TREE IMPROVEMENT AND REPRODUCTIVE BIOLOGY STUDIES IN TAMARIND

B.Nagarajan[1], A.Nicodemus[1], A.K.Mandal[2], Rajkumar Verma[2], K.Gireesan[1], Mohan Varghese[1] R.Natarajan[1], A.Durai[1] and S.S.R.Bennet[1]

Abstract:-- Reproductive biology and breeding system were studied in five Tamarind clones. Considerable phenological variations were observed between clones. Flowers showed entomophilous adaptations, open pollination fruit setting was 1 - 2 %. Controlled pollinations indicated that it is a preferential outcrosser with very little selfing, apomixis was absent. Pollens showed dimorphism and low sterility, long term storage was possible. Fruits were produced in pink and green colours.

Key words: Breeding system, Clone, Controlled pollination, Dimorphism, Phenology, Pollen storage, Tamarind.

INTRODUCTION

Tamarindus indica L. commonly known as tamarind is a monotypic genus belonging to the family Leguminosae and is widely distributed in Africa and Asia. It grows upto forty five feet in height and has a dense spreading crown with a clear trunk and grows in a wide range of agroclimatic conditions and is a highly drought tolerant species . It is an excellent multipurpose tree species which is used as food, food preservatives (Tsuda 1995), fodder (Kaitho 1996), drugs (Mustapha 1996), timber and fire wood. Tamarind fruit pulp is very rich in ascorbic and tartaric acids and it is the most commonly used preservative in pickle industry.

Tree improvement activities in tamarind were initiated in India almost a decade ago. Many forest agencies have surveyed and identified high yielding genotypes and have also established germplasm banks. Generally tamarind plantations are raised from seedlings, but nowadays tamarind clonal planting is also becomming popular. Though tamarind is mainly grown for fruits, it has been very poorly understood for its reproduction. Hence a detailed study was carried out with the following objectives :

* to know the phenology and floral biology
* to understand the breeding system

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[1]Institute of Forest Genetics and Tree Breeding, Indian Council of Forestry Research and Education, P.B.1061, Coimbatore,lndia.

[2]Tropical Forestry Research Institute, RFRC P.0 Mandla Road, Jabalpur, India

MATERIALS AND METHODS

Phenology recording. Studies were conducted during 1996 in five tamarind clones NBN1, NBN2, NBN3, RDB Patna and JRK (herein after refered as C1 ,C2,C3,C4 and C5) in a State forest department clonal bank at Karnataka in India. In each clone five ramets were selected for observation. Phenological parameters such as terminal and axillary shoot elongation,leaf production, inflorescence length and flower production per inflorescence and per branch were recorded. Five hundred (hundred per ramet) measurements or counts were made depending upon the characteristic.

Controlled pollination. Controlled pollination was done in four clones (C1,C2, C4 and C5) using a full diallel mating design (Zobel and Talbert 1984). Sixteen crossing and selling combinations and four apomixis treatments were made. Flowers were emasculated with aid of a clean fine tip forceps from 15.00 to 20.00 hrs and flowers were pollen dusted using a dry painting brush or needle from 6.00 to 11.00 hrs. In an inflorescence only the treated flower was retained. In each clone 100 flowers were operated per day per treatment and all treatments were repeated for seven days. Thus 700 flowers were operated for each treatment. Flowers operated were caged in paper covers (in size of 12 x 7 cms). and were tagged properly. Bags were removed on the seventh day for recording fruit set.

Pollen biology. Pollen samples were stored in clean 1.5 cm. diameter plastic Petri plates in ambient (37°C) and cold (5°C) conditions. Prior to cold storage the pollen was dried in sunlight for 2 - 3 hours in the mornings. Pollen viability was assesed using a differential stain, in which viable pollen stained pink and dead ones stained green (Alexander 1969). Slides were prepared and analysed according to the procedures described by Radford etal., (1974).

Data Analysis. ANOVA, T - Test (Waller and Duncan 1969) and coeffiecient of correlations of means were done using SAS package 6.09E version.

RESULTS

Floral biology. Flowers are showy, bisexual, herkogamous, five sepals, five petals, three anthers fused at base with filaments incurving towards the ovary base, style simple, stigma is unbranched and pappillate, ovary superior with 12 - 14 ovules. Ovary base has numerous hairs with copius nectar. Pollination is mostly by honey bees. Anthesis starts at 20.00 hrs and flowers are completely unwound by 02.00 hrs, but anther dehiscence is only by 08.30 in the morning. Stigma is receptive for almost 48 hours with peak receptivity on the day of anthesis. Fruits are produced in two distinct colours,clone C2 produced pink fruits while all other clones produced green fruits.

Vegetative phenology. Vegetative shoots are produced annually and they bear flowers only the next season. Two types of terminal shoot production could be observed, Clones C 1 and C2 produced shorter terminal shoots ("erect type") C3, C4 and C5 produced long shoots ("drooper type") (Table 1). Clones also varied considerably for axillary shoot length. Clones with lengthy terminal shoots produced more foliage, clone C5 showed the maximum foliage production (Table 1).

Reproductive phenology. Production of flowers varied between clones (Table.1). Clones with longer vegetative terminal shoots produced more flowers (Table.1). Ovary and style length varied between clones (Table.1).

Table.1. Vegetative and reproductive phenology in tamarind clones

	Clones							
	C1	C2	C3	C4	C5	Sem	LSD at 5%	CV%
Terminal shoot length(cm)	15.42_{D}	14.38_{E}	19.12_{C}	19.41_{B}	21.45_{A}	0.039	0.084	0.347
Axillary shoot length(cm)	6.75_{D}	6.18_{E}	8.41_{B}	7.54_{C}	9.34_{A}	0.008	0.017	0.167
Terminal shoot leaf length(cm)	8.24_{C}	8.24_{C}	8.15_{D}	9.37_{A}	9.12_{B}	0.021	0.043	0.376
Leaves per terminal shoot	8.78_{D}	8.55_{E}	13.76_{A}	12.18_{C}	13.13_{B}	0.016	0.034	0.224
Leaves per axillary shoot	5.34_{A}	4.45_{B}	4.06_{C}	4.05_{C}	3.67_{D}	0.067	0.14	2.45
Inflorescence length (cm)	4.38_{D}	4.85_{C}	5.70_{A}	5.07_{B}	4.91_{B}	0.110	0.234	3.50
Inflorescence per branch	7.56_{D}	13.69_{B}	13.59_{B}	16.32_{A}	11.92_{C}	0.174	0.368	2.18
Flowers per inflorescence	13.28_{C}	8.05_{E}	15.57_{B}	17.09_{A}	12.21_{D}	0.024	0.053	0.296
Flowers per branch	100.47_{E}	109.12_{D}	212.70_{B}	279.80_{A}	145.61_{C}	2.769	5.871	2.583
Style length(mm)	4.57_{B}	4.62_{A}	4.74_{A}	4.30_{C}	4.64_{A}	0.064	0.137	2.237
Ovary length(mm)	6.60_{B}	6.74_{A}	6.61_{B}	6.13_{D}	6.21_{C}	0.038	0.080	0.927

Means with same letters are not signif¹cantly different by Duncan's Multiple Range test (p=0.05)

Pollen biology. Pollen sterility was found to be very low (Table 2). Under ambient conditions (37°C - 40°C) pollen viability was nearly 88% until 3 days. Pollen stored in 4 C remained viable upto 97% till 100 days. Pollens were produced in two distinct sizes (40 uM and 25uM), pollen dimorphism percentage increased in the late flowers (Table 2).

Table 2. Pollen biology of Tamarind

	Clones					Sem	LSD at5%	CV%
	C1	C2	C3	C4	C5			
Pollen sterility (%)	1.18_B (1.08)	1.13_B (1.06)	0.79_c (0.88)	1.80_A (1.33)	**1.93_A** (1.38)	0.038	0.081	5.262
Pollen dimorphism(%)	11.03_c (3.32)	13.39_A (3.65)	12.08_B (3.47)	9.63_E (3.10)	**10.23D** (3.19)	0.039	0.083	1.856
Pollen viability in ambient storage (%)	88.00_A (9.38)	88.20_A (9.39)	84.80_A (9.20)	85.60_A (9.25)	**86.60A** (9.30)	0.145	NS	2.464
Pollen viability in cold storage (%)	97.40_A (9.87)	96.80_A (9.84)	97.0_A (9.85)	96.60_A (9.83)	**97.0A** (9.85)	0.032	NS	0.523

Means with the same subscript are not signif¹cantly different by Duncan's Multiple Range test (p=0.05). The values in parenthesis are transformed means (square root transformation)

Breeding system. Fruit set under open pollination condition ranged 1 to 2% among the clones, Clone C2 showed significantly higher fruit set than other clones (Table 3). In controlled cross pollination fruit set was as high upto 88% in clone C1 , in contrast only very low fruit setting was observed in selfing (Table 3). Clone C2 showed highest rate of selfing than others. Cross incompatibility and apomixis were absent.

Table 3. Breeding system of Tamarind

	Clones					SEm	LSD at5%	CV%
	C1	C2	C3	C4	C5			
Open pollination (%)	1.65_B (1.28)	2.32_A (1.51)	**1.15_c** (1.07)	1.47_B (1.21)	**1.44B** (1.19)	0.082	0.174	10.379
Cross pollination (%)	84.20_A (9.16)	88.20_A (9.39)	87.40_A (9.34)	75.80B (8.70)	na	0.182	0.396	3.145
Self pollination (%)	2.40_c (1.51)	6.80_c (2.59)	**2.60_c** (1.59)	4.60B (2.13)	na	0.107	0.234	8.683

Means with the same letter are not signif¹cantly different by Duncan's Multiple Range test (p=0.05)e Values in parenthesis are transformed means (square root transformation) parenthesis.

DISCUSSION

Zobel and Talbert (1984) have opined that knowing the biology of tropical trees is critical before initialising any tree improvement programme. Knowledge on reproduction is one important aspect which needs much attention, also it helps to know the amount of genetic variation in a species (Costich 1995). In tropical trees many reproductive biology studies have been made on ecology and evolutionary terms (Bawa etal., 1985) however only a very few

applied studies are available (Venketesh and Sharma 1975, Egenti 1976, Veerendra and Ananthapadhmanaba 1996).

In this study we were able to understand the patterns in vegetative phenology and their considerable influence over reproduction. Clones with longer vegetative terminals shoots clearly showed higher flower production. Long inflorescences are invariably more attractive to insects (Inoue 1985) and often have a greater probability of maturing in to fruits (Ackerman and Montalvo 1985) selection of clones with longer inflorescences should be advantageous while raising clonal plantations.

Very low fruit set in open pollination (1-2%) in tamarind is not an unusual phenomenon, such a low flower to fruit ratio is known in many tropical tree species (Nagarajan etal., 1996). These failures are because of pollinator limitation (Calvo 1990), inadequate visits of pollinators (Aker and Udovic 1981) or may be due to self-incompatibility which is quite common in tropical trees (Bawa 1974, Kaur et al., 1977, Chan 1981). Also in legumes a tripping mechanism is known to exist, in which in a mixed pollen dusting flowers prefer cross pollen against self pollen (Arroyo 1978). This process considerably influences fruit setting in open pollination.

Though plants are known to show increased fruit set with cross pollen (Johnson 1991, Young and Young 1992), studies made earlier in tropical trees have reported only low fruit settings (Egenti 1976) due to the pollination techniques used, flower abortions (Bawa and Webb 1984), and inbreeding (Haber and Frankie 1982). In this case high fruit setting was because only the earliest formed flower was used for crossing. It is well know that fruits initiated from early flowers have a lower probability of aborting than the fruits initiating late (Udovic and Aker 1981) which is mainly due to positional advantage (Bawa and Webb 1984, McNeilage 1991) and assured maternal investment.

Fruits in pink and green colours seems to quite unique in tamarind. Colour dimorphism in reproductive organs has been reported in temperate species (Steinhoff 1974, Farris and Mitton 1985) as a single gene inheritance (Steinhoff 1974). However this is probably the first report of fruit colour dimorphism being observed in a tropical tree.

CONCLUSIONS

Tamarind is a preferentially outcrossing species, it is self-incompatible with negligible amount of selfing. Low fruit set in open pollination seems to be a pollinator limitation. Controlled crossing yields nearly 90% fruit setting. Flowers being adapted with herkogamy and unique stamen arrangement are added advantages for outcrossing. As pollen storage is possible transfer of paternal germplasm is should be easier between locations. With a clearly understood breeding system and with standardised controlled pollinations techniques tamarind needs to be further exploited for its variations.

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