GROWTH OF CASUARINA FROM IMPROVED SEEDS
THE IMPACT OF IDRC - FINANCED PROJECT
(3-P-75-0048 AND 80-0027)

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Old evaluation report number was 2.1.16

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1. INTRODUCTION:

The Casuarinas are the most commonly planted trees in Egypt followed by eucalypts.

Casuarina is mostly used for the protection of field crops (as shelterbelts and windbreaks, Figures 1, 2 and 3),) to stabilize irrigation and drainage canal banks, for protection of buildings and for lining of highways. In addition, wood is used extensively in manufacturing particle boards, (Figure 4) flooring, charcoal (Figure 5), making and as a fuel.

Casuarinas were introduced in to Egypt more than a hundred years ago. Badran et.al. (1976), El-Lakany et.al. (1977) and Saleh and El-Lakany (1979) recognized three species of Casuarina in Egypt, namely Casuarina equisetifolia, C. cunninghamiana, C. glauca and a natural hybrid between the last two species.

Casuarina equisetifolia is less widespread and is found only along the Mediterranean Coast. Other species are extensively planted inland and in desert areas.

As a result of the intensive plantings of Casuarina trees in Egypt more attention was given to this genus (the genus has been recently divided taxonomically into four genera). A Casuarina project was initiated by the Department of Timber Trees and Wood Technology at the Faculty of Agriculture, Alexandria University with the financial support of the IDRC of Canada. The objective of the first phase (1977-1980) was to select superior mother trees and to establish improved seed orchards. The second phase (1980-1984) aimed at testing and evaluating the selected material.

As a result of the two phases of the project more Casuarina was grown from selected material. The farmers and managers of agricultural companies have realized the importance of using selected material, whenever possible.

2. OBJECTIVES:

The aim of this report is to gather and document information on the extent to which the improved casuarina propagation material developed in the two phases of the Casuarina Project (3-P-75-0048 and 80-0027) is being used in Egypt and to estimate some economic indicators of casuarina planting.

Fig. (1): A high way protected by a windbreak of Casuarina

Fig. (2): Field windbreaks of Casuarina protecting a desert farm

Fig. (3): Protecting farms in sandy soils by Casuarina windbreaks; the first stage of land reclamation

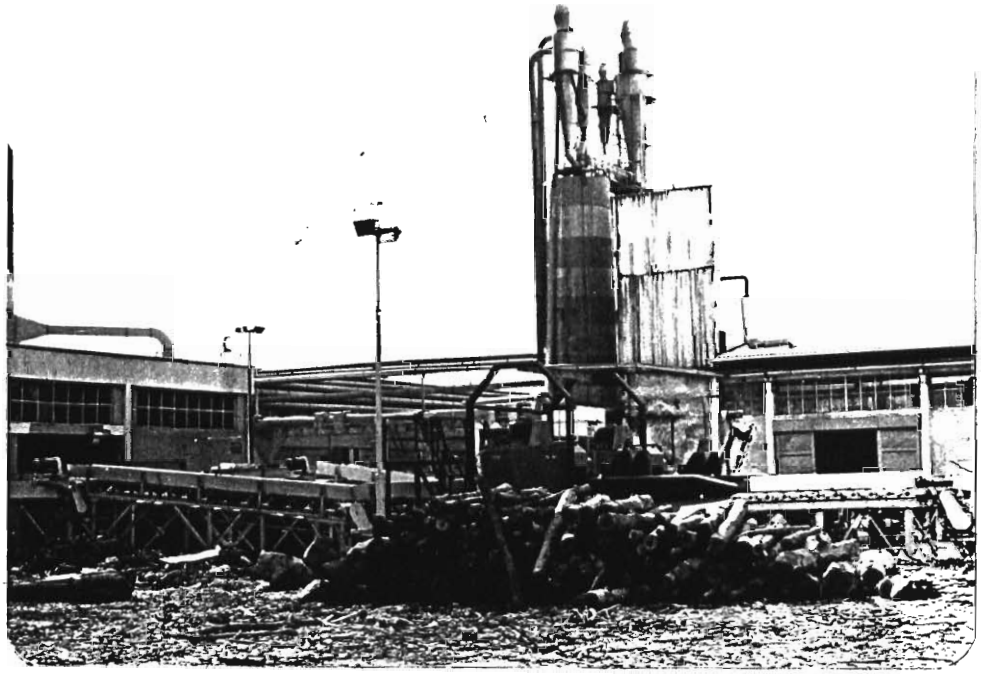

Fig. (4): Casuarina wood being used for particle - board manufacturing, near Alexandria

Fig. (5): Charcoal making (earth Kilns) from Casuarina Wood in the Delta

Specific Objectives:

The following specific objectives have been studied:

(i) Estimating the amount of improved and/or selected Casuarina seed used annually, and the number of seedlings produced from improved and/or selected seeds, used to establish shelterbelts by farmers and Agricultural Companies in Egypt.

(ii) Estimating the area of land protected by the new shelterbelts from improved (selected) Casuarina seeds.

(iii) Measuring the extent to which the Egyptian farmers or Companies have responded to the recommended usage of improved or selected seeds from casuarina planting in two selected newly reclaimed areas (El-Nahda and El-Noubaria).

(iv) Estimating economic indicators regarding the benefits of using improved (selected) Casuarina seeds.

3. METHODOLOGY:

To achieve the aforementioned objectives, the following methods were emplimented:

a- Field visits to the nurseries to evaluate the production of casuarina seedlings.

b- Vists to the farms and Agricultural Companies to study the response to planting casuarina.

c- Visits to seed orchards established during the project to be used as a seed source and comparing their growth with the trees randomly used by farmers and Agricultural Companies.

d- Conducting a reconnaissance survey of casuarina shelterbelt planting in North Western Egypt (El-Nahda and El-Noubaria).

e- Determination of the growth and yield of some casuarina plantations grown from mother trees selected during the project, as comapred to non-selected material.

4. RESULTS AND DISCUSSIONS:

4.1. Production of Casuarina Seedlings:

The production of Casuarina seedlings in Egypt has increased steadily during this decade. Governmental companies and agencies as well as private sector produce casuarina seedlings. Seeds are collected from standing tess, (Fig. 6), extracted naturally, then sown in seedbeds (Fig. 7). Transplants are maintained in a protected greenhouse at least two month after transplanting (Figs. 8 and 9).

Two types of containers are used in Egypt, clay pots which are becoming expensive, and polyethlene pags.

One of the objectives of the casuarina project was to provide farmers and nurseries with improved seeds from superior trees. A Seed Bank was established at the Department of Timber Trees and Wood Technology, Alexandria University to provide seeds locally and abroad. However, only a few cots of seeds are available now due to the lack of funds needed to cover the costs of seed collection, storage and shipping.

The work carried out during the project proved that using certain locally selected and tested Seed Production Areas is as good as using individually selected mother (plus) trees. Using non selected seed sources result in producing seedlings of low quality. As a result, more attention is given now to the seed source of Casuarina. Trees of desirable characteristics are used now as a seed source. The graduates of our Department of Forestry at Alexandria University are responsible now for the management of many tree nurseries around the country. They are well trained in Tree Breeding.

The following are estimates of the amounts of improved seedlings produced by some nurseries based on field surveys:

4.1.1. Production of governmental nurseries:

Nurseries were classified into three types, (a) governmental nurseries which are under the supervision of the Ministry of Agriculture, (b) nurseries of Agricultural Companies and (c) private nurseries.

Fig. (6): Seed collection from a Casuarina Seed Orchard near Alexandria

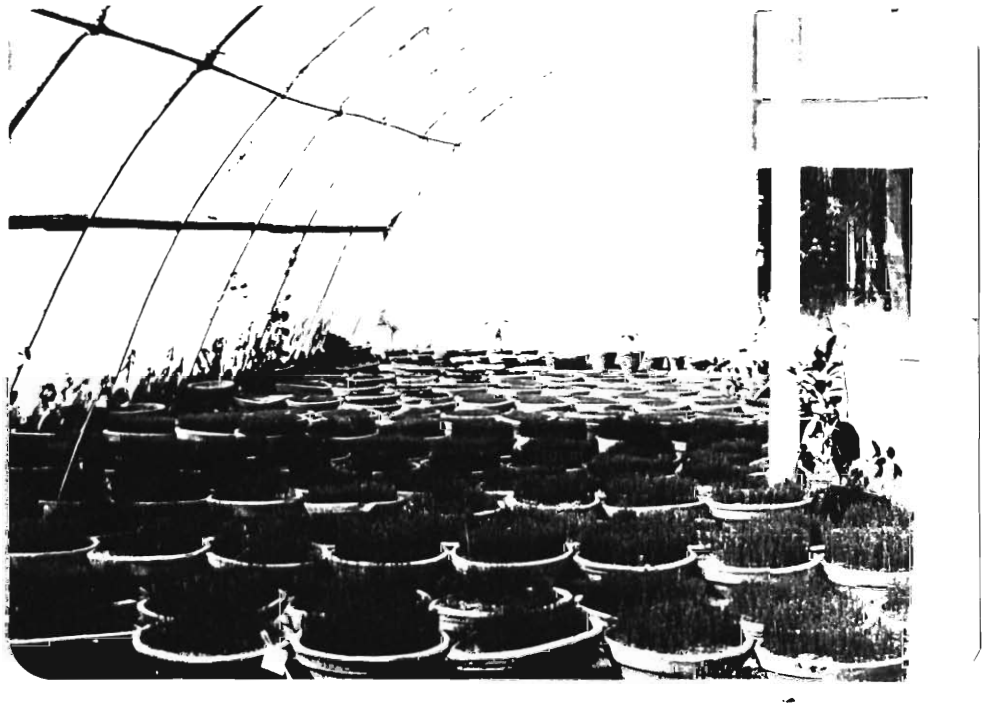

Fig. (7): Sowing of Casuarina seed in clay pots (seed beds)

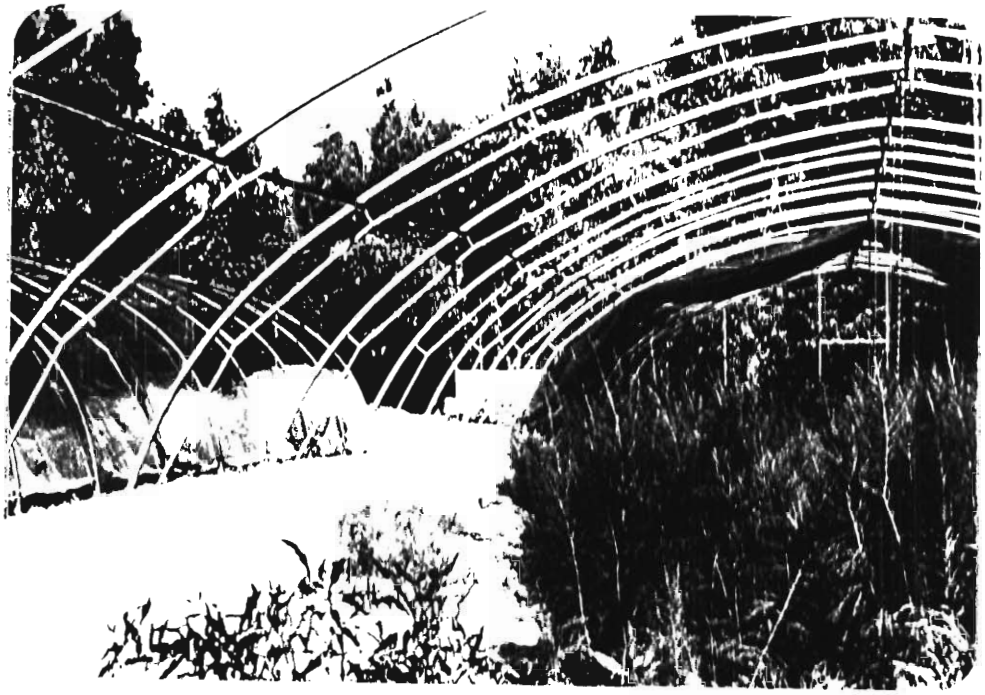

Fig. (8): New transplants in a modern nursery

Fig. (9): New transplants in a traditional nursery

The lack of reliable information in most nurseries was a limiting factor to collect data for previous years. Some nurseries owned by public sector's agricultural Companies have been turned to private ones such as the Nubaseed Nursery.

Tables (1 to 4) show the production of some nurseries in locations where superior mother trees were selected and recommended.

Table (1) shows the annual production of Casuarina seedlings at El-Sabahia research station which is about 200 meters from our Departmental nursery. The data indicate that the production varied from one year to another. The price of seedlings grown in clay pots is high as compared to those grown in plastic bags. The prices in governmental nurseries are fixed by the Ministry of Agriculture at nominal values to encourage planting of trees.

Table (2) shows the production of Casuarina equisetifolia at El-Maamora where the only man-made forest of Casuarina equisetifolia exists. Seedlings are planted to protect villas and cabins along the beaches at prices of 25 P.T. each. As shown from the data, annual production of Casuarina equisetifolia is decreasing.

Table (3) shows the production of El-Boseli nursery, which is located about 50 km. from Alexandria. This region is characterized by the presence of drifting sand dunes. Costs are higher than selling prices, but the difference is subsidized by the Ministry of Agriculture to encourage farmers to plant casuarina around their fields for the protection from sand and to prevent soil erosion. The annual production of seedlings indicates that it has been constant in the last three years. The small differences are attributed to the survival rate in the nursery.

Table (4) shows the production of casuarina seedlings at El-Kanater Research Station. The annual production has been nearly doubled in the seasons of 1985/1986 and 1986/1987 as compared to the previous years. The net income

Table (1): Production and Costs of Casuarina Seedlings at El-Sabahia Research Station Nursery, Abies during the period from 1984/1985 to 1986/1987

YEARS OF PRODUCTION	NO. OF PRODUCED SEEDLING	TOTAL COSTS L.E.	PRICE OF* SEEDLING P.T.	TOTAL INCOME L.E.	NET INCOME L.E.
1984/85	4679 (in plastic pags)	233	7	327	94
	948 (in pots)	85	25	237	152
1985/86	16,000	800	7	1120	320
1986/87	6,381	319	7	446	127

* Prices are fixed by the Ministry of Agriculture.

Table (2): Production and Costs of Casuarina equisetifolia Seedlings at El-Maamora Nursery during the period from 1984/1985 to 1986/1987

YEARS OF PRODUCTION	NO. OF PRODUCED SEEDLINGS	TOTAL COSTS L.E.	PRICE OF* SEEDLING P.T.	TOTAL INCOME L.E.	NET INCOME L.E.
1984/85	5,410	487	25	1352	865
1985/86	4,035	363	25	1008	645
1986/87	2,220	222	25	555	333

* Seedlings are produced in clay pots.

Table (3): Production and Costs of Casuarina Seedling of the Governmental Nursery at El-Boseli During the Period 1984/1985 to 1986/1987

YEARS OF PRODUCTION	NO. OF PRODUCED SEEDLING	TOTAL COSTS L.E.	PRICE OF SEEDLING P.T.	TOTAL INCOME L.E.	NET INCOME L.E.
1984/85	18,184	1636	7	1272	- 364
1985/86	18,895	1790	7	1392	- 398
1986/87	17,315	1558	7	1212	- 346

Table (4): Production and Costs of Casuarina Seedlings at El-Kanater Nursery Research Station for the Years 1983/1984 to 1986/1987

YEARS OF PRODUCTION	NO. OF PRODUCED SEEDLING	TOTAL COSTS L.E.	PRICE OF SEEDLING P.T.	TOTAL INCOME L.E.	NET INCOME L.E.
1983/84	11,645	472	6	698	226
1984/85	10,785	456	6	647	191
1985/86	23,925	957	8	1914	957
1986/87	19,595	783	10	1959	1176

increased 4-5 times in the last two years as compared to the years before. This nursery is supervised by one of our graduate students who recently got his M.Sc. on the viability of Casuarina seeds. He is using seeds from selected mother trees.

It is generally noticable that the production of governmental nurseries which were visited is very low. Other nurseries in the Delta produce many thousands of seedlings.

4.1.2. Production of agricultural companies:

Tables (5 and 6) show the production and costs of casuarina seedlings in the Public Sector Agricultural Companies of West Nubaria, Nubaseed, Wadi Kom-Imbo and El-Bihera Company.

The annual production of West Nubaria Company is 250,000 seedlings. The net income decreased in the seasons 1985/1986 and 1986/1987 due to the rising coasts of clay pots which are used and the costs of casual labor.

The data in Table (6) show the average production and costs in Nubaseed, Wadi Kom-Imbo and El-Bihera nurseries during the last three years. The production of Nubaseed nursery is the same as West Nubaria, but its net income is higher due to the low price of the polyethelyne bags. The overhead costs of Agricultural Engineers and administration are not included in the costs of production in nurseries of Agricultural Companies and governmental ones.

4.1.3. Production of private nurseries:

Table (7) shows the production of a sample of six private nurseries at El-Kanater El-Khairia during the season 1986/1987. the data indicate that the production varied from 10,000 up to 50,000 seedlings annually and that the costs of production are less than the governmental companies. Fig. (10) shows the production of one of the private nurseries we visited during the summer of 1987.

Fig. (10): Casuarina seedlings produced by a private nursery, near Cairo

Table (5): Production and Costs of Casuarina Seedlings at the Nursery of West Nubaria Company during the period from 1984/1985 to 1986/1987

YEARS OF PRODUCTION	NO. OF PRODUCED SEEDLING	TOTAL COSTS L.E.	PRICE OF SEEDLING P.T.	TOTAL INCOME L.E.	NET INCOME L.E.
1984/85	240,000	16,118	8	19,200	3,082
1985/86	250,000	22,800	10	25,000	2,200
1986/87	240,000	23,860	10	24,000	140

Table (6): Average Production and Costs of Casuarina Seedlings at the Nurseries of three Agricultural Companies in the last three years (1984/1985 to 1986/1987)

MEAN ANNUAL PRODUCTION	AVERAGE TOTAL COSTS (L.E.)	PRICE OF SEEDLING	AVERAGE TOTAL INCOME (L.E.)	ANNUAL NET INCOME (L.E.)
		NUBASEED		
250,000	13,750	8	20,000	6,250
		WADI KOM-IMBO		
10,000	8,300	10	10,000	1,700
		EL-BIHERA		
200,000	10,840	8	16,000	5,160

Table (7): Production and Costs of Some Private Nurseries at El-Kanater Region for the Year 1986/1987

OWNER'S NAME	NO. OF SEEDLINGS PRODUCTED	TOTAL COSTS (L.E.)	PRICE OF SEEDLING P.T.	TOTAL INCOME L.E.	NET INCOME L.E.
1. Ramadan Abdel Wahab	31,225	1,249	8-9	2,600	1,351
2. Fawzi Dahi	35,627	1,425	10	3,562	2,117
3. Fawzi Ibrahim El-Hag	50,234	2,009	10	5,023	3,014
4. Saleh Ibrahim Mahmoud	10,000	4,000	8	800	400
5. Hamdy Dowich	20,000	8,000	8	1,600	800
6. Abdel Khalik Maghawry	18,260	7,400	10	1,826	1,086

The private nurseries sell their production locally. Most of them select the mother trees after advice from the research team. In many cases the Department of Timber Trees and Wood Technology at Alexandria University provides the private nurseries with some improved seeds whenever available. All governmental and public company nurseries obtain their seeds from selected Seed Production Areas.

4.2. Socio-Economic Survey of the Response of Farmers and Agricultural Companies to the Use of Improved Casuarina Seed:

A primary reconnaissance survey of Casuarina shelterbelt planting in North-Western Egypt was conducted. Then a single interview survey was conducted in two selected reclaimed areas (El-Nahda and El-Noubaria) in order to: (i) verify and quantify the findings of the reconnaissance survey and (ii) collect information on the extent of using improved seed by farmers and companies.

The sequence of the development of the needed questionnaire proceeded as follows: determining the type of questionnaire, deciding on wording of questions, deciding on question sequence, determining layout and length and finally pre-testing and revising.

Two different kinds of questionnaires(*) were conducted, one for Farmers and another for Agricultural Companies which are dealing with Casuarina planting in newly reclaimed areas.

4.2.1. Sampling:

The study took place in the North-West region of Egypt, especially the new farms close to the Cairo-Alexandria desert road.

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* Blank samples of the two questionnaires are given in Appendix A.

The sample for testing the degree of farmer's response to using selected seeds and seedlings consisted of 25 farmers distributed as follows (Table 8): 13, 8, 10, in El-Boustan, West Noubaria and El-Ammerya areas, respectively. On the average, 25% of the farmer's population were interviewed in each community. The study also included 6 farmers who do not plant casuarina, selected randomly from the above mentioned areas. The reason was to compare the yields of the crops protected by casuarina with the yields of unprotected fields. The samples were chosen randomly after frequent visits to each community and acquaintance with farmers in the areas under study. Field visits and interviews were done with the head of the household directly or the person in charge of making the agricultural decisions.

Table (8): The Sample Frame for Testing the Degree of Farmers and Agricultural Companies Response to Planting Casuarina

SAMPLE UNIT	FARMERS		AGRICULTURAL	COMPANIES
AREA	NUMBER	%	NUMBER	%
El-Boustan	13	42	2	50
West Nubaria	8	26	1	25
El-Ammerya	10	32	1	25
TOTAL	31	100	4	100
Sample as % of the Studied Community	25%		50%	

As for testing the degree of Agricultural Companies' response to the use of selected casuarina seedlings, the sample consisted of 4 land reclamation companies. They were all chosen randomly from the districts of El-Boustan, West Noubaria and El Ammerya. This sample represents more than 50% of the total number of the Agricultural Companies in the region.

4.2.2. Cross - sectional data analysis and results:

Analyses of Tables (9 through 16) lead to the following conclusions:

a- The majority of the farmers (81%) grow casuarina while only 19% do not, (Table 9).

b- The majority of the farmers (92%) plant casuarina because they realize its protecting role. Only a few farmers, however, realized its direct role in increasing the yield. Other reasons included improving the environment and sand stabilization.

Some farmers, however plant casuarina to obtain timber, thus it can be concluded that farmers grow casuarina not for direct economic gain, but rather for protecting the crop. It is obvious also from Table (10) that a good number of farmers grow casuarina for more than one reason, i.e. as a multipurpose tree. Figures (5, 6 and 7) show casuarina trees used for protecting high ways, fields and fixing the sand.

c- 44% of the farmers face nor problem in planting casuarina, while an almost equal percentage (40%) have some problems, (Table 11).

d- The problems facing the farmers, as given in Table (12) are several. Nearly half of the farmers face irrigation problems which were mainly related to special provisions for irrigation in terms of canals, ditches and drip irrigation lines. The second

Table (9): Percentage of Farmers Planting Casuarina (A Sample of 31 Farmers in Newly Reclaimed Land)

FARMERS	NUMBER	%
Plant Casuarina and intend to continue	25	80.6
Do not grow Casuarina	6	19.4

Table (10): Reasons for Planting Casuarina

REASONS	NUMBER	%
To proetct crops from strong winds	23	92
To improve yield	0	-
To make the farm looks good	8	32
To sell or use its wood	5	20
To fix the sand	7	28
It does not need much effort	3	12
I don't know other species	1	4
My family used to plant it	1	4
Other reasons	1	4

Table (11): Problems of Growing Casuarina

FARMERS GROWING CASUARINA	NUMBER	%
Having no problem in growing Casuarina	11	44
Having problems in growing Casuarina	10	40
Did not answer	4	16

Table (12): Problems Preventing Farmers from Planting Casuarina

PROBLEMS	NUMBER	%
Irrigation	5	42
Labour	3	25
High prices of seedlings	1	10
Disease infection	2	14
Casuarina shades cultivated crops	1	10

important problem (40% of the Farmers) hindring casuarina growing is the cost of labor. Some farmers (20%) do not plant casuarina because they believe that it may transmit diseases such as nematode. Studies by the Department of Forestry proved that C. cunninghamiana and C. glauca can be infected by nematodes and that trees are not nematode carriers. Only 10% of the farmers who do not plant casuarina gave high cost of seedlings as a reason. Another 10% suspected that casuarina has a detremental shading effect on other crops i.e. they do not like it for its negative effect. However, the studies made by the research team during the project proved that casuarina shelterbelts in West Nubaria region increase they yield of wheat by 15% over the non protected fields within a horizonal area up to 20 times the tree height. In corn, the icnrease in yield was 23%.

e- The majority of the farmers (56%) planted casuarina in the last 5 years which is the period after the end of the Casuarina Project. This reflects the impcat of the project on the farmers, as they were convinced with the benefits of using improved casuarina seeds as well as its good survival and growth under such harsh conditions. Other indirect benefits were also understood by the farmers. About one fifth of the farmers had casuarina for 7-20 years, Table (13).

f- The survival percent of casuarina plantations indicates that nearly half of the farmers have 80-95% survival in their casuarina plantations (Table 14) while only 10% of them had low survival (30-35%). This indicates that the Egyptian farmers can grow and care for casuarina. This also reflects the fact that the farmers use improved seed which can tolerate adverse environmental conditions in the early stages of growth in the permanent site. Proper planting and maintenance methods are also well understood by the farmers as indicated by the recommendation gained from the project.

Table (13): Length of Time for having Grown Casuarina

TIME	NO. OF FARMERS	%
1-5 years	14	56
7-20 years	5	20
Since receiving the land	4	16
Did not know	2	8

Table (14): Estimated Seedling Survival Rates in Casuarina

SEEDLING SURVIVAL RATE (%)	FARMERS	
	NUMBRE	%
30-50	3	12
50-80	8	32
85-95	11	44
Did not know	3	12

g- It appears that most of the farmers (80%) grow Casuarina glauca (Table 15). This species has been recommended by the research group for this region. It has proved to be quite tolerant to the highly calcareous soils of the region and has a faster rate of growth as compared to other species (El-Lakany et.al., 1981). The other two species C. equisetifolia and C. cunninghamiana are grown to a lesser extent and they likely hybrids or even mis-identified. The farmers obtain these seedlings from governmental nurseries since the prices are subsidized and the seed sources are known. Most of the governmental nurseries in the region are managed to our graduate who are trained on the methods of selecting proper mother trees.

The shelterbelts of the region are mostly composed of two rows (Table 15) as recommended by our research team.

Most of the land protected by shelterbelts belong to small holders, farming 5-10 feddans. Thus the impact of the project is felt by the majority of farmers.

h- A governmental nursery at Noubaseed was taken as an example to study the economics of seedling production in details. The estimated costs of production per one seedling was 5.7 P.T. distributed to the cost items of seeds, labour, fertilizers and plastic bags. The average selling price of one seedling is 10 P.T. in the area, so it makes a net profit of about 4.3 P.T. for each seedling (Table 16). However the overhead (Agriculture engineers, management and administration) are not included.

It is estimated that each feddan requires 200-300 seedlings for sheltering on the average at a cost of approximately 10 P.T./seedlings for site preparation and planting. Thus the feddan costs 40-60 L.E. including seedlings costs.

Table (15): Types of Seedlings, Sources, Number of Rows Planted in Shalterbelts and Areas Covered by Shelterbelts in the Studied Region in 1987

	NO. OF FARMERS	%
1. TYPE OF SEEDLINGS:		
Casuarina glauca	20	80
C. equifetifolia	4	16
C. cunninghamiana	1	4
2. SOURCE OF SEEDLINGS:		
Governmental nurseries	24	96
Private nurseries	1	4
3. NUMBER OF ROWS PLANTED PER SHELTERBELT:		
One row	7	28
Two rows	14	56
Three rows or more	4	16
4. SIZE OF FARMS PROTECTED BY SHELTERBELTS:		
5-10 feddans	18	72
11-20 feddans	5	20
More than 21 feddans	2	8

Table (16): Economics of Producing 100,000 Casuarina Seedling in the Area in 1987 (Nubaseed Company)

COST ITEMS*	AVERAGE VALUE (L.E./SEASON)	NOTES
Seed:	200	20 kg. seed is collected yearly from seed production areas at a cost of L.E. 10 per kg. (labor)
Labour:	3000	
Fertilizers	75	
Plastic pags	2400	
TOTAL COST OF PRODUCTION	5675	
COSTS OF PRODUCTION PER ONE SEEDLING	5.7 P.T.	
SELLING PRICE/SEEDLING	10 P.T.	
POFIT PER SEEDLING	4.3 P.T.	

* Note that overhead (Agricultural engineers, management and administration) is not included.

It was difficult to estimate the total returns of casuarina cultivation through the current study. A good data base for a time series is needed to estimate returns of using casuarina for protection (estimating of apprortunity costs of no casuarina protection) of cropping patterns, the return from selling the wood production of casuarina trees and the return for using casuarina in animal feeding and as fuel.

It is suggested to have a seperate study dedicated for the returns of the different uses of casuarina. As a result of the survey the estimated return of protection is represented by the increase in the yield of protected crops against the decrease in production from unprotected crop with a percentage varying from 15% to 23%. This percentage causes an increase in the return of the protected cropping pattern.

Finally, from the survey results it was evident that the farmers and Agricultural Companies are responding favourably to the use of selected seeds of casuarina. That was after knowing the strong correlation between the high percentage of surviving plants from selected seeds compared to the low percentage of surviving plants from non-selected seeds.

4.3. Growth of Selected Material:

Selected material was mainly planted in two locations, the Experimental Station of the Faculty of Agriculture, Alexandria University and in the West Nubaria and Nubaseed Agricultural Companies.

4.3.1. Growth of trees from selected material at the experimental station:

A comparison was made between two plantations. The first was a grafted seed orchard (Figures 11 and 12) originated from selected plus trees, while the second was from seedlings of the same trees (i.e. seedling seed orchard). Both were established in 1979.

At the age of 8 years, the height, d.b.h., volume and annual rate of growth were compared in the two plantations. The height of each tree was measured to the nearest cm and the diameter (d.b.h.) was measured to the nearest 0.1 cm. The volume of growth depended on stocking which was 70% on the average.

The following formula was used to calculate the volume of the tree:

$V = \pi r^2 LF$ where
V = Volume of tree.

πr^2 = basal area at b.h.

L = tree height
F = cylindrical form factor

The cylindrical form factor is an expression of the degree of tree tapering. It was considered 0.6 for this plantation. Table (17) shows the estimated volume of wood per feddan (4200 m^2) in cubic meters as well as the mean annual growth.

The following is a brief summary of results obtained:

a- In grafted trees the growth of Casuarina glauca was slightly higher than that of Casuarina cunninghamiana.

Table (17): Growth of 8 Years Old Grafted Casuarina and Seedlings from Selected Material in (m^3) at the Experimental Station of the Forestry Department Near Alexandria

SPECIES	GRAFTED SEED ORCHARD		SEEDLING SEED ORCHARD	
	VOLUME/FEDDAN	ANNUAL GROWTH/ FEDDAN	VOLUME/FEDDAN	ANNUAL GROWTH/ FEDDAN
Cas. cunninghamiana	70.7±20.3	8.80	55.4± 7.08	6.9
Cas. glauca	79.6±21.4	9.95	80 ±10.70	10
Cas. glauca X Cas. cunninghamiana	-	-	51.9±24.10	6.5

Fig. (11): Successful grafting of Casuarina (Alexandria University Seed Orchard)

Fig. (12): Un-successful grafting of Casuarina (Alexandria University Seed Orchard)

b- Irrespective of seed origin; the growth of Casuarina cunninghamiana and the hybrid is nearly the same. Casuarina glauca has better heights and diameters and its yield is about 1.5 times that of the others two taxa.

c- It can be concluded that the growth of 8 years old Casuarina glauca produced either by gravting or from seedlings from the same mother trees is similar. This indicates a high heritability of growth in Casuarina glauca. However, in Casuarina cunninghamiana, the trees produced by grafting had slightly larger volume than those produced from seedlings. The volume growth of the hybrid is comparable to either of its suggested parents.

Thus, it is recommended to use open pollinated seeds from superior tree of Casuarina glauca without much loss of growth vigor.

Another study was undertaken to compare the growth of trees produced from selected and un-selected mother trees. The seedlings of the un-selected materials were produced in a local nursery using the traditional methods of seed collection and seedling production. Seven years old plantations were used for this study. The volumes obtained are given in Table (18).

It is clear from the comparison between the last two tables that Casuarina equisetifolia had the least mean annual growth which is attributed to inadaptability to the site. The differences among Casuarina glauca, Casuarina cunninghamiana and the natural hybrid are not pronounced.

The mean annual growth values indicate that using seeds of superior trees increased the mean annual growth by 33% in Casuarina cunninghamiana, 122% in Casuarina glauca and 55% in the natural hybrid.

Table (18): Growth of 7 Years Old Un-selected Casuarina Species Grown in the Experimental Area of the Forestry Department

SPECIES	VOLUME/FEDDAN (M^3)	ANNUAL GROWTH/ FEDDAN (M^3)
Cas. equisetifolia	18.7 ± 1.59	2.7
Cas. cunninghamiana	36.7 ± 3.58	5.2
Cas. glauca	31.5 ± 2.94	4.5
Cas. glauca X Cas. cunning	28.1 ± 2.50	4.0

The data reflect the importance of using seeds from selected superior trees as a very simple and effective method for improving the growth of planted Casuarina trees.

4.3.2. Growth of trees from selected material under saline conditions:

Increased salinity is a major problem in many areas of the northern coast. A trial was established to evalute the growth of selected material collected during the second phase of the project under saline conditions. Table (19) shows soil analysis in the two sites of variable levels of salinity chosen for this respect. Table (20) illustrates the growth of trees in both locations. The data in Tables (17) and (20), which represent the growth under normal and adverse saline conditions, repectively, indicate that the growth was reduced under the saline conditions. The mean annual growth was reduced from 6.9 m^3 (normal conditions) to 2.03 m^3 (location 1) and 0.152 m^2 (location 2) for Casuarina cunninghamiana and from 10 m^3 to 3.52 m^3 and 0.43 m^3 for Casuarina glauca, respectively. In the natural hybrid, mean annual growth was 6.5 m^3 and 2.15 for normal conditions and location 1, respectively. It could be concluded that the studied species tolerate the moderate level of salinity in location 1.

As a result of the high toleratce of Casuarina to harsh environmental conditions, it was chosen to protect the Alexandria - Cairo desert highway which includes 60 kilometer within the area where the Casuarina Project was implemented. Also Casuarina is chosen as the main tree for establishing a greenbelt around the great Cairo.

Table (19): Physico - Chemical Analysis of the Soil at Some Locations Affected by Salinity, Near Alexandria

DEPTH* cm	CLAY %	SALT %	SAND %	TEXTURAL CLASS	pH	EC m/mhos/cm	SOLUBLE CATIONS				SOLUBLE ANIONS			
							Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
				LOCATION NO. 1										
Zero-30	26	30	44	Clay loam	7.3	7.5	28	17	30	2	-	6.5	40	30
30-60	19	42	39	Clay loam	7.4	4.9	5	13	22	1.5	-	3.0	20	38
				LOCATION NO. 2										
Zero-30	49	17	34	Sandy Clay loam	7.1	16	62	19	87	1.5	-	4.0	140	12
30-60	44	20	36	Clay loam	6.7	12	32	12	40	2.0	-	3.5	66	14

Table (20): Growth of 6 Years Old Casuarina from Selected Material in Two Saline Locations at the Experimental Station of the Forestry Department

SPECIES	LOCATION NO. 1		LOCATION NO. 2	
	VOLUME/FEDDAN (M^3)	ANNUAL GROWTH/ FEDDAN (M^3)	VOLUME/FEDDAN (M^3)	ANNUAL GROWTH/ FEDDAN (M^3)
Cas. equisetifolia	14.4 ± 2.17	2.4	2.8 ± 0.46	0.47
Cas. cunninghamiana	12.2 ± 2.35	2.03	0.91 ± 0.21	0.15
Cas. glauca	21.1 ± 2.7	3.52	2.6 ± 10.5	0.43
Cas. glauca X Cas. cunninghamiana	12.9 ± 2.07	2.15	-	-

4.3.3. Selected trees as a source of fuel:

A casuarina plantation at the experimental station was designated as a fuelwood plantation. The original trees were cut at the age of one year, then the coppice was maintained as a fuel source. Table (21) shows the average number of stems per tree, the height of the tallest stem and the diameter at breast height of the thickest stem. Casuarina glauca yielded more coppice and had taller and thicker stems in comparison to Casuarina cunninghamiana and the natural hybrid (Figures 13 and 14). Casuarina glauca is recommended as a fuel wood tree under such conditions.

4.3.4. Growth of trees from selected material at West Nubaria Agricultural Companies:

Nubaria region was chosen as an experimental site during the project duration. It represents the majority of the newly reclaimed land. Experiments were carried out at the Agricultural Companies of West Nubaria and Nubaseed as follows:

4.3.4.1. Second grafted seed orchard:

A Grafted Seed Orchard was established at West Nubaria nursery. (Figure 15). Seedlings were planted at 2 X 2 m and grafted in 1979 using scions from plus trees.* The growth of Casuarina glauca was found to be better than Casuarina cunninghamiana (Table 22). The volume of tree stems averaged 0.267 m^3 for the two species, respectively. The volume of the stems was 7-9 times that of the trees grown in the Experimental Station of the Department, which reflects the response of Casuarina to site conditions.

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* Details are given in final report of the Casuarina Projects.

Fig. (13): Coppice of Casuarina glauca for fuel (near Alexandria)

Fig. (14): Coppice of Casuarina cunninghamiana (near Alexandria)

Fig. (15): Grafted Seed Orchard at Nubaseed Company

Table (21): Average Number of Stems, Height of the Tallest Stem, d.b.h. of the Thickest Stem of FuelWood Trees Planted in 1979 at the Experimental Station of the Faculty of Agriculture, Alexandria

SPECIES	AVERAGE NO. OF COPPICE STEMS	HEIGHT OF THE TALLEST STEM (m)	d.b.h. OF THE THICKEST STEM (cm)
Cas. cunninghamiana	4.4 ± 0.34	3.6 ± 0.14	3.9 ± 0.22
Cas. glauca	5.5 ± 0.45	6.3 ± 0.18	5.3 ± 0.20
Cas. glauca X Cas. cunninghamiana	3.8 ± 0.30	4.1 ± 0.22	4.7 ± 0.37

Table (22): Volume of 8 Years Old Grafted Casuarina Plantation from Selected Material in m^3 at West Nubaria Region

SPECIES	GRAFTED SEED ORCHARD	PLANTATIONS	
	AVERAGE VOLUME OF TREE STEM	VOLUME/ FEDDAN	ANNUAL GROWTH/ FEDDAN
Cas. cunninghamiana	0.192 ± 0.012	-	-
Cas. glauca	0.267 ± 0.014	122.5 ± 7.6	15.3 ± 0.98

4.3.4.2. Growth of trees from selected material at Nubaria:

Two man-made small forests were planted at West Nubaria in two locations where it was difficult to plant field crops. They consist only of Casuarina glauca. Trees were planted from selected material at a spacing of 2 X 1.5 m in 1979. Measurements were carried out at one of the two plantations (Figure 16).

The data in Table (22) indicated that trees are now of a good heights (15.4 m on the average). However, the radial growth is still small. A thinning program should be emplimented to reduce the density of trees in order to stimulate the radial growth.

Fig. (16): An 8-years old Casuarina glauca plantati
from selected material (West Nubaria regio

5. GENERAL CONCLUSIONS:

a- The production of seedlings from seeds collected from selected Seed Production Areas has been increasing as a result of the recommendations of the project team.

b- The Seed Orchards and Woodlots planted during the project are considered as an extension farms for the Agricultural Companeis and private sector to show the importance of using good (improved) seed sources.

c- Most of the nurseries in the area are trying to secure good seed sources, but the amounts of seeds are not enough. As a result of lack of funds needed for collecting and providing good seeds from the Seed Production Areas, and Seed Orchards which have been selected, established and tested by the project, supply of improved seeds is not as easy as it was hoped to be. However, the farmers and government officials are fully anware of the benifits of using improved material. The two Seed Orchards established by the Project provide improved seeds to government and private nurseries. In our opiyon planting of Casuarina has increased at least 10 folds in the past ten years. The Casuarina Project contributed substantially to this trend. Few post graduate theses and research papers were originated from this project as listed in Appendix B.

APPENDIX (A)

Sample Questionnaires

(1) For Farmers
(2) For Agricultural Companies

(Note: Arabic Originals are attached)

(1) A QUESTIONNAIRE FOR THE DEGREE OF FARMER'S RESPONSE TOWARDS PLANTING CASUARINA*

- Name:

- Region, Village:

- Farmer's Origin. (The region from which he migrated to the new land).

- Size of Farm:

- Land Tenure Status:

- Cropping Pattern:

- Prennial Crops: Area: Average/Yield/Feddan

  1.
  2.

---

* This questionnaire is designed to serve only the objectives of scientific research dealing with the planting of casuarina in the new land. Information given by the farmer is confidential. Original questionnaire is in Arabic.

- Summer Crops: Area: Average/Yield/Feddan

  1.
  2.
  3.

- Winter Crops: Area: Average/Yield/Feddan

  1.
  2.
  3.

- First Part: Planting of Casuarina

  1. Do you plant casuarina on your farm?

     Yes No

     In case the answer to the first question is No:

  2. Why don't you plant casuarina?

     - because I can't find seedlings
     - because I don't know much about methods of planting
     - because planting is expensive
     - because I had a bad experience with it before
     - because I have no crops that need protection
     - because it takes a long time to get returns
     - other resons (explain)

3. How would you change your mind and plant casuarina?

In case the answer to the first question is YES:

4. When did you start planting casuarina?

5. Why do you plant casuarina?

- to protect crops from strong wind
- to makes my farm looks good
- to sell or use wood later on
- it gives good return
- because it doesn't need much effort
- to fix the sand
- because I don't know of other windbreaks
- because my family used to plant it
- other reasons (explain)

6. Do you intenf to continue planting casuarina?

Yes No

* In case the answer the sixth question is No

7. Why don't you intend to continue planting casuarina?

8. What are the problems you face while planting casuarina?

* In case the answer to the sixth question is YES

9. What are the types of seedlings you use? (species, variety)

10. From where do you obtain seedlings?

11. Out of 100 planted seedlings how many plants survive?

12. What distance do you keep between rows and between seedlings in each row?

13. How may lines do you plant as a windbreak?

14. How many feddans are protected or grown by casuarina in your farm?

15. What are the different uses for the casuarina you grow?

16. Have you been visited or contacted by the Research Team from Alexandria?

- Second Part: Economics of Casuarina Planting

Table (1): Returns from Selling Casuarina Wood

	Quntity	Area	Year of Cutting	Value in L.E.
Return from selling wood: Quantity produced Quantity sold Quantity used for own purpose				

Table (2): Yields of protected and unprotected crops

Crops Culivated in the area	Yield/feddan in kg	
	With the protection of Casuarina	Without the protection of Casuarina
1. Field Crops ■ Wheat ■ Barley ■ Peanuts ■ Clover ■ Others		
2. Vegetables ■ Peas ■ Onions ■ Beans ■ Others		
3. Fruits ■ Graps ■ Citrus ■ Others		

The opportunity costs of using casuarina in protecting the fields = (the losses in the production of unprotected crops)

(2) QUESTIONNAIRE FOR AGRICULTURAL COMPANIES:*

- Name of the Company: Region

- Cultivated Area:

- Cropping Patterns

- Perennial Crops Area

  1.

  2.

  3.

- Summer Crops Area

  1.

  2.

  3.

  4.

- Winter Crops Area

  1.

  2.

  3.

  4.

---

* This questionnaire is designed to serve only the objectives of scientific research dealing with the economics of producing and planting casuarina in the new land. (Original in Arabic)

- First Part: Sources of Casuarina Seeds

  - What are the sources of the casuarina seeds? (local - imported)

  - How much you collect annually?

  - How do you recognize the characteristics of the trees from which seeds are collected? (Mother trees).

  - How important is the use of the seeds from the selected trees?

  - What is the importance of using selected seeds from the Nursery supervisors point of view?

  - What are the differences between the off-springs of selected trees and those from the un-selected?

- Second Part:

1. Nursery Area?

2. Number of greenhouses and shadehouses in the nursery?

3. Number of seedlings produced annually?
   (average of the last 5 years)

4. Price of seedlings?

5. The percentage of success of in the nursery.

6. Production costs*

   a) Cost of seeds

   b) Cost of seedling production

   c) Do you use clay pots or plastic bags?

   d) The cost of pots or plastic bags?

   e) How many laborers in the nursery?

   f) Wages of permenant labor

   g) Wages of seasonal labor

   h) Costs of organic and chemical fertilizers.

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* Management costs not included.

- Third Part:

The size of the area grown with Casuarina woodlots and windbreaks.

I. Woodlots:

1. Area

2. Species and varieties of Casuarina used

3. Spacing

4. Costs of cultivation

a) seedlings pits labor

b) planting labor

c) fertilizer and irrigation

d) tending

II. Number of Rows of Casuarina Trees (Windbreaks):

1. Around the farms

2. Along the main roads and canals.

3. Around sewage desposal areas.

4. Distance between trees.

APPENDIX (B-1)

M.Sc. and Ph.D. Theses on Casuarina Granted During and After the Project

M.Sc. THESES:

1- Al-Farrajii, F.A.M., 1978

Growth of some timber tree seedlings under different calcium carbonate percentages and irrigation treatments.

2- Mohamed, S.Y., 1979

Intra- and inter- specific variation in the growth and root distribution of casuarina grown under different soil characteristics.

3- El-Baha, A.M., 1979

Effect of soil type and fertilization on growth and NPK content of some timber tree seedlings.

4- Mohamed, Y.M., 1979

Weed control in relation to growth and mineral content of casuarina trees.

5- Shehata, M.S.S., 1987

Variation in seed germination and seedling growth in casuarina species grown in Egypt.

Ph.D. THESES:

1- Hassan F.A.E., 1984

Analysis of wood extractives in relation to infestation level of Casuarina glauca with casuarina stem borer (Stromatium fuluum) and entomogenous fungi associated with larvae.

APPENDIX (B-2)

List of Publication on Casuarina Granted During and After the Project

1- Badran, O.A., M.H. El-Lakany, M.L. El-Osta and H.A. Abo-Gazia (1976). Breeding and improving Casuarina trees. 1. Taxonomy and morphological characteristics of Casuarina spp. grown in Egypt. Alex. J. Agric. Res. 24: 683-694.

2- Badran, O.A., M.H. El-Lakany, T.A. Omran and N.Y. Shehata (1977). Growth and mineral content of some woody tree species as affected by soil type and level of water table. Alex. J. Agric. Res. 25: 519-524.

3- Badran, O.A., and M.H. El-Lakany (1977). Breeding and imrpoving of Casuarina for shelterbelt plantations in Egypt. 3rd World Consultation on Forest Tree Breeding. Canberra, Australia, pp. 573-578.

4- Badran, O.A., and M.L. El-Osta (1977). Intraincrement specific gravity and total extractives of Casuarina glauca. Alex. J. Agric. Res. 25: 535-540.

5- Badran, O.A., T.A. Omran, A.B. El-Sayed and F.A.H. Farragii (1977). Growth of some timber tree seedlings under different calcium carbonate percentages and irrigation treatments. Alex. J. Agric. Res. 28: 359-375.

6- El-Lakany, M.H., L.G. Samaan and M.A. Abdel-Rehim, (1977). Genotypic relationships between some Casuarina taxa as determined by serological methods. Australian Forest Res. 7: 291-294.

7- El-Lakany, M.H., O.A. Badran, A.B. El-Sayed and S.Y.M. Ahmed (1981 [a]). On the performance of Casuarina species as influenced by soil characteristics. Alex. J. Agric. Res. 29: 381-394.

8- El-Lakany, M.H., O.A. Badran, A.B. El-Sayed and S.Y.M. Ahmed (1981 [b]). Intraspecific variation in the growth and performance of Casuarina. Alex. J. Agric. Res. 29: 961-972.

9- El-Lakany, M.H. (1981). Breeding and improving of Casuarina, a promising multipurpose tree for arid regions in Egypt. Proceedings of Casuaring ecology, management and utilization. International Workshop Canberra, Australia. pp. 58-65.

10- El-Lakany, M.H., O.A. Badran, S.Y.M. Ahmed and M., Saad-Allah (1982). Root distribution of young Casuarina as influenced by soil characteristics. Egypt J. Hort. 9: 31 1.

11- El-Lakany, M.H. (1983). A review of breeding drought resistant Casuarina for shelterbelt establishment in arid regions with special refrence to Egypt. Forest Ecology and Management 6: 129-137.

12- El-Lakany, M.H., and K.R. Shepherd (1983). Variation in seed germinability, seedling growth and biomass between provenances of Casuarina cunninghamiana Miq. and Casuarina glauca Sieb. Forest Ecology and Management 6: 201-216.

13- El-Lakany, M.H., T.A. Omran and M.S. Shehata (1987). Variation in seed germination of Casuarina species grown in Egypt. I. Effect of seed collection time and location on tree grown (in preparation).

14- El-Lakany, M.H., T.A. Omran and M.S. Shehata (1987). Influence of seed storage on the growth of Casuarina seedlings in the nursery (in preparation).

15- El-Osta, M.L., O.A. Badran and G.R. El-Sayed (1979). Specific gravity variation in Casuarina species as determined from increment cores. Alex. J. Agric. Res. 27: 351-357.

16- El-Osta, M.L., M.H. El-Lakany and M.M. Megahed (1981). Anatomical characteristics of some Casuarina species grown in Egypt. IAWA. Bulletin 2: 35-98.

17- El-Sayed, A.B., T.A. Omran and A.E. Khalil (1983). Influence of windbreaks on crop yields in West Nubaria region. Alexandria Science Exchange 4 (2): 181-195.

18- Fawaz, K.A.S., Abde-Ghafar, M.N. Alaa El-Din, and M.H. El-Lakany (1985). Nodulation and nitrogenase activity in Casuarina under Egyptian conditions. Alex. J. Agric. Res. 33:

19- Omran, T.A. and A.N. Nour (1981). Chemical composition and nutritive value of some tree species foliages and branchlets. Alex. J. Agric. Res. 29: 973-981.

20- Omran, T.A., M.H. El-Lakany and A.B. El-Sayed (1983). Propagation of Casuarina by air layers. Communications. Agrisciences Development Research No. 22. pp. 8.

21- Omran, T.A., I.A. Gaaboub, O.A. Badran and F.A. Hassan (1986). Studies on Casuarina glauca and Stromatium fulvum. I Relationship between infestation level and tree diameter, wood moisture and wood extractive content (Accepted for publication in Alex. J. Agric. Res.).

22- Omran, T.A., E.A. Gaaboub, O.A. Badran and F.A. Hassan (1986). Studies on Casuarina glauca and Stromatium fulvum. II Entomogenus fungi associated with larvae of Stromatium fuluum. (Accepted for publication in Anzeiger fur schadling skunde. PF lanzen-und umveltochutz. Verlag Paul parey. Berlin und Humburg.

23- Omran, T.A., I.A. Gaaboub, O.A. Badran and F.A. Hassan (1986). Studies on Casuarina glauca and Stromatium fulvum. III Effect of inoculation with fungal isolates on legnin and extractive content of the wood (Accepted for publication in Anzieger fur schodlings kunde. pflanzen-und unmwettschutz Verlag Paul Parey. Berline und Humburg.

24- Omran, T.A., M.H. El-Lakany and M.S. Shehata (1987). Variation in seed germination of Casuarina species grown in Egypt. III. Effect of seed storage (in preparation).

25- Rezk, M.A., A.B. El-Sayed and T.A. Omran (1985). Effect of Meliodogyn incognata on the growth and physiology of Eucalyptus, Casuarina and Acacia seedlings. Alex. J. Agric. Res. 30: 1148-1154.

26- Saleh, N.N. and M.H. El-Lakany (1979). A quantitative variation in the flavinoids and phenolics of some Casuarina species. Biomchem. Sys. Ecal. 7: 13-15.

27- Shepherd, K.R., and M.H. El-Lakany (1981). A provenance trial of Casuarina glauca and C. cunninghamian - Proceedings of Causarina Ecology, Management and Utilization. International Workshop. Canberra, Australia pp. 122-125.