least estrogenic content as determined by uterine weights of mice.

Cattle Feeding

Leucaena is well accepted by cattle which consumes the leaves, flowers, young pods and the young shoots less than 5 mm in diameter. It forms a very valuable supplement to grasses and crop residues by supplying protein, phosphorus, calcium and sulphur. However, the plant material is low in sodium and iodine. High sodium grasses such as pangols and other digitaria species such as rhodes grass, either kazungula and harok setaria could correct for the low sodium intakes in leucaena. If grown with guinea grass, then salt should be fed.

Digestibility of the leaves and young shoots in feeding trials indicate a digestibility coefficient with cattle and goats of about 70 percent. Crude protein digestibility is also high at about 78 percent and the intake of dry matter at 2.76 kg/100 kg body weight (Uphadhyay et al 1974). In grazing trials of leucaena/guinea grass pastures in Hawaii, grains of 200 to 522 g/head/day were recorded in Aberdeen Angus cattle over a 3-year period. The mean annual gains were related to the rainfall received (Henke et al 1940). When used as a supplemental pasture occupying ----- (c/o Dr. Jones) of the native grassland area in Fiji, leucaena doubled the mean gains attained from the native pasture alone indicating the marked supplemental value of this feed for animal production in the tropics (Patridge and Ranacou). A lesser improvement due to leucaena was obtained when the naturalized pasture of *Heteropogon contortus* had been improved by the use of superphosphate and *Styloson thes humilis* in Queensland.

Very high liveweight gains of 900 g/head/day over 212 days were attained with 2-year old steers grazing a Nandi setaria – leucaena pasture in S.E. Queensland (R. Jones) and from calves running with their mothers on the same pasture.

Milk production from rations in which leucaena formed 50 percent of the total diet was 3752 kg compared with 3396 kg from similar cows fed napier grass and protein supplement with 10.9 percent CP (Henke 1958). The milk from cows that were fed with green leucaena has a distinct taint which is objectionable to most people. However, the taint is removed by pasteurization.

In the subtropical environment of S.E. Queensland, annual heifer liveweight gain was approximately 250 kg/ha for Desmodium and Siratro pastures and 350/kg ha from leucaena pastures (R.J. Jones unpublished data).

In a recent feedlot fattening trial, Linggodjivo, *et. al.* (1976) reported that cattle fed with Leucaena leaves supplemented with concentrate gave an average daily gain of 1.1 kg. compared to those that were fed with leucaena leaves supplemented with molasses – urea of 0.7 kg.

IV. MIMOSINE AND D.H.P. OCCURENCE IN THE PLANT

The toxic amino acid mimosine is found in all cultivated forms of leucaena. Within these leucaena forms, there is little variation in the content of mimosine, although very vigorous types tend to be higher than the less vigorous. High concentrations are found in the actively growing parts of the plants such as growing tips, young leaves, flowers, young pods and seeds. Older stems, roots and the empty seed pods contain low amounts usually 1.0 percent of the dry weight (see Table showing mimosine in plant parts, c/o Dr. Ray Jones). The decrease in mimosine concentration in older leaves and stems may occur by dilution as the older leaves become larger and accumulate more dry weight. This aspect has not been fully studied. In the sub-tropics, the concentration of mimosine in the frowing tips and young leaves is higher in summer when the plants are actively growing than in the winter season (Jones and Hegarty, unpublished results) but detailed studies of the effects of environmental and nutritional factors in determining mimosine concentration in the plant parts have not been made.

Drying of the cut forage reduces the mimosine concentration in the material. The reduction is greater if drying is prolonged in a moist atmosphere and correspondingly less if dried quickly with ample ventilation. The nature of the loss is not quite clear, but under some circumstances the breakdown product, 3, 4-dihydroxypysidine (DHP) is formed.

The Toxicity of Mimosine to Animals

a) Non-ruminants

For along time, It has been known that leucaena feeding has adverse effects on non-rumimant animals. Hair loss is a characteristic symptom reported if consumed in appreciable quantities by horses, pigs, rats, mice and even man. The reasons for conflicting reports of the effect of leucaena feeding have been attributed to the quantity of leucaena and especially the quantity of mimosine consumed per unit of body weight, the duration of feeding, the species concerned and the stage of development of the hair follicle (Hegarty, Schinckel and Court (1949). For example, horses readily lose hairs of the tail and mane because these are continually growing and are the first to be affected. Cessation of leucaena feeding results in normal growth of hair although in some cases this may be a somewhat different color. In some areas (specify), boars are fed with leucaena to cause shedding of the coarse bristles, a practice used to increase the sale price of the animals and to invigorate them.

Adverse effects of mimosine on the reproductive efficiency of mice, rats, poultry and pigs follow the feeding of leucaena. In rats as little as 0.5 percent in the diet over a long period resulted in irregular and a typical oestrus cycles (Hylin and Lichton 1965). When fed to pregnant rats mimosine also caused death of the developing embryos (Bindon and Lamond 1966). A similar effect was noted with pigs.

No comparable information is available on the influence of leucaena feeding on humans although it is apparent that countries where leucaena forms part of the diet still have a high birth rate.

Although the toxicity of leucaena can be reduced by adding ferroussulfate to the diet (Matsumoto et al 1951), this practice is not adopted. The problem is usually overcome by restricting the intake of leucaena so that the level of the anti-mitotic agent mimosine is kept below a critical level.

Although the tips, young leaves and young seeds form a regular part of the human diet in Mexico, Thailand and New Guinea released but few reports of hair loss or of other adverse reactions. This is rather surprising and warrants further investigation to know if the mimosine is destroyed in the gut in some way and rendered harmless by other items in the diet.

The plant has been used experimentally for teeding fish in ponds but not adverse effects have been reported. The metabolism of mimosine in fish needs to be studied because the leaflets of leucaena could form a valuable feed for edible fish production. There are no studies to indicate whether mimosine is retained in the tissues of non-ruminant animals fed with leucaena. Equipment capable of detecting very low concentrations of mimosine is now available and so information in this important field should become available.

b) Ruminants

Ruminants suffer less from apparent leucaena toxicity than the non-ruminants. This is due to the degradation of mimosine to 3, 4 – dihydroxipyridine (DHP) by micro-organisms in the rumen of animals accustomed to feeding on this material (Hegarty, Schinkel and Court 1964). This destruction of mimosine in the rumen may not occur in animals not used to eating leucaena who are introduced suddenly to large quantities of leucaena forage. The mimosine that escapes degradation is absorbed from the digestive tract and may then result in depilation as for non-ruminants. Dramatic fleece shedding occurs when sheep are fed a pure diet of leucaena. Loss of fleece occurs some 10 days after the attainment of mimosine levels above a critical value for a period of 48 hours (Reis et al 1975). Pelleting the leucaena results in faster movement through the rumen; thus, reducing the opportunity for microbial degradation. In Australia, this method has potential for the chemical shearing of sheep in a commercial scale.

c) Ruminants and DHP

It was formerly thought that DHP was a fairly harmless substance and that adapted to leucaena feed would remain free of problems when grazing or being fed with this forage. However, the occurrence of hair shedding, profuse salivation, incoordination of gait, the birth of goitarous calves and the presence of large goiters in cattle apparently well adapted to leucaena feeding threw doubt on this assumption. It s now known that goiters in cattle grazing leucaena pastures are a common, if not a characteristic, clinical sign (Jones, Blunt and Homes 1976). This is associated with low thyroxine concentrations in the blood serum (to 10 n mol/liter or less), hair loss cue to these low thyroxine concentrations, low feed intake and low live-weight gains (Jones and Blunt – unpublished data 1976). DHP has now been identified as a powerful goitrogen in rats, the effects being particularly severe on low iodine diets (Hegarty, Coutt and Christie 1976). The effect on grazing cattle is cumulative and is more serious in some localities than others. The reasons are not clear but the mimosine concentration of the feed and the amount of feed eaten are thought to be implicated. When leucaena forms a relatively small part of the diet (tentatively suggested as less than 30-50%) then problems are rarely encountered and cattles thrive. No effect in Australia (Hamilton *et al* 1968, R. J. Jones unpublished data) but in New Guinea heifers have been difficult to get into calf when grazing a virtually pure stand of luecaena (Holmes 1976).

It should be emphasized that no deaths resulting from leucaena feeding in the field have been reported. Also, animals recover when removed to a leucaena-free pasture or are fed with other materials. In this respect, it is less dangerous than the widely grown temperate legumes white clover and lucerne (alfalfa) which result in deaths due to bloat each year. It is possible, however, that a chronic reduction in feed intake in preventing maximum production in systems utilizing this plant for forage. Consequently, attempts to bread low mimosine lines should be actively encouraged. This will extend the use of the plant for non ruminants alike and should encourage the wide use of this plant for human consumption.

V. RESEARCH NEEDS

1. Overcoming slow establishment, especially in overseeding situation – weed control, seed treatment, fertilization, varietal selection, planting time, economical methods for establishment.
2. Relation between soil and plant tests and Leucaena growth
3. Selection and breeding of Leucaena lines for low fertility acid soils
4. Production of low mimosine lines or mimosine free lines by mutation or

breeding. This would improve the value of the plant economically.

5. Elucidate management responses over sites x cutting x fertilizing x density interactions. Develop models for these interactions and for responses to grazing management and animal production.
6. Further studies on the toxicity of Leucaena with the objective of; a) overcoming the problem; b) finding new uses for these potent compounds.
7. Determining the digestibility and feeding value as influenced by animal species, including fish.

MANAGEMENT AND UTILIZATION OF LEUCAENA SPECIES AND ECO-SYSTEM IMPROVEMENT

TASK FORCE GROUP NO. 4

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I. INTRODUCTION

The successful management of a forest for wood production requires a ready and stable market for its products and the availability of adequate information concerning the technical and economic aspects of wood production and utilization. *Leucaena* is one of the most promising tree species that has been recognized to yield varied wood products that have good market potentials. It is also known to be an excellent reforestation species for soil rejuvenation and water conservation; wind-and firebreaks; and could be a very good species for agro-forestation purposes.

A rational approach for the effective production of *Leucaena* species for wood and protection purposes is to develop an integrated production system that will coordinate relevant activities that are necessary in the production of the various wood products and other end-uses. In the development of an intergrated approach, it is initially necessary to determine various management objectives, compile relevant technical and economic data concerning its production and utilization; and close various research gaps that will provide a sound and practical base for efficient management of this species for wood production and eco-system improvement.

II. MANAGEMENT OBJECTIVES

A. Wood Production

1. Fuelwood, Charcoal and Distillation Products

According to a United Nation's report (FAO, 1975), fuelwood production increased from 1,035 million m^3 in 1962 to 1,146 million m^3 in 1973. This includes the wood equivalent of the charcoal produced in those years. Charcoal exportation was 206,000 mt in 1962 and decreased slightly to 276,000 mt in 1973.

Fuelwood

To the underdeveloped countries of the world, the fuel for cooking food has always been and will always be firewood. Only a small portion of the population, those concentrated in urban areas cook with kerosene, bottled liquified petroleum gas (LPG) or electricity. In many cases, not only for domestic cooking but for commercial baked products, is firewood utilized.

In the Philippines, as late as 15 years ago, train loads and boatloads of firewood called "rajas" or rejitas, were brought in Manila, Cebu and such urban cities for retail in public markets and in bulk shipments to bakeries. The principal source of fuelwood has been mangrove which is the hard, slow and regenerating variety called bakawan or the common *Leucaena* in many areas. Due to market demand, the easy-to-reach mangroves had become depleted, the land converted to fishponds making remaining groves more distant; therefore, the supply dwindled and became more expensive to transport to the market. On the other hand, the big oil companies convinced the commercial bakeries and household wood users in the urban centers to use liquified petroleum gas (LPG). Today, in the urban centers only a few use fuelwood.

Significantly, Mt. Makiling, where a man-made common *Leucaena* forest still exists, has continued to supply firewood to the surrounding communities for many years.

The 1973, energy crisis caused the price increase of fuel oil from less than $3 per barrel to more than $11 per barrel or an increase of three - four times.

The people who switched away from fuelwood are now looking at this again. However, the abundance of firewood during the fifties could no longer be found in the seventies.

The reality of 1976 is that the true cost of petroleum-based fuels is not yet fully reflected in retail prices of LPG. Most countries have price control systems and under their socialized pricing schemes, fuel gas is subsidized. Eventually, however, the retail prices will have to be readjusted to cope up with increasing oil prices.

The only way to restore the wood supply is through the planting of fast growing varieties like giant *Leucaena*.

The conservation of imported, foreign exchange costing petroleum fuel is the concern of all developing and under-developing countries. Fuel for steam and electrical power generation in these countries mainly came from coal and petroleum. Increasing costs for coal and oil will eventually force those industrial plants, where lands for planting are available at reasonable transport distance, to plant fast-growing wood for their future operations.

Most fuelwood today comes from natural forests and alarm has already been expressed by the depletion of these forests due to excessive cutting for fuelwood.

Expansion of the existing fuelwood plantations, such as those already existing on a small scale in the Philippines, and the establishment of new ones would seem to be required to meet the exoected large demand for fuelwood.

Charcoal

Charcoal for domestic fuel, for industrial use as a reducing agent, for metallurgical processes and chemical raw material is well known. The industrial use lies in its ability to supply the carbon atom in chemical compounds. Although carbon could be supplied from petroleum coke or coal coke or even anthracite coal, the unique properties of charcoal is its low impurities especially in sulfur and phosphorus. Its reactivity and conductivity makes charcoal a premium material.

In metallurgical process industries, charcoal is used in the production of calcium carbide, pig iron, ferroalloys, carbon disulfide and a host of other products. To the less and underdeveloped countries without any petro-chemical industries, the only building block for an organic chemical industry is acetylene from calcium carbide.

A country with its metallurgical industry based on charcoal is Brazil. It is reported that annual production and use of eucalyptus wood charcoal is 3 million tons. This is the sole feed to 4 calcium carbide fumaces, 10 ferrosilicon furnaces, a hundred foundries and even a few of the smaller steel mill blast furnaces producing pig iron. The only steel mill in Malaysia is reported to be operating small low blast furnace using charcoal from old rubber trees.

The famed Swedish and Norwegian steel at the turn of the 20th century was produced from charcoal.

Distillation Products

The co-products (or by products) of the exorthermic cracking of wood are heat and volatile combustible matter. The carbonization of wood is the foundation and a rationale for a wood distillation chemical industry.

In a country that does not have a petrochemical or coal chemical industry and desires to be self sufficient, the establishment of a wood distillation may make sense today.

2. *Pulp, Paper and Fiberboards*

It is desirable that for these products, the species should have long fiber with a cell-wall thickness and lumen width such that the Runkel ratio (twice the cellwall thickness divided by the lumen diameter) is less than 1, especially in the production of high-strength paper such as bag and wrapping papers. For papers grades requiring lower strength such as printing and writing papers, *Leucaena* kraft pulp would be an asset for its high opacity, good formation and good printability as is to be expected for short-fiber pulp.

The pulping data on chips from unbarked trunks of the 7-year old Canlubang K28 and on debarked 1.5 year old K28 trunks, all from the Philippines, are given in Table 1. These data indicate that "Giant" *Leucaena* could be a suitable raw material for pulp and paper (Bawagan and Semana 1976).

Hardboards, of acceptable quality from "Giant" *Leucaena* could possibly be made. The current shortage of low-cost housing in the Philippines and other developing and underdeveloped countries points to the need for a lowcost building material like fiberboard.

3. *Lumber, Plywood and Particleboards*

Leucaena species can attain a size suitable for the manufacture of lumber, plywood and particleboard. A K28 variety planted by Provident Tree Farms, Inc. in

Table 1. Pulping of Giant Leucaena

Ref. No.	Sample	NaOH %	No_2S %	Chemical Consumption: Bone-dry Material %	Chemical Consumption: Chemicals Charged %	Pulp Yield: Accepts %	Pulp Yield: Rejects %	Kappa Number
14	UPLB, debarked trunk, 1.5 yr. old	15	5	12.9	82.9	50.3	0.6	19.8 (14.4 K No.)
11	Canlubang unbarked trunk, 7 yr. old	15	5	12.8	81.9	52.4	0.4	26.9 (About 18K No.)
	Range for 4 fast growing pulpwoods	15*	5*	13.6-14.9	87.3-95.6	45.3-55.7	0.2-0.8	(10.9-23.9 K No.)

Other pulping conditions:
4:1 Liquor to material ratio
90 Minutes to maximum temperature of 170 deg. C.
90 Minutes at maximum temperature

*Used for 3 species *A. falcataria* - 13.3% NaOH and 6.7% Na2S

San Teodoro, Oriental Mindoro, Philippines has reached a 40 cm dbh and 15 m height in 10 years. Bawagan and Semana (1976) reported that a preliminary study on sawing *Leucaena* species for lumber yielded an average of 54 percent recovery. They further reported that the wood has good machining properties which may be comparable with other hardwood species being used for lumber and plywood manufacture.

Production estimates for sawlogs depend primarily on spacing, thinning materials and appropriate rotation age. Initially, the seedlings should be densely planted and then followed by periodic thinnings until the number of trees per hectare is optimal for maximum sawlog production.

4. *Other End-Products*

a) Fencing - Two year-old poles (or older) that are thinned out of plantations can be utilized as fence posts for gardens, backyards, farms and ranch. Although young untreated poles may last for not more than two years, the fence can be made permanent if seedlings are planted between the fence posts which after a year or so can serve as live and growing replacements to the original fence posts. By chemically treated ipil-ipil fence posts, it is possible to extend its service life by an appreciable number of years.

b) Round Timber Construction - Poles in the round form, 12 centimeters or more in diameter are used in the construction of temporary sheds and houses in the rural areas. They serve as posts, girts, girders, floor joists and rafters, etc.

c) Banana Props — Since its introduction into the Philippines, giant ipil-ipil has been used as props for bananas. It also has promise for use as supports for other vegetative crops and climbers.

d) Mine Timbers, Railroad Ties, Telecommunication and Transmission Poles - Because of its treatability and strength properties *Leucaena* can likewise be used as mine timbers, railroad ties, power transmission and communication poles.

e) Wood Sugar and By-products*

Leucaena may be able to produce large volumes of dry wood weights per unit area or 25 tons bone dry wood per ha per year on 4 to 7 year rotations (Bawagan and Semana, 1976). This may make it possible to economically supply industrial units with raw material to produce wood sugar by acid hydrolysis. Assuming that an economic size wood sugar plant would need 60 tons of dry wood per day, a *Leucaena* plantation managed on a 7-year rotation would only need less than 1/2 ha. a day to supply its daily wood requirements. This would mean 150 ha per year or 1,000 ha managed on a 7-year rotation. Harvesting and transportation costs should be minimal.

The wood sugar so produced can be used directly as an animal food or fermented to produce torula yeast, a protein (circa 50%) animal nutrient to supplement soybean meal or fish meal.

The wood sugar can also be fermented to produce ethyl alcohol. One hundred and sixty liters can be produced per ton of dry wood or approximately 10,000 liters of alcohol per day from 1/2 ha of *Leucaena* managed on a 7-year rotation.

Many other fermentation products can be made from wood sugar among which are butyric acetic and lactic acids, butyl and isopropyl alcohols, 2 and 3 butylene glycol and glycerine.

The lignin by-product from wood hydrolysis can be briquetted and used as a fuel to partially supplement the energy requirements of the operation.

Ethyl alcohol can be blended with gasoline or used directly to run internal combustion engines.

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*Anon, Wood hydrolysis for sugar production, 2029, Forest Products Research Laboratory, Madison Wisconsin, 1959.

f) Water gas and derivative products**

Ipil-ipil wood can be burned in special water gas production units to supply cooking gas (Hydrogen plus carbon monoxide) or this gas could be further processed to produce methane (CH_4) and/or methyl (CH_3OH) alcohol. This alcohol could also be blended with gasoline or used alone for fueling internal combustion engines as well as for other fuel needs.

Individual production units for generating water gas could be located along a main pipe line and the gas pumped to large scale plants for production of methane and/or methyl alcohol (methanol). Further processing could produce formaldehyde and other items presently coming from petroleum feed-stocks.

For countries without soil and gas wells, this wood-based program might be a desirable trend. Since petroleum is a non-renewable resource, governments may require that a certain percentage of a nation's liquid fuel and other items now derived from crude oil be obtained from wood. This would insure a continuing program of technology development to make the processes more economic, efficient, and competitive.

B. Reforestation

Leucaena is being used to reclaim waste grassland areas. As a grassland species, it competes with *Imperata sp.* and other grasses successfully. It has been observed to flourished in areas that have been devoid of top soil as in road cuts, and even in rocky slopes where the roots are penetrating deep into the cracks. It is reported to grow in semi-arid regions with as low as 250 mm of rain per year as well as in wet regions of 4000 mm rain per year provided no long flooding occurs. It also thrive from sea level to 1500 meters (Djikman, 1950).

1. Soil Rejuvenation and Water Conservation

As a pioneer species, *Leucaena* is notable for its soil building characteristics. It has a good nitrogen-fixing property that allows it to thrive in less fertile soils. The aggressive and deep rooting system deepens top soil, breaks up and aerates impervious soils. Soil organisms particularly earthworms are observed to increase significantly thus, increasing soil property. Nutrients from deep strata gradually find their way to the soil surface through the decay of the leaves and other plant parts. As the plant sheds its leaves regularly, valuable organic matter are formed in the top soil.

Leucaena has also been found to be peculiarly fitted for soil erosion control and possibly water conservation. As the deep growing roots pierce compact-strata, and renders the soil more aerated and porous, water infiltration is increased. Surface run-off and soil erosion are thus decreased and water quality is consequently improved.

This legume can be planted at closer spacing and with its fast growth, soil conservation is attained much earlier. It likewise coppices vigorously and readily so that harvesting will not seriously jeopardize its protective role. More economic utilization of the land is therefore attained.

2. Fire Protection and Windbreak

Fire has always been a major problem in reforestation. Each year, sizable areas of forest lands are burned to waste. Firelines constructed by clearing 10-20 meters wide strips around the plantation are not only expensive but also not effective and short lived. Ipil-ipil planted very closely on newly constructed firelines could provide an effective, inexpensive and year-round fire break. It will also serve as an efficient windbreak.

3. *Agro-forestation*

As defined — the planting of denuded or cultivated slope lands with perennial tree-species and simultaneously cultivated with other tree species and/or with annual crops. The perennial trees may be in a pure stand but cultivated on a short rotation basis for the specific purpose of producing particular end-use products for specific markets. Agro-forestation may be multi-purpose in nature whereby *Leucaena* could be first planted and harvested for wood use such as banana props, fuelwood, etc.; then allowed to regenerate to be harvested as forage, green fertilizer, seeds, etc.

Properties - *Leucaena*, as a member of the legume family, is known to possess the characteristics of nitrogen fixation in its roots as well as the accumulation of nitrogen, phosphate and potash in its leaves. The exact quantity of the available amounts of each mineral is yet to be determined but tests carried out at the University of Hawaii (Guerero 1976) has established the fact that it produces sufficient quantities of N-P-K to adequately fertilize (applied as a green manure mulch) annual crops at a ration of 1 ha of *Leucaena* to 2 ha of annuals. This is, of course, dependent upon soil fertility and population density. *Leucaena's* reputation as a fast growing species (Brewbaker 1975, Bawagan and Semana 1976) makes it a financially competitive species to be seriously considered as both a forest crop on a short rotation as well as a viable pioneer reforestation species for denuded lands (Francia. 1961 and Amos,

Cultural Practices - *Leucaena* used as a component in an Agro-forestation scheme can serve well as a companion tree crop and shade tree. Planted as a source of fertilizer, it can easily be worked into schemes incorporating banana, abaca, coconut, coffee, cacao, bamboo or other trees. *Leucaena* which is planted for the primary purpose of short or long term wood production such as firewood, charcoaling materials, etc. could be feasibly interplanted with shade tolerant annual crops such as the family of *Dioscorea* and the edible *aroids*. Other schemes could be devised whereby denuded hillsides in proximity to lands cultivated by shifting (swidden slash and burn) cultivators could be planted to *Leucaena* in five meter bands on the contour of the hillside with interspacing of one meter by one meter; and alternating ten meter bands could be left open to be planted with annual crops of corn, rice, etc. *Leucaena* could be harvested as a wood crop and the remaining stumps allowed to coppice. The regrowth could be cut and applied as a green manure to annual crops planted in the vacant areas. Such a planting would allow for a well established root system to develop which would insure larger supply of mineral stored in the *Leucaena* leaves giving them a greater fertilizer value. Agro-forestation schemes such as these would stop the destruction of valuable timber cut in the slash and burn practices; reduce soil erosion and degradation, while decreasing the area of land required to support shifting cultivations, transforming them into a sedentary (stationary) agriculture practice.

Leucaena -is adaptable to varying systems of cultivation aside from the above mentioned and numerous schemes may be in actual practice, but, as of this time they are unknown to those researchers. Much research is needed to answer the many questions which may evolve from the use of *Leucaena* in Agro-forestation systems; this is in the areas of production and environment. Yet such agro-forestation schemes offer promising alternatives to the existing problems faced, embracing hillside farming and denudation.

Production estimates - Agro-forestation systems which include *Leucaena* have the potential to increase income of the hillside and shifting swidden/slash and burn cultivators. In the case of the shifting cultivators, it should decrease his labor input of field preparation which could be diverted to other activities to include increased area which he could cultivate. In areas of limited available arable land, it is important to note that an increase of one third total land area would be required in a system utilizing *Leucaena* as a source of cut and carry fertilizer. Such a system would provide a source of tree fertilizer, a commodity which is abnormally unavailable to the shifting cultivators. Brewbaker and Guerrero (1975) reported a 133 percent yield increase of corn fertilized with *Leucaena* over that of an unfertilized plot. Francia (1961) reported a doubled inventory return per hectare by growing a common Philippine variety of *Leucaena* as a firewood compared to rice, corn, coffee and bananas.

Bawagan and Semana (1976) recorded a trunk yield of 45 cu.m./ha/yr and a branch yield (down to four cms.) 10 cu. m./ha/yr on a stand of K-28 *Leucaena* planted at Canlubang Sugar Estates, Calamba, Philippines. Other Projected yields from dense stand of *Leucaena* at the University of the Philippines at Los Baños were considerably higher. A yield of this type sold at P32.00/cu.m. would give a farmer an income of P2,240/ha/yr (calculated P7.5 to $1.00 U.S.). Benge and Curran (1976) estimated that *Leucaena* firewood farmers at Los Banos were capable of earning P5,622.21/ha/yr by selling wood at a roadside price of P1.20 per bundle. Lugod (1975) estimated yields of 30 mt/ha of a variety of the root crop *Dioscorea* could be gained from interplanting this crop under a normal forest canopy. This yield seems exceptionally high. A market price of *Dioscorea* at P.50/kg, multiplied by Lugod's projection of 30 mt/ha, would give an income of P15,000/ha/yr in addition to the wood crop. Root crops normally give a 25 percent to 50 percent response to fertilizer application. Root crops planted under *Leucaena* would presumably give a higher yield.

PICOP (Paper Industries Corporation of the Philippines) (1975) gave a profit of P2,312.00/ha/yr for tree farmers who raised *Albizia falcataria*. This was over and above their maintenance crops of rice, corn, sweet potatoes, etc. which had been intercropped. *Leucaena* sold as a firewood or converted to charcoal has a much higher per cu. meter value than that of *Albizia*. Benge and Curran (1976) gave a per ha income of P2,400 for charcoal producers who sold their product at a wholesale price of P200.00 ($26.50US)/M.T. The aforementioned Agro-forestation production estimates are by no means conclusive. Yields, of course, depend upon soil fertility, management practices as well as many other factors. The net profit gain depends upon the type of product, market price and logistics involved. The point that is stressed is that *Leucaena* is a versatile plant which can be utilized in many ways in systems which will reforest (not in the classical sense); offer environmental protection to the soil; while producing food and/or forest products with a market value to enable hillside farmers to significantly improve their standard of living.

C. Seed Production

Much has been said about the usefulness of the *Leucaenaa leucocephala* and people have put up demands on the seeds as planting materials. As of now source of the seeds is limited, hence, it would be logical for us to look into the supply to meet the present public demands.

With the public welfare in mind, it becomes more imperative that commercial seed banks be established.

Production Estimates - A well grown ipil-ipil plant on a suitable site can produce at least 1 ganta (2.2 kilograms of seeds) per tree (approximate) within the first 18 months. A hectare of *Leucaena* plantation of 2 x 5 meters spacing will have 1000 trees. With ninety percent survival, this will yield approximately 2,000 kilograms of seeds per hectare. Each kilogram contains roughly 21,000 seeds (Dijkman 1950) which is adequate to reforest 2.4 hectares of land with a spacing of 1 x 1 meters.

III. ESTABLISHMENT AND CULTURAL TREATMENTS

Leucaena plantations may be established by seeds, seedlings or cuttings. The last is seldom used because of limited success.

In direct seeding, seeds are dibbled, drilled or broadcasted in well-prepared sites. Coating seeds with 7.5 percent thiram (tetramethyl thiram disulfide) may minimize rodent depredation. Seed scarification and inoculation may be necessary. The seedlings are tended for about six months.

Production seedlings in the nursery seems to be a well established practice. Seeds are first treated with either hot water, hydrochloric acid or sulfuric acid, or subjected to mechanical scarification. The hot water treatment is preferable in the field as it is economical and easy to use. The seeds are soaked for 12 hours in water with an initial temperature of not more than 80°C. Seeds are then planted in pots, seedboxes or beds, as the case maybe. Inoculating the seeds with rhizobia may be necessary. In some cases, the soil can be inoculated by mixing some dirt taken from a place where the legume does form nodules. The seedlings are normally kept in shade for the 1st month and gradually exposed to full light as they get older. For potted seedlings, roots protruding out of the pots has to be cut periodically. They may be outplanted by the second month. In the case of bare root or stump planted seedlings, older seedlings may be required.

Leucaena is generally a slow starter. Results could however be greatly improved by preparing the sites properly and keeping the competing vegetation low at least for the first six to 12 months. Periodic weeding is therefore necessary. Judicious application of lime and phosphorus may also accelerate growth.

Spacing or density of planting depends upon the objectives of management. For erosion control, closer spacing of 1 x 1 meter may be desirable to effect earlier soil protection. Likewise, for end products requiring smaller stem bole, like charcoal, fuelwood, etc., this density may be satisfactory. For other end products such as pulp and pulp and paper, lumber, etc., a spacing of 2 x 2 m to 3 x 3 may be sufficient. Thinning may have to be done in the later stages of growth, if bigger stems diameter is desired.

Regeneration of the stand could be easily attained by coppicing. The height of stumps and the number of sprouts to maintain varies from one end-product to another. Generally, however, 1-3 sprouts could be maintained from 10-59 cm high stumps.

IV. WOOD PROPERTIES

The early history of research and development shows the importance of undertaking an applied research program before the necessary fundamental knowledge (background information) about the raw material is available. Information on its physical, mechanical and chemical properties is considered very important since it can serve as basis in the utilization of *Leucaena*. Therefore, benchmark information on the said properties should desirably be available before any attempt is made to conduct applied research.

A. *Physical Properties* - Of the various properties of wood under the category of physical (such as specific gravity or density, grain pattern, color, finish, thermal conductivity, thermal expansion, specific heat, texture, porosity, shrinkage, etc), specific gravity seems to be the most important and quite often it is the first one being determined. Table 2 shows the specific gravities of Leucaena in 3 places in the Philippines (Bawagan and Semana, 1976), along with data obtained on common *Leucaena* (Rocafort, et al, 1971).

Data on the fiber dimensions and derived values of some giant *Leucaena* grown in the Philippines are given in Table 3. The average fiber length of the giant *Leucaena* samples are longer than that of the common type. The Runkel ratio values of the various *Leucaena* samples are all less than 1, thus passing Runkels' criterion for good papermaking fibers. The fiber length, however, is shorter than those of the pine (conifer) species. The paper producible from *Leucaena* would be characterized by high capacity, low tearing strength, average tensile strength and low folding endurance. Therefore, they would generally be suited as a pulp-furnish component in the manufacture of printing and writing papers, along with long-fiber pulp.

B. *Mechanical Properties* - So far, no strength tests have been done on *Leucaena* wood. Specific gravity data, however, give a good approximation of the latent strength of any species. Since the specific gravity values for giant *Leucaena* give a higher range (0.50-0.59) than those of the Philippine Mahogany species, it would be expected to give better strength properties (tensile, compressive, binding, shear, etc.) than the latter species (Bawagan and Semana, 1976).

C. *Chemical Properties* - So far, only the proximate chemical analysis of wood has been done. Table 4 shows proximate chemical composition of various samples of giant *Leucaena* 0.5 to 6 yrs. old grown in the Philippines (Bawagan and Semana, 1976). Considered as its significant assets are its holocellulose content and low contents in ash, lignin and alcohol-benzene and hot-water solubles, particularly when they are utilized for pulp and paper manufacture. However, ultimate analysis needs to be done since this relates to the use of the wood for fuel.

Table 2. Specific Gravities of Leucaena Species

Ref. No.	Sample	No. of Trees	Age Years	Specific Gravity*
13	Common Philippine ipil-ipil Giant ipil-ipil	1	**	0.73
14	UPLB K28, trunk	20	1.5	0.52
20	UPLBK28, branches of No. 2	20	1.0	0.41
21	Davao	3	3	0.50
22	Davao	3	3	0.59
18	Canlubang K28, trunks	2	6	0.52
19	Canlubang K28, branches of No. 18	2	6	0.49
12	Canlubang K28, trunk	1	7	0.54

* Equals numerically density based on oven-dry weight in grams/green volume in cm^3.

** Unknown.

Table 3. Average Fiber Dimensions and Derived Values of Giant Leucaena Species

Ref. No.	Sample	Age Years	Length (L) mm	Width (D) mm	Lumen Width (l) mm	Cell Wall Thickness (w) mm	Slenderness Ratio L/D	Flexibility Ratio l/D x 100	Runkel Ratio 2w/l	Group	Mulsteph %	Mulsteph Group
13	Common Philippine ipil-ipil	*	1.01	0.024	0.015	0.004	42	62	0.53	!	61	III
	Giant ipil-ipil											
14	UPLG K28, trunk	1.5	1.04	0.026	0.016	0.005	40	62	0.62	I	62	III
20	UPLB K28, branch of No. 14 above	1.0	1.17	0.028	0.017	0.005	42	61	0.59	I	63	III
18	Canlubang K28, trunk	6	1.20	0.025	0.015	0.005	48	60	0.67	I	64	III
19	Canlubang K28, branches of No. 18 above	6	1.09	0.024	0.014	0.005	45	58	0.71	I	67	III

*Unknown

Table 4. Proximate Chemical Composition of Leucaena Species

Ref. No.	Sample	Number of Trees	Age Years	Holo-cellulose %	Pentosans %	Lignin %	Solubilities in: Alcohol-Benzene %	Solubilities in: Hot-Water %	Ash %
13	Common Philippine ipil-ipil, trunk*	2	**	63.2	17.8	25.6	7.8	2.7	0.8
	Giant ipil-ipil								
14	UPLB K28, trunk	20	1.5	72.6	20.1	22.7	1.7	2.0	0.9
15	Davao, trunk	1	0.5	69.8	8.9	25.4	1.4	2.5	0.9
16	Davao, trunk	2	2.0	69.9	16.0	26.0	1.5	1.9	0.7
17	Canlubang K28, trunk	1	5.0	73.9	17.5	21.8	2.5	1.1	0.7
18	Canlubang K28, trunk*	2	6.0	71.0	13.6	23.3	2.6	2.3	0.8
19	Canlubang K28, branches of No. 18	2	6.0	72.0	13.6	22.6	2.9	1.7	0.8
	Average for trunks Nos. 14 to 18			71.4	14.9	23.8	2.0	2.0	0.8
	Comparative analysis								
	Average for 95 Philippine hardwoods			63.6	16.4	25.7	4.2	3.0	1.5

*Average for separate analyses of 2 trees

**Unknown.

D. *Other Properties.* - A study of the wood anatomy is necessary to furnish information on the structure of the wood which may also be necessary for an understanding of its properties. Heating value studies of various strains/species at various ages would develop data on optimum ages and the most suitable species fuelwood. There are probably other strains/species with better heating values than those obtained so far in Table 5 (Bawagan and Semana, 1976).

Table 5. Heating Values of Some Giant Leucaena Species Samples

Ref. No.	Sample	No. of Trees	Age Years	Heating Value Btu/lb	Heating Value Cal/kg.
15	Davao trunk	1	0.5	8000	4445
14	UPLB trunk	20	1.5	7700	4278
16	Davao trunk	2	2	7700	4278
17	Canlubang K28 trunk	4	5	7600	4223
18	Canlubang K28 trunk	2	6	7500	4167
19	Canlubang K28 branch of 18	2	6	8000	4445

IV. RESEARCH NEEDS

Three (3) areas of research are identified namely: production, utilization and reforestation.

Production research involved inputs for establishment, cultural practices and production estimates. This covers the production of wood for fuelwood, charcoal and distillates; pulp, paper and fiberboards; lumber, plywood and particleboards; and other products. The following areas of research are recommended:

1. Varieties or strain for quality timber under different soil type and climatic conditions.
2. Optimum morphological grade of planting stocks for better survival and initial growth.
3. Spacing according to end-products desires, including practical methods of site preparation and tending operations.
4. Fertilizer use for newly established plantation.
5. Plantations development and cut scheduling
6. Regeneration methods
7. Pest and disease control
8. Growth, yield and economic rotation
9. Pulpwood volume equations and tables
10. Weight-volume and solid-stacked volume relationship
11. Harvesting methods
12. Seed production techniques

Utilization research covers both the basic and applied aspects, including studies on pilot-scale and to deal with the following:

1. Characterization of wood properties to effectively accelerate and expand various uses of the species
2. Sawmilling and veneering techniques, including plywood manufacture
3. Lumber drying and preservation
4. Papermaking qualities of various species, including dissolving pulp and other cellulose derivatives
5. Fiberboard and particleboard manufacture
6. Production of chemicals
7. Continuous processes and equipment for carbonization of wood, including techniques of activating charcoal.
8. *Leucaena* as a source of energy

Many countries in the tropic face the problems of drought during the dry season and excessive floods and landslides during the wet season. These are attributed to denudation of forest cover. The panel recommends that the following research be undertaken;

1. Use of *Leucaena* as cover crops or shade trees and fertilizer in establishing forest plantation.
2. Combination of *Leucaena* and selected agricultural crops for hillside farming to maximize land utilization.
3. Performance of various trains in soil rejuvenation and water conservation.
4. Species suitability for wind- and fire-breaks at various elevations and climatic conditions.

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