Contribution of Casuarina to Soil Fertility in Egypt*

by

M.H. El-Lakany
Professor of Forestry, Alexandria University

and

Desert Development Center, A.U.C. Egypt

Abstract:

Casuarina equisetifolia, *C. cunninghamiana* and *C. glauca* are the most commonly grown trees in Egypt. They are planted mainly as windbreaks and in wood lots. This paper summarizes studies on nodulation, rate of nitrogen fixation and overall contribution of Casuarina to soil fertility. The results drawn from several nurseries and plantations as well as laboratory experiments substantiate the high efficiency of casuarina as a nitrogen fixer and soil improver. Artificial inoculation experiments proved the cross-inoculation ability among the three species.

* Paper presented at the "Nitrogen Fixing Trees Workshop, Biological improvement of soil", Dakar, Senegal, March 17-25, 1986.

INTRODUCTION

Natural forests existed in Egypt only 6-10 centuries ago, especially in the South where relics of these forests still remain as scattered trees and shrubs. Now, Egypt is one of the poorest countries in natural forests in the world. The integration between forestry and agriculture has been practiced in Egypt long before the term "Agroforestry" was coined. Ancient Egyptians were perhaps the first to introduce exotic trees. The merchant ships brought home seeds and tree seedlings from East Africa, Ethiopia, Yemen ad many other countries as early as the 20th century, B.C. In modern times, most likely in the early 1800's, Egypt witnessed extensive cultural, agricultural and technological developments. Many tree species were introduced; most important among which are members of the genera Eucalyptus, Casuarina and Acacia as well as some other ornamental trees and shrubs.

In Egypt, trees and shrubs are planted primeraly as windbreaks around the cultivated fields, along irrigation and drainage canals as well as along roads and highways. The farmer seldom leaves a spot that can support a tree without planting. The area of line plantations is estimated to be over 100,000 acres out of the 5.5 million acres cultivated area. The network of windbreaks and line plantation in Egypt maybe the most extensive and elaborate system of its kind in the arid regions of the world.

In the old land, the Nile Delta and Valley, the trees are grown to demarcate the borders of properties, to provide shade for people and farm animals, to act as windbreaks, to provide a reserve fodder and to provide wood for some cottage industries. The wood is seldom used for fuel as the traditional sources of energy are crop by-products or residues such as cotton and corn stalks, rice straw, cow dung and kerosene. Charcoaling is well known in Egypt using forest and fruit trees. Nevertheless, the process is still very primitive and wastefull.

In the new land, which is mainly located on the desert fringes, trees are primeraly grown for protection against desiccating winds. Shrubs, such as Acacia are often grown for sand dune stabilization on the Northwestern Coast and Sinai. On marginal and/or waste lands such as saline and water-logged areas where conventional field crops cannot be grown economically, certain Casuarina species have proved to be very successful.

Casuarina is the most extensively grown tree in Egypt at it represents over 80% of the total number of trees planted. Three species were identified in the country; namely C. equisetifolia, C. glauca and C. cunninghamiana. A natural hybrid between the last two species was also identified and described (Badran et al; 1979). While C. equisetifolia is mainly grown on the Mediterranean coast, the other taxa are grown inland without preference to specific site conditions. A casuarina breeding program was initiated at Alexandria University aiming at obtaining genetically improved material adapted for planting as shelterbelts or in wood lots in arid regions. The early results have been reviewed by El-Lakany (1983).

Casuarina contribute to soil fertility through nitrogen fixation, litter deposition and protection of top soil against soil and wind erosion. Nodulation and nitrogen fixation efficiency have been studies since 1978, (Fawaze et al; 1982). This paper is intended to summarize some of the results obtained so far.

MATERIAL AND METHODS

Several tree nurseries and plantations were studied where the roots of Casuarina seedlings and trees of different ages were examined for the presence of nodules. Clusters were counted then incubated with acetylene for 4 and 24 hours, immediately after collection for measuring nitrogenase activity. Ethylene production was measured using gas chromatography (Varian Aerograph Model 144010).

Cross inoculation experiments were carried out among the four Casuarina taxa using the water culture method (Bond and Hewitt, 1961). The seedlings were inoculated with a suspension of fresh-crushed nodules and were retained in a greenhouse for 183 days then examined.

RESULTS AND DISCUSSION

Field observations revealed that, in general, the nodulation of Casuarina differed between species and from one location to another for the same species. C. equistifolia and C. cunninghamiana appeared to produce fewer nodules than C. glauca.

The morphology of the nodules fits the description of Mowry (1933) to a large extent. They were found immediately under the main stem, at the beginning of the root system and were connected directly to the main root. Nodule masses with a diameter of 2-3 inches were not uncommon. The species of Casuarina examined did not differ in the morphology of their nodules.

It appeared that soil affects nodulation as the Casuarina trees grown on sandy soils bear relatively more nodules than those grown on heavy clay soils. Also, in the calcareous soils, Casuarina bears appreciable amounts of nodules, irrespective of the species. Casuarina trees grown on canal banks have more nodules than those grown far from the irrigation canals.

The amounts of nitrogen fixed/gm dry nodular tissue/year for C. glauca and C. cunninghamiana nodules at different ages and under different growing conditions are shown in Table (1). From the same nursery and at the same age, C. glauca fixed nitrogen at a higher rate than C. cunninghamiana. Differences within each species were related to nodular size as discussed below. In C. glauca trees, a negative correlation existed between nodular size and specific nitrogenase activity expressed as the amount of nitrogen fixed/gm dry weight/year.

When the activity of nitrogenase was determined in the nodules of old C. glauca trees grown as windbreaks in different locations, it was found that the amount of nitrogen fixed/gm nodule tissue was pronouncedly affected by site characteristics, Table (1). Nodules from trees bordering a grape farm had a higher activity than those obtained from trees bordering an olive farm. The grape farm is more frequently irrigated than olives and the later is mostly rainfed. Thus, it can be deduced that irrigated Casuarina plantations fix more nitrogen than those found on dry sites. Also, nodules obtained from trees grown under water logging conditions (on canal sides) fix nitrogen at a lower rate than those of nearby trees.

Generally, the uninoculated plants that were supplied with a nitrogen-free nutrient solution showed an entire lack of vigour, a yellowing and loss of foliage and no appreciable growth. Most of the plants inoculated with nodule homogenates and furnished only with nitrogen-free nutrient solution were nodulated, Table (2). Cross inoculation affected nodulation, dry weight and nitrogenase activity. Uninoculated Casuarina plants were characterized by lack of nodules and very low or absence of nitrogen fixation. The results described herein clearly show that cross inoculation is possible between the following taxa: C. glauca seedlings with C. equisetifolia nodule and vice versa, C. cunninghamiana seedlings with C. glauca nodules, and the natural hybrid (C. glauca x C. cunninghamiana) seedlings with C. glauca nodules.

Similarly, Bowen and Reddell (Personal Comm.) noted that the degree of nodulation varied between species and soils. Furthermore, members of the genus Allocasuarina nodulated less frequently than those of the genu Casuarina. They also found that Frankia from the Casuarina only occasionally nodulated species of Allocasuarina and vice versa; evidence for host specificty.

Our future research will deal primeraly with the estimation of the amounts of nitrogen fixed in different soils by different Casuarina species with special attention to desert sandy soils.

REFERENCES

- Badran, D.A., M.H. El-Lakany, M.L. El-Osta and H.A. Abu Gazia (1979). Breeding and improving casuarina trees. I. Taxonomy and morphological characteristics of Casuarina spp. growing in Egypt. Alex. J. Agric. Res. 24: 683-684.
- Bond, G. and E.J. Hewitt (1961). Molybdenum and the fixation of nitrogen in Myrica root nodules. Nature, 190: 1033.
- El-Lakany, M.H. (1983). A review of breeding drought resistant casuarina for shelterbelt establishment in arid regions. Forest Manag. Ecol. 6: 122-137.
- Fawaz, K.M., M.N. Alaa El-Din and M.H. El-Lakany (1982). Nodulation and nitrogenase activity of casuarina under Egyptian conditions. Alex. J. Agric. Res. (In Press).
- Mowry, H. 1933. Symbiotic nitrogen fixation in the genu Casuarina. Soil Sci. 36: 409-425.

Table (1): Nodulation and nitrogenase activity in different Casuarina trees

Species and tree characteristics	Nodular tissue (clusters) / tree			mg N_2 - fixed/ gm dry nodules/ year
	Average number	Average volume (cm^3)	Average dry weight (gm)	
C. glauca (1 yr. old seedlings in a nursery)	1.3	5.0	0.77	127
C. glauca (3 yr. old trees in a plantation)	4.5	37.5	6.55	266
C. glauca (Old trees on an irrigated graoe farm)	4.0	20	5.65	24
C. glauca (Old trees on a rainfed olive farm)	3.0	25	10.57	4
C. cunninghamiana (3 yr. old trees in a plantation)	1.5	4.5	1.07	14

Table (2): Average values of nodulation and nitrogenase activity in cross-inoculated Casuarina species

Seedling Species	Nodule Species	Nodulated plants %	No. of clusters / plant	Fresh Weight (gm)		Activity (n·mol/ System/h)	Sp. Nitrogenase/ activity (n mol/gm/nodule/h)	Total N_2 -fix. activity (gm/year)
				Nodule	Plant			
C. equis.	equis.	60	3.0	0.039	5.05	44	2664	217
C. equis.	glauca	58	2.0	0.042	4.48	88	7285	296
C. cunn.	equis.	100	2.0	0.033	4.81	79	2374	193
C. cunn.	glauca	87	1.9	0.030	3.58	79	2834	242
C. glauca	glauca	89	1.8	0.036	3.56	73	2122	135
C. glauca X C. cunn.	glauca	100	1.3	0.035	4.46	112	4272	349
C. cunn.	(control)	0	0	0	1.11	2.5	-	-