Introductory Remarks
A Brief Account of Casuarina Research: Past Achievements and Future Trends

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Abstract

Casuarina research is recent relative to that directed towards other more commercially important forest trees. This multipurpose tree caught the attention of researchers and foresters alike because of its versatility as far as site requirements and utilization. Research interest moved from bio-nitrogen fixation, taxonomy, species and provenance trials in different sites, suitability as shelterbelts, tolerance to harsh environmental conditions (e.g. soil and water salinity, drought, pollution etc.), and yield studies, to allelopathic effects. So far very little has been done on wood properties and utilization. There is a current revival in micro-symbioses research after the identification of superior Frankia strains and the industrialization of inoculant production. Future research is expected to address selection and growing of casuarina under adverse environmental conditions, irrigated plantations (especially the use of municipal waste water), tolerance to pollutants, microbiology, and clonal propagation of genetically improved material. This paper outlines the recent developments in biological and environmental research on casuarina and points out potentials for future trends.

Introduction

Casuarinas offer a good model to trace historical and technical developments in forestry research on the so-called "less important tree species". After an active period of taxonomic research around the turn of the century, casuarina research slowed down due to the then insignificant value of its timber relative to other more important genera in its native land, such as Eucalyptus. It was not until the late 1950s and early 1960s when its biological nitrogen fixation ability was realized, that a new window was opened for research. The discovery of Casuarina/ Frankia association soon after has given research a momentum ever since, though undertaken mostly by non-foresters.

By the late 1960s, casuarina ecophysiology, and to a less extent, forestry research was emphasized in Australia and many other countries, where casuarina has been introduced since the turn of the century. Introduction and large scale planting has covered extensive areas around the world extending from India and China to the Middle East and West and East Africa, and even to south and southwestern United States and limited parts of South America. Some primary research must have accompanied species introductions in its early stages. The species most commonly introduced has been C. equisetifolia, although C. cunninghamiana and C. glauca were often included in the early trials.

Organized species introductions followed by provenance trials began in the 1970s, notably at Alexandria University, Egypt. The CSIRO Australian Tree Seed Centre, in collaboration with the author, organized the first provenance collections of C. glauca and C. cunninghamiana in 1977. That was followed by several expeditions to collect these and other species (Vercoe and Midgley 1993). The latest of such collections covered a large part of the natural distribution of C. equisetifolia, along with several land races from around the world where casuarina has been introduced (Pinyopusarak and House 1993). These seed sources have formed the basis for international provenance trials in several countries.

Casuarina research has moved systematically from species to provenance trials especially under adverse climatic and edaphic conditions (e.g. aridity, drought, soil and water salinity and waterlogging), and these have yielded some very valuable results which are being applied in many countries. But most scientific advancements in basic and applied research have been accomplished in the field of Casuarina/Frankia symbioses. After the successful isolation and culturing of Frankia, the most promising strains are being produced.

The following account gives some examples of recent research undertaken in different parts of the world on casuarina. It is by no means intended to cover all aspects of research, nor is this a literature review. Research prior to 1990 has been summarized by El-Lakany et al. (1990). Important subjects for future research to fill existing gaps

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are recommended with special emphasis on the role of casuarina research in a changing world.

**Current Research**

**Casuarina/Frankia association**

The *Casuarina/Frankia* association is the most extensively researched subject, judging from the number of articles, reports, books, symposia and workshops produced and undertaken in the last ten years. A quick survey of the pertinent literature in the last five years revealed that over 70% have dealt with subjects related directly to N-fixation. The research has covered various topics including micro-biological aspects (e.g. Benson and Schultz 1990; Schwencke 1991; Selim and Schwencke 1994; Sellstedt and Mattsson 1994), effects of external factors on nodulation, *Frankia* effectiveness and N-fixing efficiency (e.g. Mariotti *et al.* 1992; Miettinen *et al.* 1992, Arnone *et al.* 1994; Selim and Schwencke 1995).

The characteristics of *Casuarina/Frankia* combinations i.e. strain specificity, have also been the subject of elaborate research (e.g. Sougoufara *et al.* 1992; Mansour and Baker 1994). Similarly, quantification of nitrogen fixation and contribution of casuarina to soil fertility have been studied at length (e.g. Parrotta *et al.* 1994).

Mycorrhizae *Frankia* interactions and complementarity were also investigated by several researchers (e.g. Gunjal and Patil 1992; Khan 1993; Myers 1993). Meanwhile, the interrelationship between *Frankia* and several pathogens received some attention (e.g. Pena *et al.* 1994).

Most of the information related to biological nitrogen fixation by casuarina has been documented in books and proceedings, (e.g. El-Lakany *et al.* 1990; Normand *et al.* 1992; Subbarao and Rodriguez-Barrueco 1993).

It is gratifying to note that *Casuarina/Frankia* symbioses lends itself to fundamental research especially in countries where casuarina has no present commercial value. The applied side of that research however, may benefit establishment of casuarinas and general silviculture where they are grown as exotic species.

**Genetics and breeding**

Research in the genetics and breeding of casuarina, in its traditional sense, has not progressed as would have been expected. Most of the work has addressed inter- and intra-specific variation in some morphological and physiological traits, (e.g. El-Lakany 1985). Breeding of casuarina has been restricted to provenance trials, which had been started by El-Lakany (1983) in *C. glauca* and *C. cunninghamiana*. Other trials have been undertaken for the same species by Merwin (1990) and Merwin (1995, pers. comm.). Multi-national provenance trials of *C. equisetifolia* are organized by CSIRO, Australia (Pinyopasarak 1995, pers. comm.). Early results (3 years), indicate significant inter-provenance variation in growth and survival, especially under adverse conditions.

**Propagation**

Although casuarina is commonly propagated by seed, which is abundant, easy to handle and germinates well (El-Lakany *et al.* 1989 a,b), there are some attempts to promote vegetative micropropagation (e.g. El-Lakany 1992; Mohender *et al.* 1994), stem cuttings, grafting (Meyers 1993) and air layering (El-Lakany and Shepherd 1983). Cloning may prove to be valuable for propagating superior genotypes that may be identified or bred in the future.

**Agroforestry**

The use of casuarina in agroforestry systems has expanded over the last decade, though research has not kept pace. The main use of casuarina is still windbreaks for orchards and crop fields, where the trees provide fuelwood and sometimes fodder in addition to their protective role. Some research has been conducted in this regard, however (e.g. Sandys and Harris 1992; Harikrishnan 1993; Holmes and Farrell 1993; Race 1993; Mason *et al.* 1994).

Few recent studies were conducted on the effects of casuarina cells on the yields of crops they protect and micro-climatic amelioration. However, the allelopathic effects of casuarina seed and litter extracts and the release of chemicals from the litter received some attention (e.g. Chaturvedi and Jha 1992, Joshi *et al.* 1992; Mallory and Margolis 1992; Sanker and Rai 1993; Constantinides and Fowunes 1994).

The distribution of casuarina root systems in mono- and multi-species windbreaks have been investigated by El-Lakany and Mohamed (1992a,b), under different irrigation systems. It appears that while casuarina can extend its root system to neighbouring fields, it is less competitive than *Eucalyptus* and *Acacia* species.

**Tolerance to adverse conditions**

The research on the tolerance of *Casuarina* species and provenances to soil and water salinity and other adverse conditions has been disappointingly less than anticipated in the last few years, considering the fact that the tree is traditionally recommended for difficult sites and harsh climates. Some results were produced by e.g. Millian *et al.* (1992); Singh *et al.* (1992); Allen *et al.* (1993); Bell *et al.* (1993); Kaneker *et al.* (1993); Lalita-Batra *et al.* (1993); Hussein *et al.* (1994).

**Susceptibility to abiotic factors**

In spite of the serious damage which is caused by microbial diseases and insects, this area of research has also received relatively very little attention. Casuarina
susceptible to fungal diseases at the seedling and adult stages especially in the wet tropics. Some mature stands of casuarina are infested with stem borers as well. Some pertinent pathological research was carried out however, notably in India. For example, Mohanan and Sharma (1993) reported on the fungal diseases of *C. equisetifolia* and proposed some control measures, while Pena et al. (1994) attempted to control damping-off fungi biologically, using strains of *Bacillus* spp. and actinomycetes. Meanwhile, Gunjal and Patil (1992) indicated that dual inoculation of the seedings of *C. equisetifolia* with *Frankia* and mycorrhizas reduced infection with wilt fungi.

**Productivity and wood properties**

Surprisingly, biomass production, fuelwood potential, and wood properties have also received little attention from casuarina researchers worldwide, in spite of increasing industrial utilization of its wood. Some interesting results have nonetheless been produced, (e.g. Dudley and Fownes 1992; El-Osta et al. 1992; El-Osta et al. 1992; Puri et al. 1994; Srivastar 1994).

**Recommendations for Future Research**

More research is needed in order to fill the gaps existing in the knowledge and information related to casuarina. There is still a need to test "less known" species, and to explore further the genetic variation in the more commonly used species, especially as related to tolerance to harsh environmental conditions and adaptability to degraded sites. There is always need for material suitable for salt-affected sites, mine tips, and marginal lands. Equally important is the identification of species, and indeed seed sources, for peri-urban irrigated plantations which are being advocated for the safe disposal of municipal sewage water.

Quantification of water-use efficiency of casuarina species and determination of competition between casuarina and different crops for water and nutrients are lacking. Such information would help in deciding on the suitability of casuarina for protective plantations.

Along the same line of basic research, the wood properties and utilization deserve more attention. As many plantations in several parts of the world approach their economic maturity as far as size and vigour are concerned, it would be a waste if they are not exploited on a sound economic basis.

The reproductive biology of different members of the family Casuarinaceae should receive due attention especially as related to the establishment of seed orchards.

Biological nitrogen fixation and *Casuarina/Frankia* symbioses will continue to be the subject of essentially fundamental, but eventually applied research. However, the current trend is more appealing to microbiologists than foresters.

**References**


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