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GENETIC IMPROVEMENT OF AILANTHUS TRIPHYSA

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ABSTRACT

Ailanthus triphysa, (Dennst.) Alston, the most suitable species for match industry needs productivity improvement, since the plantations are pest susceptible and less productive. There is a very high demand for this species while supply is very much limited. Two of the options for productivity improvement were selection of suitable species of *Ailanthus* and genetic improvement of *A. triphysa.*

Experiments were conducted to study the nature of genetic variability, heritability and correlation of economically important characters and also the breeding system prevailing in *A. trphysa*. Establishment of seed orchard also has been envisaged.

The study conducted has revealed that *A. triphysa* has a high family heritability for height and moderately high heritability for basal girth. The single tree heritability was found to be moderately high for height while it was low for basal girth. The phenotypic and genotypic coefficient of variation were found to be low for both characters: Strong positive genetic correlation was noted between height and basal girth which makes the improvement programme easy. Growth characters with high heritability value also make productivity improvement faster in the sense that phenotypic selection without the recourse of progeny test will suffice to a certain extent.

The results from species trial have shown that *A.integrifolia* ssp. *calycina* is better in growth performance in early years besides having a high level of pest resistance. But *A. triphysa* is preferred for the match industry since it has aromatic resin in its wood which avoids waxing of splints.

As the basic step in any tree improvement programme, 70 plus trees of *A. triphysa* were selected from natural forests, house compounds and plantations in Kerala. A seedling seed orchard is established at Palappilly of Chalakudy Division in an area of half a hectare with 27 progenies which will be a source of improved seeds.

The study conducted to understand the breeding system has revealed that *A. triphysa* is dioecious and strictly cross breeding. Since it is a widely outcrossing species, intrapopulation variation is expected to be very low.

1. INTRODUCTION

The genus *Ailanthus* is having 5 tree species occurring in Southern Asia, Malaya, China and Australia. Among these four occur in India inclusive of one introduced and naturalized (Basak, 1980). The fifth one, *A. fordii* Nooteboom, a native of Hong Kong,is not yet introduced in the country.

The species which occur in India are 1)A. excelsa Roxb.,generally seen in dry areas is found in Bihar, Chota Nagpur, Central provinces, Gujarat and in forests of Ganjam, Vizagapatanam and Deccan. 2) *A. integrifolia* Lam. (syn. *A. grandis* Prain) grows in Assam and Darjeeling hills. 3) *A. triphysa* (Dennst.)Alston (syn. A. *malabarica* DC.) grows in the evergreen forests upto 1500 m of Western Ghats and Andamans and 4) *A. altissima* (Mil1.)Swingle (syn. *A. glandulosa* Desf.), a native of China and Japan is an ornamental tree occasionally planted in North India.

A. triphysa and *Evodia lunu-ankenda* are generally considered to be the best Indian tree species for match splints (Nair, 1961). *A. triphysa* produces a highly viscous aromatic resin which obviates the necessity of dipping the splints in the wax and hence, this species has been counted as best matchwood species. *A.excelsa* also yields an inferior type of Hog gum.

A. triphysa is recommended as a short rotation plantation species due to its quick rate of growth The tree attains utilizable girth in 6-8 years. The tree is not much branchy and hence needs very little aerial space. It fetchesvery good price and ready market. Even branches of the size > 35 cm. with bark is accepted in match industry. The fast growth, minimum space requirement, ready market and substantial revenue make this species very attractive to farmers also.

Earlier *A. triphysa* was grown as mixed plantation along with Teak, Bombax and Evodia. However, since 1980this species isbeing raised as pure plantations. In Kerala, there are about 2500 ha of mixed plantations and 533 ha of pure plantations (Anon, 1991).

There are about 144 match factories in Kerala. Only 10 percent of the total requirement of the industry is met from the forests of Kerala and hence the demand is very high (Nair, *et al*. 1984). Increasing productivity ofplantations through genetic improvement methods is a potential strategy to meet the increasing demand of the industry. With this end in view, this project has been inititated which consisted of the following objectives.

- **i.** to study the genetic variability, heritability and correlation of economically important characters
- **ii.** to study the breeding system and
- **iii.** to establish a seed orchard.

In general this species has not been subjected to much study except for insect Susceptibility and silviculture

This report is arranged in 7 sections: introduction, genetic studies, species comparison, breeding system, seed orchard, conclusions and references.

2. GENETIC STUDIES

2.1 Introduction

On the genetic aspects of *A. triphysa* no study has been undertaken earlier. As any other tree improvement programme, this study also started with screening of base population to select plus trees followed by progeny trial to estimate the genetic variability and heritability and evaluation of plus trees. As height and girth are the economically very important characters preference was given to these characters.

2.2. Materials and Methods

a) Plus tree selection

The programme was started with the screening of natural variation and selection of superior phenotypes. Almost all forest divisions in Kerala have been covered during this survey. Both plantations and natural forests were scanned. Mixed plantations raised during 1950s and 60s at Kannoth, Kottiyur, Peruvannamuzhy and Kurichiat were visited. Though the assessment of superiority of trees is more reliable and easier in plantations, natural forests of Kulathupuzha, Achenkovil, Kodanad and Nilambur were also surveyed to select the giant trees and also to locate the natural variants, if any.

Among the plantations visited, selections were made only from a few plantations (Table 1) having enough stock and moderate growth .

For plus tree selection, the plantations were screened thoroughly. The phenotypically superior and healthy trees were selected first as 'candidate trees' and then confirmed plus trees using the check tree method (Venkatesh, et al. 1986). The main characters noted were height, height, girth at breast height, straightness, clear bole length, less branching and narrow compact crown, good pruning ability and absence of defects and diseases. In some areas, trees with moderate height were also selected where the percentage of clear bole length to total height was vey high. The superiority of plus trees were confirmed after comparing with five co-dominant trees within a radius of 25-50 m.

Table 1. Plantations from which plus trees were selected

Range	Beat	Year of planting	Area Surveyed (in hcctares)	Mixed plant ation
Kannoth	Kannoth	1953	72.30	Bombax & Ailanthus
"	"	1954	8.00	"
"	Kottiyur	1961	12.05	Teak, Bombax & Ailanthus
"	"	1962	20.68	"
"	"	1963	21.55	"
"	"	1964	22.06	"
"	"	1967	--	"
‘’	Nedumpoil	1955	31.97	Bombax& Ailanthus
‘’	"	1956	38.04	Evodia & Ailanthus
‘’	"	1959	171.46	"
‘’	"	1960	150.05	,,
P.P. Malavarum	Peruvanna muzhy	1960	39.00	Ailanthus & Evodia
‘’	"	1961	38.54	‘’

b) Progeny Test

As a part of the breeding programme, half-sib progeny test has been conducted to acquire informations on the variability and inheritance pattern of'growth characters.

Open pollinated seeds from plus trees and other average trees were collected tree wise during March and April. The seeds are winged and very light and hence there was every chance for the seeds mixed up. So utmost care was taken to avoid such problem.

Nursery was raised at Peechi in May and four month old seedlings were polypotted after taking growth measurements.

Depending upon the availability of seedlings. field planting was planned. The design opted for field planting at Nilambur was randomized block design with 10 treatments (Table 4) (ie 10 families derived from 5 plus trees and 5 average trees), 3 blocks and 15 plants/family. Ten plants were selected for taking growth measurements at the age of 15 and 42 months.

Another plot was also raised in the next year with 5 families (Table 8) with 3 blocks and 15 plants along with a species trial. The 5 families were derived from 5 plus trees. The height measurements of 10 plants each were taken at 2nd year and 3rd year and the basal girth measurements were taken at the age of three years.

Statistical analysis of the data was carried out as suggested by Wright (1976) and Singh and Chowdhary (1985). Mean values of the families were compared using the procedure given in Calinski and Corsten (1985). Genetic gain was calculated according to Falconer (1 960), where "i" was taken as 1.76 at 10% selection intensity and h^2 as family heritability.

2.3. Results and Discussion

a) Plus trees selected

Of the total seventy four Plus trees selected 4 fell down during the course of the experiment due to natural causes.

The particulars of the trees selected are given in Table 2

Table 2. Plus trees of *Ailanthus triphysa* selected in Kerala

Tree No	Range	Beat	Plantation/ Naturalforests/ Private	Height m meters	Clear bole length m meters	% clear hole to Height	ghh m cm	Sex	Remarks
1	Kannoth	Kannoth	1954 Plantation	22 8	14 3	62 7	105	F	
2		''	''	23 I	10 3	83 6	212	M	
3		''	1953 Plantation	26 3	18 0	68 4	140	F	
4		''	''	25 0	20 0	80 0	134	M	
5		Nedumpoil	1960 Plantation	24 0	15 0	62 5	126	F	
6		''	1959 Plantation	25 3	17 0	68 0	170	M	
7			''	280	22 0	78 0	137	-	
8		''	1955 Plantation	30 0	20 0	66 7	185	M	
9		''	''	24 0	18 5	77 0	140	M	
10		''	''	21 0	15 0	71 4	125	-	slightly tapering
11		''	''	22 0	17 0	77 7	103	F	
12		''	''	26 0	18 0	69 2	108	F	Very clean bole
13		''	''	25 0	20 0	80 0	130	F	
14		''	1956 Plantation	23 0	19 0	82 6	160	F	No tapering
15		''	''	22 0	17 0	77 3	130	-	
16		''	''	21 0	11 0	52 4	128	-	
17		''	''	25 0	18 0	72 0	142	M	
18			''	22 0	12 0	54 6	152	F	
19			1959 Plantation	23 0	17 0	73 9	137	M	

Tree No.	Range	Beat	Plantation/ Naturalforests/ Private	Height in meters	Clear bole length in meters	% clear bole to Height	gbh in cm	Sex	Remarks
20.		''	''	22 0	16.0	72.7	126	F	
21.		Kottiyur	I962 Plantation	29.7	26.1	87.5	132	M	
22.		''	''	17.6	14.0	78.6	110	M	
23.		''	''	26.5	16.0	60.4	I50	M	
24.		''	''	24.7	15.0	60.7	I20	F	
25.		''	''	24.5	21.5	87.8	110	M	
26.		''	''	22 0	15.0	68.2	114	F	
27.		''	''	16.3	14.9	91.4	113	M	
28		''	''	21.1	14.0	66.4	124	F	
29.		''	''	26.0	14.0	53.9	I20	F	
30.		''	''	23.5	19.0	80.9	109	F	
31.		''	''	24.6	19.7	80.1	125	M	
32.		''	''	33.0	28.0	84.9	110	F	
33.		''	''	23.0	18.0	78.3	109	F	
34.		''	''	27.0	22.0	81.5	107	F	
35.		''	196l Plantation	27.6	18.1	65.6	122	M	
36.		''	I963 Plantation	23.0	20.0	87.0	112	F	Trunk slightly bend
37.		''	''	20.0	16.8	84.0	102	F	
38.		''	''	20.0	16.0	80.0	105	M	Branches very thin
39.		''	''	26.8	21.4	79.9	12l	F	Excellent natural pruning
40.		''	1967 Plantation	22.0	20.0	90.9	105	F	
41.		''	''	26.4	18.0	68.2	105	F	
42.		''	''	24.0	17.0	70.8	112	M	
43.			''	26.2	21.0	80.2	105	-	Slight bend & tape
44.		''	1964 Plantation	31.5	20.0	63.5	110	*	
45.	P.P.Malavanum	Peruvanna	1960 Plantation	15.0	16.5	76.0	138	M	
46.		muzhy	''	18.0	13.5	75.0	120	M	
47.		''		17.0	13.5	79.4	110	M	
48.		''	''	17.0	12.5	73.5	115	F	
49.		''	196l Plantation	17 0	13.0	76.5	132	M	
50.		''	''	18.0	13.5	75.0	122	F	
51.		''	''	16.5	12.0	72.7	111	F	
52.		''	''	20.5	16.0	78.l	117	F	
53.		''	''	20.0	15.5	73.8	125	M	
54.		''	''	21.5	15.0	71.4	126	F	
55.		''	''	21.5	17.0	85.0	130	M	
56.		''	''	20.0	18.0	90.0	119	M	
57.	Malappuram Dist.	Pulamanthole	Private land	28.5	17.5	61.4	175	M	
58.		Cherukara	''	29.0	17 0	58.6	140	F	
59.	Kodanad	Mallana	Natural forest	55 0	25.0	45.5	480	-	
60.	Nilambur	Edacode	''	50.0	26.0	52.0	265	F	White bark
61.		''	''	35.0	25.0	71.4	205	F	
62.		''	''	45.0			560	-	branched at 2 m above base
63		Muttikadvau	''	35.0	14.0	40.0	240	F	
64.		Panayangode	''	29.5	19.0	64.4	170	M	
65.		Valluvasseri	''	42.0	15.0	35.7	340	F	
66.	Kulathupuzha	Sankili	''	48.0	22.0	45.8	470	M	
67.		Mylainoodu	''	60.0	35.0	58.3	345	F	
68.	KVTP, Achenkovil	Kallar	''	49.0	21.4	43.7	280	-	

Tree No	Range	Beat	Plnantation/ Natural forests/ Private	Height m meters	CIcar bole length m meters	% clear bole to Height	gbh in cm	Sex	Remarks
69		''	''	49.5	20.0	40.40	270	-	
70		Chittar	''	60.0	36.0	60.00	450	-	
71		Vazhaperiyar	''	55.0	30.0	54.55	400	F	fallen down
72		''	''	55.0	32.0	58.18	430	F	''
73		''	''	50.0	33.0	66.00	441	F	''
74		''	''	55.0	35.0	63.64	483	F	''

- Sex not known

b) Progeny test

The analysis of variance showed that there were significant differences among families for tree height at all ages obsewed (Table 3). For girth, the difference was not significant. The analysis also showed that there was significant difference between plus trees and average trees.

The mean height at different ages for each family and grand mean and the range are presented in Table 4. Family No. 2 and 3 of Achenkovil origin showed the best and the second best performance among all the families (Fig. 1). Family No. 1. though of plus tree origin, performed poorly. Among families of average tree No. 7 was fast growing.

Family heritability, single tree heritability, Phenotypic and genotypic coefficient of variation and genetic gain with 10% selection intensity are given in Table 5 Family heritability for height was found to be high at all ages but single tree heritability which was high in early ages decreased with age and was moderately high at the age of 3 1/2 years. High heritability in earlier ages and a decrease in later years have been reported in other species also like *Tecomella undulata* (Jindal, *etal*. 1992), Sitka spurce (Samuel and Johnstone, 1979) and Black Walnut (Rink, 1984)

Phenotypic and genotypic coefficient of variation were found to be low Since phenotypic variance was very low, genetic gain also happened to be low. Johnson, *et al*.(1955) has opined that high heritability need not always be accompanied by greater genetic progress The present study in two separate experiments also supports this view.

For basal girth. phenotypic and genotypic coefficient of variation were very low Single tree heritability and genetic advance were also low Family heritability was found to be moderate Moderate family heritability and low single tree heritability for girth is attributable to non-additive gene effects

The genetic correlation (rg) between height and basal girth was found to be high as 1.0, while phenotypic correlation (rp) was 0.69 at the age of three years. The strong positive correlation makes the improvement programme easy since positive slection made for one character will automatically improve the other character also. .

Table 3. Analysis of Variance for seedling height and girth in *Ailanthus triphysa*

Sources	Expcrinicnt No. 1 Hcight 4 months	10 months	11/4 years	31/2 years	Experiment No. 2 3 year height	3 year girth
	DF	**MSS**	**MSS**	**MSS**	**MSS**	**DF**	**MSS**	**MSS**
Block	2	0.074	0.789**	0.145	1.974**	2	0.244	0.085
Family	9	0.361**	0.565*	0.589''	0.746**	4	0.448*	0.162
B1 x Fam	18	0.068**	0.161**	0.152	0.193*	8	0.102	0.068
Trees with in plot	270	0.031	0.589	0.125	0.104	135	0.057	0.042
Total	299					149		

*, ** Significant at 5% and 1% level, respectively.

Table 4. Mean Height at different ages in cm.

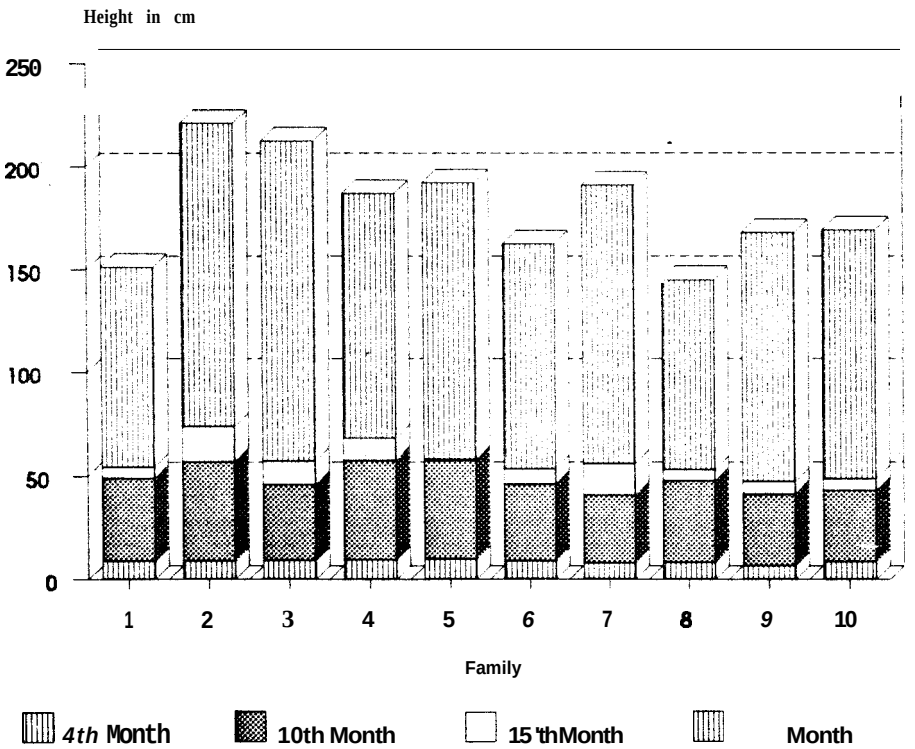
Family	Seed source	4 months	10 months	1 1/4 years	3 1/2 years
Plus trees					
1.	Nilambur PT 1	8.55*	48.93*	54.17	151.30
2.	Achenkovil PT2	8.57*	56.80*	73.60*	221.33*
3.	Achenkovil PT3	8.92**	45.73	57.17*	212.40*
4.	Achenkovil PT4	9.19*	57.53*	68.03*	187.00*
5.	Achenkovil PT5	9.73*	57.33*	57.93*	192.17*
Average trees					
6.	Moovattupuzha	8.68*	46.23	53.47	162.59
7.	''		40.70	55.93	190.93*
8.	''	8.08	47.60	52.90	145.23
9.	''	6.53	41.63	47.43	167.76
10.	''	8.27	42.97	48.57	169.23
Mean		8.44	48.55	56.92	179.99
Range		4-13.5	17-88	14-117	55-370

* Better than average

Table 5. Variation, heritability and genetic gain for height and girth in *Ailanthus triphysa*

Age	PCV	GCV	Family herita-bility(%)	Single tree heritability (%)	Genetic gain	Genetic gain as % of Mean
Expt. 1						
4 months Height	5.21	4.69	81.22	88.09	0.16	7.44
10 months ,,	7.45	3.03	71.58	66.01	0.36	9.38
1 1/4 years ,,	3.52	3.03	74.24	41.04	0.18	4.60
3 1/2 years ,,	3.07	2.65	74.13	56.13	0.21	4.02
Expt. 2						
3 years Height	2.83	2.49	77.23-	63.16	0.17	3.85
3 years Girth	0.82	0.62	57.40	26.00	0.07	0.83

Figure 1. Mean Height in *Ailanthus triphysa*



3. SPECIES COMPARISON

3.1. introduction

In Kerala the performance of *Ailanthus* plantations is not that attractive, since two major pests, *Atteva fabriciella* and *EIigma narcissus* cause serious damage to young plants (Varma, 1986). Pure crops of *A. excelsa* Roxb. also is attacked by these pests in Tamil Nadu and Madhya Pradesh (Chattejee, et al. 1969). Repeated attacks of these pests cause stunted growth and branching of plants. Moreover, attack during flowering and fruiting seasons results in scarcity of seeds.

During the survey for selection of Plus trees in *A. triphysa*, it was noticed that a small plot of 0.4 ha area of *A. integrifolia* raised at Kodanad of Malayattoor Forest Division was completely free from pest attack. This species was introduced from North Eastern States by the Kerala Forest Department in 3963 . It is well known for its quicker rate of growth, very straight cylindrical bole, less tapering and restricted crown, excellent natural pruning and apical dominance (Guhathakurta and Ghosh, 1972). Wood is used for match splints and box, box planking and newsprint grade of pulp and plywood. Hence work was initiated to study its growth performance and its susceptibility to insect pests compared to those of *A. triphysa*.

3.2. Materials and Methods

The species used were *A. triphysa* and *A. integrifolia* ssp. *calycina*. Seeds from 5 plus trees of *A. triphysa* from Wynad and Nilambur divisions and seeds from 5 mother trees of *A. integrifolia* ssp. *Calycina* from Kodanad were collected.

Nursery was raised at KFRI campus, Peechi. Seedlings were polypotted when they were 4 months old. During second year they were field planted at Nilambur in a randomized block design with 10 families (Families 1-5 of *A. integrifolia* ssp. *calycina* and 6-10 of *A. triphysa*) with 3 replications of 15 plants each (Table 8). Observations were taken on the pest attack in the nursery and survival in the field. Height and basal girth were measured in 10 plants per replication in the nursery as well as in the field at the age of 3 years.

Statistical analysis was done as described in the previous chapter.

3.3. Results and Discussion

A. integrifolia ssp. *calycina* was found to be completely free from insect pests while, *A. triphysa* was attacked many times which was controlled by insecticidal application.

Two years after field planting (at the age of 4 years) the survival rate was noted (Table 6) and it revealed that the mean survival was only 63 percent in *A. integrifolia* where as in *A. triphysa* it was 78.66 percent. But family No. 4 of *A. integrifolia* showed good survival rate of 83.33 percent.

The height measurements of 2 year and 3 year old plants and the basal girth measurements of 3 year plants were taken for which the analysis of variance was worked out (Table 8). From the analysis it is evident that there was significant difference in mean height between families and between species, *A. integrifolia* performing better. But the difference in girth between families and between species is not significant. The components of variance due to block, family, interaction and error have been indicated as percentage (Figures in parentheses, Table 7) of the total variance. These figures indicate that the genetic variance for height was about 71 to 93 percent but for girth, it was only 16.69 percent.

When the mean values of the families were compared the following pattern as shown in the bar notation below, was obtained.

2 years height	F8	F7	F9	F6	F10	F3	F1	F2	F5	F4
3 years height	F7	F8	F6	F10	F9	F1	F2	F5	F3	F4
3 years girth	F8	F7	F1	F5	F6	F2	F10	F3	F4	F9

With regard to height, during second year. there were four groups, while in the third year, it was reduced to two groups But as far as girth is concerned, there was no significant difference was seen between families Families Nos 8 and 7 were the poorest families while No 4 was found to be the best for height growth and second best for girth It's survival rate was also found to be high The mean plant height and girth for each family and the range and grand mean are given in Table 8 Though the total growth was good for *A. integrifolia.* the growth rate during third year (after field planting) was more for A.triphysa compared to that of *A. integrifolia* Growth rate was evidently higher for families No. 8 and 9 *A. triphysa* which are trees from Nedumpoil of Wynad Division (Fig 2)

The better growth performance and pest resistance of *A.infegrifolia* ssp. *calycina* indicate its potential as a plantation species in Kerala to partly replace *A. triphysa.* Its high level of pest resistance itself is a positive criterion for selecting the species for plantation programmes since, pest problem is one of the main reasons for low productivity in *A. triphysa* plantations.

However, *A. integrifolia* ssp *calycina* is considered inferior as it lacks aromatic resin the presence of which in *A. triphysa* makes it more attractive since it avoids the process of dipping the match splints in wax Morever, small scale field planting done in various localities showed that *A. triphysa* performed equally well in degraded soil as in fertile land, whereas *A. integrifolia* failed to survive in such degraded areas.

Table 6. Survival percent of *A. integrifolia* and *A. triphysa.*

Species	*A. integrifolia ssp. calycina*					*A. triphysa*				
Family	I	2	3	4	5	1	6	7	8	9	10
Survival %	56.67	63.33	60.00	83.33	46.67	83.33	80.00	56.67	83.33	90.00
	62%					78.66%				

Table 7. Analysis of Variance for Height and Girth

Source	DF	2 years height MSS	3 years height MSS	3 years girth MSS
Block	2	0.229 (4.08%)	0.334 (16.98%)	0.462* (62.18%)
Family	9	5.263** (93.83%)	1.405*** (71 43%)	0.124 (16.69%)
Sp[1] vs Sp[2]#	1	33.683**	8.926***	0.004
Bl x Fam.	18	0.085** (1.52%)	0.179** (9.1%)	0.118*** (15.88%)
Error	270	0.032 (0.57%)	0.049 (2.49%)	0.039 (5.25%)
Total	299			

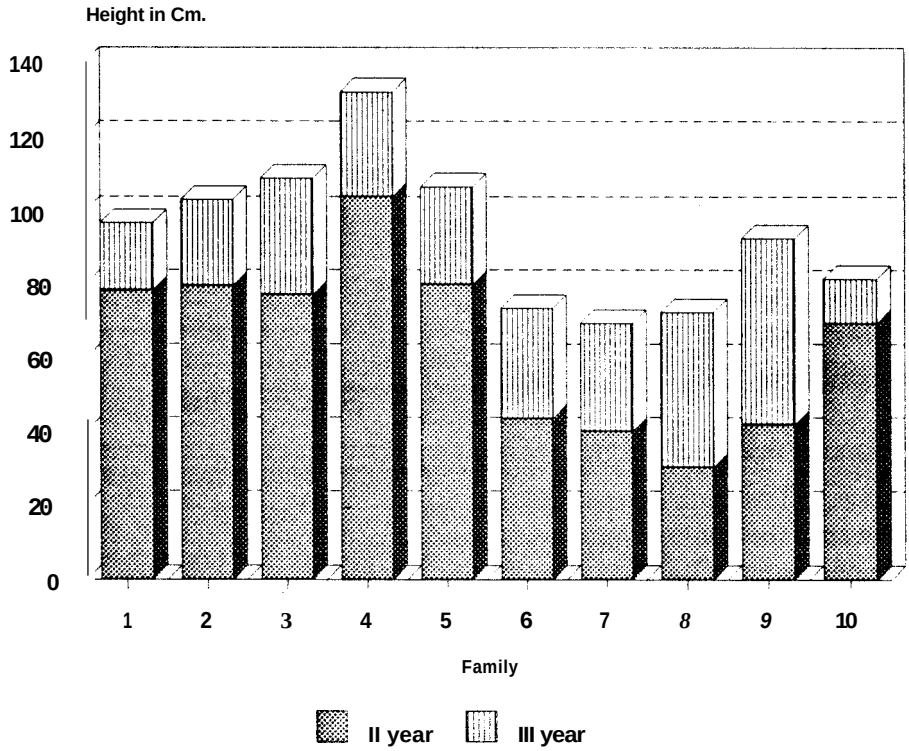
Figures in parentheses is the portion out of total variance
*, ** Significant at 5% and 1% levels respectively.
#Sp[1] *A. integrifolia* ssp. *calycina* and Sp[2] *A. triphysa*

Table 8. Mean height, girth and range

Family	Seed source	Mean plant height in cm 2 year	3 year	Mean girth in cm 3 year
A. integrifolia ssp.*caIycina*				
1. Mother tree 1	Kodanad	78.13*	96.46*	8.4
2. M.T.2	"	79.33*	102.83*	8.8
3. M.T.3	"	76.96*	108.56*	9.3*
4. M.T.4	"	103.60*	131.53*	9.9*
5. M.T.5	"	79.80*	106.23*	8.7
A. triphysa				
6. Plus tree 3	Kannoth	43.50	73.30	8.8
7. PT4	Kannoth	39.90	69.26	8.5
8. PT4	Nedumpoil	30.10	72.23	8.4
9. PT19	Nedumpoil	41.80	92.26	10.0*
10.PT1	Nilambur	69.33*	81.26	9.0*
Mean		64.25	93.39	8.98
Range		14-140	21-189	4-15

*Families better than the average

Figure 2. Mean Height in *Ailanthus integrifolia* ssp. *Calycina* (Fam. 1-5) and *A. triphysa* (Fam. 6-10)



4. BREEDING SYSTEM

4.1. Introduction

For any genetic improvement programme, a thorough knowledge on the breeding system is necessary for making decisions on the method of selection, seed orchard design, effective gene conservation and also for further improvement programmes *Ailanthus* was reported to be polygamous with male, female and bisexual flowers (Brandis, 1906, Gamble, 1915) and also as dioecious (Nooteboom, 1962) No other details are available on the breeding system except the floral descriptions.

4.2. Materials and Methods

General observations on floral biology were taken at Nilambur, Peechi and other localities. Detailed study was conducted in trees growing at Vellanikkara, Trichur District. In that area, a number of male and female trees were growing together. The main criterion for selecting the trees for pollination experiments was the accessibility of flowering branches.

Additional data in the form of observations on floral biology were collected to determine the flowering season, flowering pattern, flower opening, anthesis, fruit set and other details Pollen grains were tested for sterility through staining technique with Acetocarmine-glycerin mixture Pollination experiments were designed to detect the presence of apomixis and self sterility and was to observe the effect of artificial cross pollination and open pollination

Detection of a) apomixis: The staminodes were removed from the mature female flowers a few hours before flower opening and bagged them to protect them from any pollen entry

b) Selfing fertiliation. Female and male flowers were bagged a few hours before the flower opening and the bags were retained.

c) Artificial cross pollination: The female flowers were emasculated as mentioned earlier and bagged. On the next morning a few hours after anthesis these flowers were pollinated with a brush After pollination the bags were replaced. In all the above cases the isolation bags were made of butter paper (Pl. 1).

d) Open pollination: Flowers and later the fruits set were counted on marked inflorescences to estimate the percentage of fruit setting

To study the variability in fruit size, seed weight and germination percent, fruits were collected from twenty trees individually. Ten fruits from each of 3 replications were measured. They were analysed for variance. The seed weight and germination percent were also estimated.

4.3. Observations and Discussion

Though *Ailanthus triphysa* was generally thought of having polygamous flowers, our studies also support the report from Malaya (Nooteboom, 1962) confirming that the species is dioecious having male and female trees separate. Appearance of male the female trees are almost identical except that in male trees the crown and leaves are more compact and the leaves being more tufted at the end of the twig (PI.1). When they are not in flower, we can not detect the sex of the tree easily. The male to female tree ratio comes about 1:1 ($x2 = 0.295$) (Table 9). Change of sex expression was also not detected during the four years under study.

Flowering starts from December onwards with a peak time in January and February. With the start of flushing, floral buds also appear. Occasionally flowering could be seen in March also. Generally the trees flower profusely.

The flowering pattern varies from male to female tree. The male trees flower at a stretch of one to two weeks, then have an inactive or resting period for some days and then again start blooming. In each male inflorescence blooming lasts for 2 to 3 days. In female trees flowering is continuous for 1 to 1½ months. Number of flowers per inflorescence is more in male. Inflorescence length varies from 30 to 45 cm generally. Though inflorescences are big, flowers are very small and off-white in colour. Male flowers are bigger than female flowers (P1.2). Number of flowers per female inflorescence varies between 150 to 600.

Male flowers have 5 petals, 10 stamens and a sterile carpellode while female flowers have 5 petals, sterile stamens called staminodes and a trilocular ovary with three ridged, large and showy stigma. Stigma is directly attached to the ovary. The sterile stamens in female flowers are half the size of those fertile stamens in the male. Stigma in the female flower is big compared to the size of the flower and it is positioned in such a way so as to easily receive pollen grains from out side. Both male and female flowers have nectariferous disc. Anthers dehisce longitudinally with very little sticky pollen. Pollen grains are having a diameter of about 22 /um and are highly fertile with only 2.5 to 5 percent sterility.

Flower opening and anthesis occur at night in between 12 and 5 am. Flowers have a mild sweet smell. Very small insects are visiting the flowers. Flowers are very small and hence there is no chance for bird pollination. Since the pollen is sticky and very small in quantity, the possibility of wind pollination also can be ruled out. Hence the insect visitors should be the pollinators.

Plate 1. A. Female tree B. Male tree C. Colour variation in fruits
D. Artificially pollinated inflorescence
E. Ill - developed fruits from unfertilized ovules.

Plate 2. A. Female inflorescence B. Male inflorescence
C. Female and male flowers during anthesis

From the pollination experiments it could be inferred that

a) There is no sign of apomixis When the female flowers are isolated from pollen entry the ovary starts developing slightly but after about 10 days they are found to be dropping (pl 1)

b) There is no fruit development on selfingboth in male and female trees by which it can be deduced that the antherodes and carpellodes are sterile.

c) Artificial pollination of female flowers elicit fruiting The pollinations done during 8 to 10 am, ie. a few hours after anthesis. are fruitful.

d) Through open pollinations only 20 to 35 percent fruiting could be seen even though the female trees were surrounded by trees of both sexes.

Table 9.Sex ratio in *Ailanthus triphysa*

Area	Female tree	Male tree
Kannoth	4	5
Nedumpoil	1 1	7
Kottiyur	10	10
Peruvannamuzhy	5	8
Nilambur	5	3
Pulamanthole	1	1
Peechi	4	6
Vellanikkara	16	24
Kodanad	2	0
Total	58	64

It takes about 11/2 months for the fruits to mature after flowering There is significant variation between trees with respect to h i t size (Table 10) The fruits are having a mean length of 8.22 em, width of 2.14cm and seed thickness of 0 17cm Fruit shape and colour also vary much where many trees are having their immature fruits creamy in colour while a few others having red fruits (PI.1). The fruits are winged and very light and there is wide variation between trees in seed weight and germination (Table 11)

Since*Ailanthus triphysa* is dioecious the species should be completely cross breeding leading to less intrapopulation variation. Although monoecism may encourage outbreeding it does not necessarily ensure cross breeding as effectively as dioecism (Styles, 1972).

One striking observation noted is that in nature some very old. isolated female trees set fruits The possibilities, of high efficiency of pollinators or the change in fertility ofstaminodes in isolation, can not be ruled out. It needs further study to throw more light on this aspect.

Another interesting observation was that while male flowers are almost completely eaten by *Atteva fabriciella,* female flowers are untouched. Hence these female trees with spread crown are thought to be of more resistant than compact crowned male trees. Striking differences in the occurrence of feeding by *A. punctella* cram upon the inflorescence of staminate and pistillate individuals of *Simarouba glauca* was noticed by Bawa and Opler (1978). Some sex correlated difference in susceptibility to Atteva is indicated for some other Simaroubaceae members as in *Castela emoryi* Gray (Powell *et al.,* 1973) and *Ailanthus altissima* Millo by Taylor (c.f: Bawa and Opler, 1978). Even though the female flowers of *A.triphysa* are kept away by *A.fabriciella* later the tender seeds are eaten leaving the wings of the samara, thereby gaining an advantage of getting more food and also building up the next generation.

Table 10. Analysis of variance for fruit length, width and seed thickness

Source	DF	Fruit length		Fruit width		Seedthickness	
		MSS	F	MSS	F	MSS	F
Total		02962	-	0.0367	-		
Between trees	19	0.7384	3.7868**	0.1051	4.9907**	0.0061	4.2377**
With in trees	83	0.1950	-	0.0211	-	100014	-

** Significant at 1% level.

Table 11. Variation in seed weight and germination

Tree No	Seeds/0g	Germination %
1	60	38.00
2	105	5.71
3	90	0.00
4	112	24.00
5	97	64.50
6	85	56.75
7	85	64.71
8	99	69.20
9	109	15.00
10	85	40.49
11	83	68.91
12	102	55.88
13	86	51.16
14	87	26.50
15	95	51.35
16	106	44.61
17	108	31.87

5. SEED ORCHARD

5.1. Introduction

A seed orchard is a plantation of selected clones or progenies for producing quality seeds through exploitation of maximum genetic gain Two types of orchards are generally established such as clonal seed orchards and seedling seed orchards.

Seedling seed orchards are preferred for short rotation, early flowering crops. Lack of data on inheritance pattern and the problems in vegetative propagation are also some of the reasons for opting seedling seed orchard. In addition, both the purposes of screening of plus trees and establishmentofseedorchard, will also be served through this.

5.2. Materials and Methods

Since *A. triphysa* is an early flowering, short rotation species, seedling seed orchard has been opted for production of improved seeds. For the establishment of seed orchard, seeds were collected from plus trees and other co-dominant trees selected earlier Nursery was raised at KFRI Campus, Peechi. At the age of four months, they were transplanted in the field at Palappilly of Chalakudy Division, Trichur. In the field, 27 seed sources were. planted, out of which 20 are of plus tree origin and 7 from co-dominant trees (Table 12). 16 plants from each seed source were assembled randomly in the field with an espacement of 2 metres.

Table 12. Families included in the seed orchards

N Poi1	8	2
Kottiyur	11	2
Peruvannamuzhy	1	2
Peechi	0	1
Total	20	7

5.3. Results and Discussion

Survival rate was good in the first year which varied from 72 to 100 percent between families. Growth was quite good during this period.

In course of time, the best individuals within the best families will be selected and retained in the orchard after evaluation, while others are rogued out. This pilot seed orchard can also serve as an experimental orchard where controlled crosses can be made to select the best combinations.

6. CONCLUSIONS

1. Single tree heritability value for height was found to be moderately high in *Ailanthus triphysa* and hence phenotypic selection without recourse of progeny screening will improve also performance.

2. Single tree heritability for girth was found to be of low value while family heritability was moderate and so it could be deduced that girth is mainly controlled by non-additive genes also. Therefore phenotypic selection alone will not improve this character.

3. *A. integrifolia* ssp. *calycina* has performed better than *A. triphysa* with respect to growth in early stages and insect pest resistance. But *A. triphysa* has an aromatic resin in its wood which makes the species more suited for match splints.

4. From the field trials conducted at various locations it can be inferred that *A. triphysa* will thrive well even in degraded soil also.

5. *A. triphysa* is dioecious and cross breeding in nature. High out crossing rate will lead to less intrapopulation variation.

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