NICARAGUA

ARAP

Agriculture Reconstruction Assistance Program

USE OF PAULOWNIA FOR FOREST PLANTATIONS IN THE LEON REGION OF NICARAGUA

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Submitted by:
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Introduction

This report summarizes findings derived from four main sources. One, published data and information about paulownia gathered from a literature search, and from the National Paulownia Center, Beltsville MD. Two, general information about the Nicaraguan forestry and agriculture sectors as related to Hurricane Mitch recovery efforts, derived from USAID and USDA reports. Three, the proposal by the Asociación de Productores Agrícolas de León (ADAL) to establish experimental plantings of paulownia in the León area. Four, visits to proposed field sites around León, interviews with farmers, and a presentation and discussions on paulownia potential at a public meeting held in León on July 29.

The three following major sections constitute the core of this consulting report. First, there is presented a general background discussion about paulownia production and its end uses. The second major section represents specific comments about the content and scope of the ADAL proposal. The third section addresses the feasibility of the ADAL project.

General Information on Paulownia

A. *Paulownia tomentosa,* (kiri), Family Scrophulariaceae.

Distribution. The genus *Paulownia* probably has its origins in subtropical China, and was dispersed and diversified into central China, Korea, Taiwan and Japan. The original native habitat of *P. tomentosa,* cannot be accurately reconstructed. At present, paulownia is mainly found in Japan and central China between 32 and 40º N Latitude, at elevations of 500-1,800 m. (1,640 – 5,904 feet). It is also cultivated in plantations in Brazil, Argentina and Paraguay. As a park and ornamental tree, paulownia is also common in temperate zones, including Germany (in the wine-growing areas), southern Europe and the United States. Paulownia was introduced into the United States in the early to mid 19th century and has become a naturalized species.

Paulownia was once an important tree crop in Japan, but the trees were destroyed by viral diseases. Efforts are now underway to reestablish paulownia cultivation in Japan.

Characteristics. Paulownia is a deciduous tree species attaining heights of 12-16 meters (39-52 feet), occasionally over 20 meters (66 feet). The crown is open and dome-shaped, containing relatively few branches, often beginning close to the ground; when young it is easily damaged by wind. The bark is smooth and delicately streaked, reddish-gray in color on young trees and a distinct gray hue on older trees. Paulownia develops a deep tap root and does not compete with shallow-rooted crops.

Paulownia has opposite leaves that are heart-shaped with a basal notch, they have a light covering of downy hairs on their upper surface and are densely pubescent below. The leaves are entire, measuring up to 35 x 25 centimeters (13.8 x 9.8 inches) and have a stalk

10-15 centimeters (3.9 – 5.9 inches) long. The pale-violet to blue purple slender campanulate (bell-shaped) flowers are up to 6 centimeters (2.4 inches) long and are borne on panicles 20-30 centimeters (7.9 – 11.8 inches) long. The fruits grow on stalks, are ovoid in shape, whitish-green in color and sticky to the touch. They are about 3 x 1.8 centimeters (1.2 x 0.7 inches) in size and 2-10 grow on each panicle.

Other species of *Paulownia.*

In total, there are about 15 species of *Paulownia.* Three species (*P. fargassii, P. fortunei* and *P. elongata*) occur in subtropical China, under warmer climatic conditions. The wood quality and other aspects of these three other species are similar to *P. tomentosa*.

B. Ecology

Climate. Paulownia prefers a warm temperate climate but can tolerate winter temperatures as low as -20º C, when it is in a dormant state. Studies in China have shown that it flourishes at daytime temperatures of 24-30º C. The mean annual temperature in those areas of Brazil where paulownia is grown on plantations for timber is 20-24º C.

Soils. Paulownia grows in moderately acid to slightly alkaline soils with a pH from 4-8. It does best with a pH of 6-8. It is relatively undemanding as to soil nutrient availability. This tree prefers well-drained sandy to loamy soils. Topsoils should be about 50 centimeters (19.7 inches) in depth to facilitate tap root penetration. Soil ventilation is vital to the tree. On poorly-drained sites, after 3-5 days of heavy rains that lead to soil saturation, paulownia will drop its leaves and die.

Topography. Level to gently rolling topography is ideal for paulownia plantations. Slopes should not exceed about 2%.

C. Cultivation

Seeds and Vegetative Propagation. Paulownia can be propagated from seed in a nursery and entire plants or root cuttings used for planting out. High germination rates are achieved in nurseries. The use of dormant root cuttings for propagation is quite common. Root suckers and branch cuttings can also be used.

Nurseries. Nursery beds can be established outside. The planting surface should be tilled, flattened and raked to loosen the surface with narrow grooves 2.5 cm (1 inch) apart and only 3 mm (1/8 inch) deep. Seed should be mixed with dry sawdust as a spreader. About 430 seeds should be sown per square meter (40 per square foot). After seeding the bed should be moistened with a fine water spray and kept moist until the seeds germinate in 20-30 days. Seedlings should be thinned by removing the smaller, weaker plants, reducing the population to 65-86 per square meter (6-8 per square foot). Watering, fertilizing and weeding is important for paulownia nurseries. If dormant root cuttings are used, the top and roots need to be pruned before planting out.

Silviculture. Paulownia is a highly light demanding species which will not grow well under a tree canopy. In China it is normally grown at wide spacings of 5 x 5 meters (16 x 16 feet) or 6 x 4 meters (20 x 13 feet), or used in agroforestry systems. It has proven to be well-suited for intercropping with wheat, cotton and maize at spacings of 5 x 20 meters (16 x 66 feet) and 5 x 50 meters (16 x 164 feet); the resulting wheat yields are 16% higher, those of cotton 7% higher, and those of maize more than 11% higher than those obtained on plots without paulownia. Sweet potato and soybean yields tend to decrease when grown with paulownia.

Paulownia bears fruit regularly from age 15 on. The seed pods each contains about 2,000 very small seeds which are very light in weight and are easily dispersed by wind. There are between 4 and 6 million seeds per kg (1.8 – 2.7 million seeds per pound).

About 4 weeks after root cuttings are planted in the field, the number of shoots is reduced to one, leaving the most vigorous shoot with the best growth form. Trees grown from seed attains a height of 3-4 meters (10 - 13 feet) by the end of the first year, with a diameter of 3-5 centimeters (1.2 – 2 inches) at ground level. Root cuttings can grow as tall as 4-5 meters (13 - 16 feet), occasionally 8 meters (26 feet) after 1 year. Underdeveloped plants are retained in the nursery, pruned back after they shed their leaves, and transplanted to the field a year later.

Paulownia plantations can be established with a density of about 1,235 per hectare (865 per manzana). These should be thinned over the first 10 years until a density of 494-741 per hectare (346-519 per manzana) is reached. Thinnings produce leaves, small branches, poles and saw timber.

Paulownia grows extremely fast. The average diameter growth increment can be as high as 8-9 centimeters (3.2 – 3.5 inches). The total standing volume of a 10-year old tree ranges from 0.5 to 3 cubic meters (17.7 to 106 cubic feet). Diameter at breast height (DBH) growth culminates between years 4 and 8 years, volume increments reach their maximum at between 8 and 15 years. Mean annual volume increments of 25-35 cubic meters per hectare (17.5 – 24.5 cubic feet per manzana) are achieved in Brazilian timber plantations.

After about age 15, the growth rate of the tree slows down and the annual growth rings become much more closely spaced. Trees may live for 125 or more years. The older the tree the more valuable the wood. A 63-year old paulownia tree cut in the United States had a diameter of about 80 centimeters (2.6 feet) and a value of US$7,000.

Silvicultural treatments include pruning, tree thinning, and protection against wind, animals, insects and diseases. Nitrogen and phosphorus fertilizers may be applied to enhance growth in the nursery and in the field.

D. Harvest.

Paulownia can be cut when it reaches 10 or more years of age. Tree felling should be done when the tree has dropped its leaves and is in a dormant state. During dormancy the sap withdraws to the root system. Because of the sap withdrawal, when the wood is cut it is almost white in color, the color most desired for high value uses. If the tree is cut at other times of the year, the sap will oxidize and produce purple streaks in the wood.

Data on the prices and export quantities of paulownia wood are difficult to obtain. In 1993, the United States exported 7,137 cubic meters (252,040 cubic feet) of rough paulownia logs, having a value of US$6,065,214. This is equivalent to US$850 per cubic meter (US$24.06 per cubic foot). It should noted that the figures for 1993 represented a decline from the two previous years: 8,856 cubic meters (312,745 cubic feet) in 1992 (US$790 per cubic meter: US$22.37 per cubic foot) and 11,169 cubic meters (394,428 cubic feet) in 1991 (US$720 per cubic meter: US$20.39 per cubic foot). More than 95% of the exports went to Japan. It is believed that the bulk of the exports from the United States to Japan were of old paulownia logs which have higher value than young tree logs. Hence the value per unit weight should be viewed with caution.

E. Coppicing

After harvest, paulownia plantations can be effectively managed to produce the next tree crop through coppice management. Commercial promotional literature from a tree-growing company in the United States claims that a plantation that is well managed and maintained should yield five quality harvests.

Three major types of sprouts occur after cutting. Cambial-stump sprouts, also called stool sprouts, come up between the bark and wood part of the stump. Root-sucker sprouts develop from adventitious buds located on the primary lateral roots, and may be inches or feet away from the stump. Root-collar sprouts arise from the root-collar zone and come up right next to the stump. The first two sprout types should be pruned away in their entirety, as well as all but the single most vigorous root-sucker sprout, which will form the next population of the plantation. The root-sucker sprouts that have been removed can be used to establish new plantings elsewhere.

F. Uses.

Timber. Paulownia wood has a uniformly colored, light-brown heartwood zone, and a narrow, light gray almost white sapwood layer. Paulownia wood resembles American ash. Physically the wood ranks between balsa and poplar. Density of paulownia at 10% moisture content is 17.91. Its specific gravity is 0.265. The chemical composition of paulownia wood is: cellulose content, 46-49%; hemicellulose pentozan ,22-25%; and lignin content 21-23%. The wood is odorless, has good physical and mechanical properties, dries easily at ambient temperature, but is only moderately durable. Because of its above average acoustic properties, in China and Japan it is used for making traditional musical instruments. Other paulownia wood use includes models, glider

construction, use for sculptures and small utensils and domestic articles. In Japan it is used for making wedding boxes, matches, wooden shoes, crates, etc. Plantation grown wood from Brazil is often utilized to make simple furniture. Paulownia logs can be peeled and used for veneering.

Fuelwood. Paulownia wood makes a good fuelwood, although it is not very dense and burns fast. If planted for fuelwood production, spacing of 65 x 65 centimeters (26 x 26 inches) is used to close the canopy and to suppress weed growth. At a density of 1,600 trees per hectare (1,120 trees per manzana), after 8 years, l hectare (1.43 manzanas) of paulownia can produce 68 cords (8,704 cubic feet) of fuelwood. A dry cord of wood weights about 1 ton and has a BTU value of 13 million, which is equivalent to 100 gallons of gasoline. The rapid production of wood volume over a fixed time period more than compensates for the lower wood densities of paulownia as compared with other trees such as oak.

The profuse coppicing of paulownia makes it a good fuelwood species. However, it should be mentioned that growing paulownia exclusively for fuelwood is labor intensive.

Green Manure. Prunings from paulownia trees can be used as green manure to maintain or enhance soil fertility. The leaves contain about 3% nitrogen. A 10-year old tree can produce 30 kilograms (66 pounds) of dry leaves each year, and 400 kilograms (888 pounds) of young branches. The leaves break down slowly as a soil amendment.

Forage. Paulownia leaves can also be gathered and used as animal feed. Goats and sheep in particular like to eat the leaves. Paulownia trees must be protected from livestock when they are young or the livestock will damage the trees, retard growth, or trample them.

Other uses. Trials in China have shown that paulownia yields an excellent chemical pulp of a quality superior to that of other fast-growing broad-leaved tree species. The leaves, flowers, fruits and roots are used in China for making traditional medications. Oil for varnish is obtained from the seeds. Paulownia trees can be planted as windbreaks, for soil reclamation and as an attractive ornamental tree.

The ADAL Proposal

The strategic objective of the proposal is to carry out trials of a new Nicaraguan forest species for purposes of reforestation and to contribute to the improvement of environmental conditions. The initial trials call for planting in pure stands a total area of 35 hectares (50 manzanas) of paulownia on up to 10 different farms in the departments of León and Chinandega. Paulownia planting will increase the local wood energy supply and permit the commercial experimentation of commercial products domestically and internationally.

The proposal sets forth five specific objectives:

1. To experiment with the adaptation of paulownia using vegetative material originating from Australia, subsequent to its adaptation in Thailand.

2. To produce wood energy and lumber from paulownia.

3. To contribute to the amelioration of environmental problems resulting from indiscriminate deforestation, through reforestation with paulownia.

4. To offer to producers a new alternative forest product which has an unfilled international and local market.

5. To contribute to the reactivation of the economy of western Nicaragua, creating employment opportunities in a zone that has been severely affected by natural disaster.

General Comments:

1. The proposal is internally inconsistent with regard to the number of intended participants. Most often 25 are mentioned, but project objectives refer to about 10 producers. This point appears moot since ADAL has four producers who, together, are interested in establishing the full 35 hectares (50 manzanas). The 4 producers are all of medium size, 105-210 hectares (150-300 manzanas). A smaller number of participants has the advantage of being easier for ADAL to support and monitor; furthermore, medium-sized producers are presumed to be in a better economic position to assume the risks associated with the project, than small farmers.

2. The first specific objective (see above) refers to the use of vegetative material from Australia via Thailand to establish the plantations. If this refers to clonal material, it is not recommended (see below). If this refers to root cuttings, costs will be relatively higher than seed, but with faster results. Confusion exists regarding how the trees will be propagated because elsewhere in the proposal the discussions of nurseries appears to indicate that seed propagation will be used.

3. The project assumes that it will be based entirely on the cultivation of *Paulownia tomentosa*. It is suggested that the proposal include one or more of the subtropical species of *Paulownia*, in the event *tomentosa* results are disappointing.

4. Not included as a silvicultural treatment is the generally recommended practice of initially establishing field plantings at a higher density and thinning out trees as they get larger over the first 10 years. It is recommended that thinning be added to the silvicultural practices.

5. All trial plantings are planned to be carried out on the farms of the participants. This means that results can only be compared from farm to farm, without any baseline data derived from a control trial. ADAL would be well advised to make arrangements for

small trial plantings of the Paulownia species used, ideally on a research facility of some type in the area, where conditions can be controlled and closely monitored. This will generate data which can be used as a control against which to compare the on-farms results. The control plot should have optimal soil conditions and receive all recommended treatments.

6. The table of cost figures in the proposal annex for the establishment of 1 manzana of paulownia, based on experiences in the United States, do not appear to be relevant to western Nicaragua. The table of cost figures for growing *Eucalyptus camaldulensis*, however, represents a reasonable set of surrogate data which could be recalculated, taking into account the differences in paulownia cultivation and adding in nursery costs.

7. The proposal should be strengthened with regard to the development of possible domestic markets for paulownia wood. Furniture, moulding, handicraft and other higher quality wood uses need to be promoted in advance of actual wood production. The project should anticipate that sample quantities of paulownia wood will need to be provided without charge to various industries for them to try out.

Feasibility of the Project

There is a considerable amount of risk inherent to the introduction of paulownia growing to western Nicaragua. Potential problems can be summarized under the following four headings.

1. Legal aspects of introducing exotic species. It has yet to be determined formally if there are any legal regulations relative to the introduction of paulownia into Nicaragua. Nicaraguan legal requirements as to exotic species, well as USAID environmental impact requirements must be studied and complied with.

2. Adaptation/Acclimatization of Paulownia in Nicaragua

Climate. Optimal temperature conditions for growing paulownia are not present in the area of León, nor elsewhere in Nicaragua. Daily maximum temperatures in León are about 4 º C higher than the ideal. Paulownia now is typically grown in climatic areas which have cool to cold temperatures for a period of months. Rainfall amounts in western Nicaragua should be adequate. It is anticipated that the paulownia trees will become dormant in the dry season between the months of December and March, and drop their leaves. If the trees are planted in nearly level sites having well drained, sandier soils, there should not be any problems related to soil.

Species selection. It is recommended that the initial growing trials include one or more of the subtropical species of *Paulownia*. By planting more than one species of *Paulownia,* the risk of failure of the project is decreased because if *Paulownia tomentosa* does not perform well, one of the more subtropical species may prove to be a suitable substitute. If other *Paulownia* species are grown, they should be tested at every site to

assure that positive results are not related to an isolated factor at one planting site. These other *Paulownia* species represent alternative species for the project.

Propagation. Seed propagation is recommended because it produces a diverse tree population and is the least expensive. Root cuttings can be produced from the project nursery for field planting. Clonal seedlings are not recommended, for two reasons. One, the trees will all be genetically identical. If there is a problem in terms of climate or some disease or pest, the entire population will suffer. Seed propagation assures a diverse tree population enhancing the chances for success in the face of adversity. Two, clonal seedlings are very expensive, US$1.50 to 2.00 each.

Growth rates. Rates of growth recorded for China, the United States and Brazil are likely higher than those which can be expected in Nicaragua because of the less than ideal climatic conditions. Because of this uncertainty, yield projections should be very conservative until such time as data are available from local plantations. Within a year or two some projections can be made based on local results. Growth rates recorded for more than one *Paulownia* species will also be valuable.

3. Market.

It is impossible to predict international market prices for paulownia logs 5 to 10 years in the future. It is known that China and other east and southeast Asian countries have established plantations of paulownia. The close proximity of those countries to the Japanese market, low labor costs and lower shipping costs, may virtually exclude other countries from selling to Japan. It is also reported that Japan is reestablishing paulownia as a tree crop within their country. Since paulownia wood has never before been offered for sale in Nicaragua, the price it might bring in the domestic market is even more uncertain. Because of the uncertainty, it is essential that the project consider both international and domestic markets for paulownia wood production. It will be necessary to promote paulownia wood within the country, for example, by educating furniture makers and others about its desirable qualities.

4. Cost-benefit

At this point in the project process, a cost-benefit analysis cannot be attempted. It should be possible to use the surrogate data on *Eucalyptus camaldulensis*, modified as applicable to paulownia, and to obtain at least the basic cost inputs of plantation establishment and management for the first 10 years. But until some local paulownia growth data are available (1-2 years) on which to project wood production at year 10, there is no way to calculate the wood volume that will be generated.

It was not possible, in the time available, to find out the current international market price for young (i.e. 10 year old) rough paulownia logs. More research could possible provide some data, as well as recent trends. It should then be possible to make some very approximate estimates of future international market prices.

The domestic market for paulownia wood represents an unknown. In terms of certain end uses, paulownia will likely compete with cedar, laurel or #1 pine. Current prices for these woods, along with production and cost trends, will provide some target domestic prices for paulownia wood.

Follow-up Actions

A revised ADAL project document should be written to bring it up to date with the current plans to involve only 4 producers to plant a total of 35 hectares (50 manzanas) of paulownia.

1. The revision should also take into account the technical issues of whether seed or root cuttings or both will be utilized to establish the plantation plots, the use of subtropical *Paulownia* species in addition to *P. tomentosa*, a control plot of paulownia on a research station and a definite tree density at age 10 after periodic thinnings are carried out.

2. A more accurate and appropriate estimate should be made of the costs of paulownia production from establishment and including management until the first projected harvest at age 10. The costs of seeds and/or root cuttings for vegetative propagation needs investigation to obtain the best material at the lowest prices. Estimated nursery costs must be calculated.

3. The revised project document should also include a plan to investigate international markets and prices for young rough paulownia logs, as well as a plan to promote paulownia wood use in Nicaragua. The investigations should include analysis of what domestic wood types and uses paulownia might supplement or replace, and the current market prices and trends for the competing woods; for example as cedar, #1 pine and laurel.

Items #1 and 2 above should be given top priority. The marketing questions can be addressed once the trial plots have been established.

ADDITIONAL TECHNICAL ASSISTANCE

If the project is approved, additional technical assistance will likely be required during the first year. This technical assistance should consist of the services of a specialist with strong tree nursery experience, knowledge of control plot design for the recommended off-farm trials and experience with the layout of the plantings on the respective farms.

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Technical Information, etc. Provided to the Project

Photocopies of 49 documents (articles, newsletters, bulletins, etc) on *Paulownia.*

Paulownia tomentosa wood samples (3).

Paulownia tomentosa seed (packet containing about 1 million seeds). Seeds should be stored at a temperature of 35-40º F. until used.

Paulownia Websites

http://www.paulownia.org

http://www.paulownia.com

http://www.paulownia.net
(Note: the National Paulownia Center, Beltsville MD does not have a website)

TERMS OF REFERENCE
USE OF PAWLONIA FOR FOREST PLANTATIONS IN THE LEON AREA OF WESTERN NICARAGUA

A. Introduction

USAID/Nicaragua's ARAP project calls for diversification of production into higher-value crops and adding value to current farming systems. The Cotton Producers Association of Leon (ADAL) have presented a project profile to ARAP for the planting of 50 manzanas (35 ha.) of paulownia, an exotic fast-growing, multi-purpose tree, which they propose to use in their crop diversification program. The ARAP project is requesting consulting services from tree-crop specialists to review the proposal and make recommendations on its economic viability and sustainability.

B. Objectives

The objectives of the assignment are to

1) Conduct desk research study of scientific and other literature regarding paulownia (2 days USA)

2) Review proposal as submitted by ADAL

3) Visit proposed sites for paulownia plantations to determine if they meet the agronomic requirements for production and are accessible to processing facilities and required infrastructure.

4) Determine financial viability of paulownia plantations given current market demand.

C. Deliverables

1) A written report covering the feasibility of the ADAL paulownia project, including cost-benefit analysis and market possibilities.

2) Provide to the project copies of scientific or other literature related to paulownia encountered in research phase of consultancy

3) Recommendations on alternative species for same project if necessary.

4) Recommendations on follow-up actions.

D. Qualifications

1) The candidate will be experienced in fuel wood and energy conversion issues (minimum 10 years)

2) The candidate will speak Spanish.

The candidate is Mr. Dennis Johnson.

E. Reporting Relationship

The consultant will report to Mr. Ramiro Irabien, ARAP Chief of Party, or his designee but work with the Leon/Chinandega agribusiness promoter.

F. Length and Timing of Assignment

The assignment will be carried out during the month of July 2000. Estimated duration is 6 workdays in Nicaragua, 2 travel days and 2 days pre-travel research for a total of 10 billable days. Saturday pay for international consultants working in Nicaragua is authorized.

ITINERARY

Date	Activity
July 18 (Tuesday)	Pre-travel research, Washington DC (travel at no expense to project)
July 20 (Thursday)	Pre-travel research, Cincinnati OH
July 24 (Monday)	Travel – Cincinnati to Managua
July 25 (Tuesday)	AM – Introductory meetings at Chemonics. PM - To León. Initial meeting at ADAL; farm visits.
July 26 (Wednesday)	AM – León farm visits with ADAL. PM – Cashew project presentation by Ian Duncan at ADAL.
July 27 (Thursday)	To Palacagüina, World Relief Project, with Ian Duncan.
July 28 (Friday)	Managua – Preparation of Paulownia presentation.
July 29 (Saturday)	To León. Paulownia Presentation.
July 30 (Sunday)	Rest
July 31 (Monday)	Managua – Report Preparation, debriefing at USAID.
August 1 (Tuesday)	Travel – Managua to Cincinnati.