Chapter I
INTRODUCTION

Background

Tree improvement is one of the most important aspects in developing the
timber industry, with emphasis on development of improved trees followed by
production of the improved planting stock. The factors which determine the
growth rate and form of the stem are of major concern. So far the objective of the
timber improvement program that has been emphasized is to increase stem volume
through genetic selection for increased growth in height and diameter, producing a
longer and clear stem bole. To accomplish the objective, genetically improved planting
stocks, such as seeds, cuttings, or emblings produced through tissue culture, need to
be processed for the regular plantation program. Kjaer and Foster (1996) stated that
the use of genetically improved teak seed is economically profitable. The total gain
in volume from a simple tree improvement program such as plus tree selection,
establishment of clonal seed orchards, progeny testing and a moderate roguing is
estimated to be about 10 percent. On the other hand, tree improvement also involves
more intensive silvicultural practices such as site preparation and fertilization in
order to obtain the overall improvement.

A major constraint to the development of genetically improved trees is the
lack of genetic information on the populations. In the case of teak in South East
Asia, low fruit and seed production and low seed germination also are major
constraints. Some biological constraints include difficulties in pollination
management (Kaosa-ard, 1995), lack of insect pollinators (Hedegart 1973), and high
level of self-incompatibility (Egventi 1978).

Teak clonal seed orchards (CSO) in East Java cover 1300 ha with about 100
trees. Fruit productions from 1999 to 2004 were 6,089, 11,629, 9,905, 49,461,
31,893 and 20,825 kg/year, respectively, ranging from 4.7 – 38.0 kg/ha. With 80%
net yield after processing, the fruit productions in those years ranged from 3.75 -
30.4 ton/year, or about 0.03 – 2.3 kg/tree.
The term "fruit" herein is used in the botanical sense and refers to the mature ovary. Although teak fruits may produce 0 to 4 seeds, the seeds cannot easily be separated from the fruits and teak fruits are used as planting material and are the dispersal units, i.e. the teak fruit functions as a seed. Consequently in this thesis, the term "seed" is used to refer to processed fruits which have been dried, cleaned, graded, etc. Using this terminology, seed production is commonly about 80% of fruit production after processing.

The seed production from the CSO was estimated to cover 40 - 50% of the need for the annual planting program and the remaining seeds were obtained from production areas (SPAs). The demand for seeds is made higher due to illegal logging. Therefore, the need to increase seed production especially from CSO is urgent.

Flower and premature fruit abortion commonly occur in perennials, causing a major loss in seed production. The most serious fruit abortion occurs within two months of anthesis and reaches up to 80%, of fertilized young fruits (Sedgley & Griffis 1989). This abortion is generally related to seed development, i.e. embryo abortion or abnormalities.

Teak is an entomophilous species, mostly bee pollinated (Egenti 1974), and the flowering period usually coincides with the rainy season. Nagarajan et al. (1996) suggested that heavy rains prevent insects from foraging, and when rains are fairly continuous, as during monsoons, that may adversely influence the insect breeding cycles leading to fewer pollinators and very few insect visitations.

The low seed production is common in many tropical plants (Bawa & Webb 1984). Self-incompatibility is thought to be one of the major causes of the low fruit and seed production due to high incidence of selfing. Hedegart (1973) suggested that the high selfing rate in teak is due to an insufficient number of insect pollinators. It has been shown in teak that fruit set from self-pollination is lower than from cross-pollination (Hedegart 1973; Tangmitcharoen & Owens 1997b). This indicates that teak is largely a self-incompatible species. An investigation using allozyme segregation of progenies carried out by Kjaer et al. (1996) indicates that teak is predominantly an outcrossing species.
Premature fruit abortion usually coincides with the rapid increase in the rate of embryo development which requires a considerable amount of auxin. In some plants, application of auxin at that stage delays fruit abscission, whereas application at a later stage reduces pre-harvest abortion (Sedgley & Griffin 1989).

Competition for nutrient resources also causes fruits to abort. The competition between developing fruits and vegetative growth limits metabolites that are available to the different parts of the tree, and may result in fruit abortion. Nitrogen is one of the most important nutrients required for fruit development.

Objectives

The main objective of this study was to determine the limiting factors for teak seed production in the CSO in East Java, and the studies were categorized into three different areas to answer three main questions:
1. How do the mating system and pollination relate to fruit set?
2. What are the important pollinators and what is the pollination efficiency?
3. What are the physiological factors affecting fruit abortion?

Research Outline

The series of research projects took place between 1999 and 2004 and consisted of eight experiments. All of these experiments were carried out in the same CSO of Perum Perhutani in East Java. They were designed to investigate factors affecting fruit abortion, which is the main problem of teak seed production in the CSOs. These experiments may be grouped into three main categories:

1. **Mating systems and pollen dispersal - representing genetic factors**
   1. Patterns of fruit set
   2. Extent of pollination in nature
   3. Mating system
   4. Pollen dispersal
Pollinators – representing biotic factors

5. Insect diversity
Potential pollinators and its behavior

Growth regulators and nutrient competition – representing physiological factors

Roles of auxin, polyamine, IAA, and ABA
Roles of KNO3 and Ca(NO3)2

Chapter III describes the first four experiments and was meant to determine the: 1). pattern of fruit set and period of flower and fruit abortion; 2). extent of pollination in nature; 3). occurrence of self-incompatibility; and, 4). the gene flow as expressed by pollen dispersal. The experiment on autogamy, agamospermy, self-pollination, open-pollination, and cross-pollination was to determine how teak seeds develop. Molecular techniques were further employed to investigate distances of pollen dispersal from a pollen source.

Pollinators represent the biotic factors in pollination and studies were done to determine if they are efficient and to investigate pollination intensity. Assuming that teak is self-incompatible, studies described in Chapter IV investigated the potential pollinators and the most efficient ones that enhanced cross-pollination.

Chapter V deals with the effects of growth regulators and nutrient competition involving experiments using various forms of nutrient spray and pruning to determine the relative importance of these factors in teak fruit retention.