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GENETIC VARIABILITY AND RELATIONSHIP OF TREE CHARACTERS AND OIL CONTENT OF *PONGAMIA PINNATA* (L.)PIERRE IN TAMILNADU

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ABSTRACT

Karanj is a medium sized tree. Native to humid and subtropical environments, mature trees can withstand water logging and slight frost. A thick yellow-orange to brown oil is extracted from seeds. The oil has a bitter taste and a disagreeable aroma, thus it is considered as non- edible oil. In India, the oil is used as a fuel for cooking and burning of lamps. The oil is also used as a lubricant, water-paint binder, pesticide, and in soap making and tanning industries. Seeds of Karanj have about 30-35 percent oil and upto 27-28 percent oil can be expressed in crusher and most of the physical and chemical properties of the oil are almost similar to those of the diesel. Thirty seed sources of Pongamia pinnata were collected from Different Agro Climatic Region of Tamilnadu. Tree height varied from 5.48 m to 7.19 m and DBH also varied significantly among all CPTs. Crown diameter varied from 5.30 m to 6.96 m. The seed oil content varied from 38.70 to 41.54 percent was recorded. These seed sources can be further screened for tree improvement traits considering their immense value in yielding bio diesel.

Key words: *Pongamia pinnata*, oil content, Diameter breast height, Crown Diameter.

INTRODUCTION

Pongamia pinnata is a medium sized tree with a short bole and spreading crown. The tree is planted for shade and is grown as ornamental tree. It is one of the few nitrogen- fixing trees producing seeds containing 30-40 per cent oil. The natural distribution is along coasts and riverbanks in lands and native to the Asian subcontinent. It is also cultivated along roadsides, canal banks and open farm lands. It is a preferred species for controlling soil erosion and binding sand dunes because of its dense network of lateral roots. Its root, bark, leaves, sap, and flower also have medicinal properties and traditionally used as medicinal plants and now a days it is gaining importance as bio diesel plant.

Pongamia is an important species with lot of variability, which can exploited for its improvement farming systems in different agro climatic requirements, evolving the superior seeds. Genetic differences associated with the place of origin have been several times as great as that among individual trees within the population. Hence it becomes necessary to conduct seed source testing prior to a more intensive breeding work (Sniezko and Stewart, 1989).For a successful promotion of large scale plantations there is a need for carefully planned and well directed seed source research. The most successful tree improvement programme is that where proper seed sources were used. The loss from using the wrong sources can be great and even disastrous (Zobel and Talbert, 1984).

MATERIAL AND METHODS

The experiment was conducted at Forest College and Research Institute, Mettupalayam, located at 11°19’N latitude and 77°56’E longitudes and an altitude of 300 m above MSL. The average annual rainfall is 945mm, most of which is received between June to September. The temperature varies from 15 to 34.9 ^{0}C. The extensive survey was under taken across six different agro climatic zones of Tamilnadu viz., Cauvery delta zone, High rainfall zone, North-eastern zone, North-western zone, South Zone and Western Zone that spread over different districts. A distance of at least 20 km between two seed sources. The individual tree was identified based on their phenotypical characteristics and the individual tree identity was also maintained. Tree height, DBH and crown diameter were recorded for each CPTs. After record of growth traits, fruits were collected from the candidate trees subjected to analysis of oil content. The genetic estimates for the selected plus trees and oil content are furnished hereunder.

Estimation of oil content using Soxhlet method

For estimating oil, the seeds were depulped, the kernels dried at 50°C for 16 hrs and allowed to cool in a desiccator. Five grams of seeds were pulverized to a fine powder in a porcelain mortar. Ground samples were placed in a filter paper and fastened in such a way to prevent escape of the meal and then carefully transferred to an extraction thimble. The thimble was then placed in a Soxhlet extractor to which sufficient quantity of solvent petroleum ether (40 - 60°C) was added and heated until eleven siphonings were completed. The oil content was recorded by evaporating the petroleum ether at 60°C. The entire extraction process was carried out in Soxhlet extractor according to AOAC (1970). The percentage of oil content was then calculated by using the formula.

$$\text{Oil per cent} = \frac{\text{Oil weight (g)}}{\text{Sample weight (g)}} \times 100$$

Variability studies

These parameters were estimated as per the method described by Johnson *et al.* (1955).

a) Heritability

Heritability in the broad sense (h^2) was calculated using the formula suggested by Lush (1940) and expressed in percentage.

$$h^2 \text{ (broad sense)} = (\sigma^2 g / \sigma^2 p) \times 100$$

b) Genetic advance

The genetic advance was worked after Johnson *et al.*, (1955).

$$\text{Genetic Advance (GA)} = \frac{\text{Genotypic Variance}}{(\text{Phenotypic variance})^{1/2}} \times K$$

Where,

K = Selection differential (2.06) at 5% level of significance.

c) Genetic advance as percentage of mean

This was calculated using the formula;

$$\text{GA as percentage over mean} = \frac{GA}{\bar{X}} \times 100$$

Where,

$\bar{X}$ = Grand mean

Correlation studies

Genotypic and Phenotypic correlations coefficients were calculated according to the method suggested by Goulden (1952).

a) Genotypic correlation

$$r_g(XY) = \frac{\text{Genotypic covariance between X \& Y}}{[\text{Genotypic variance of (X) x Genotypic variance of (Y)}]^{1/2}}$$

b) Phenotypic correlation

$$r_p(XY) = \frac{\text{Phenotypic covariance between X \& Y}}{[\text{Phenotypic variance of (X) x Phenotypic variance of (Y)}]^{1/2}}$$

The genetic estimates for biometric attributes were classified as detailed below.

Genetic parameter	Low	Moderate	High
GCV and PCV	<20	20-30	>30
Heritability	<30	30-60	>60
GA as % of mean	<30	30-60	>60

Path coefficient analysis

Path co-efficient analysis was estimated as suggested by Dewey and Lu (1959) to study the direct and indirect effects.

Result and Discussion

Variability studies

The present study revealed that significant amount of variability existed among different Pongamia pinnata in growth and oil content investigated viz., Tree height, DBH, Crown diameter and oil content. The heritability values were high with only marginal difference. To understand the causes of variation, apportioning of total phenotypic variance has more utility. The genetic variance which is heritable could be exploited for future utility. In the current study, DBH moderate phenotypic and low genotypic variance in different identified *Pongamia pinnata* seed sources. The other traits Tree height, Crown diameter and oil content expressed low phenotypic and genotypic variances. Similar reports on moderate PCV and low GCV for DBH was observed in *Eucalyptus globulus* (Paramathma and Surendran, 1999); *E. grandis* (Pugazhendi *et al*., 1999) *Madhuca latifolia* (George Jenner *et al*., 1999); and *Casuarina equisetifolia* (Mohan Varghese *et al*., 1999). In the present study, the information obtained from the seed source of *Pongamia pinnata* showed that the phenotypic variance this indicates that the traits were influenced by non-additive gene action (Table 2).

Table.1 *Pongammia pinnata* seed source collection from different place in Tamil nadu

Source	Latitude	Longitude	Altitude	Tree height (m)	DBH (m)	Crown diameter (m)	Oil content (%)
FCRIPP 1 (Anjetti)	12°19'N	77°45'E	1816	6.52	0.23	6.37	40.25
FCRIPP 2 (Denkanikottai)	12°31'N	77°46'E	2919	6.48	0.22	6.23	40.15
FCRIPP 3 (Hosur)	12°43'N	77°49'E	2895	6.90	0.27	6.71	40.67
FCRIPP 4 (Krishnagiri)	12°30'N	78°12'E	1630	6.14	0.20	6.18	39.97
FCRIPP 5 (Pennagaram)	12°07'N	77°53'E	1703	6.77	0.28	6.44	40.78
FCRIPP 6 (Dharmapuri)	12°05'N	78°05'E	1579	6.38	0.26	6.41	40.60
FCRIPP 7 (Harur)	12°02'N	78°28'E	1170	6.84	0.26	6.58	40.32
FCRIPP 8 (Palacodu)	12°17'N	78°04'E	1708	5.97	0.21	6.07	39.73
FCRIPP 9 (Chinnalapatti)	10°16'N	77°55'E	1021	6.40	0.24	6.57	40.32
FCRIPP10(Thirumangalam)	9°49'N	77°59'E	403	6.72	0.25	6.60	40.41
FCRIPP 11 (Theni)	9°59'N	77°27'E	1094	6.09	0.21	6.00	40.13
FCRIPP 12 (Cumbum)	9°43'N	77°16'E	1460	6.59	0.23	6.24	40.11
FCRIPP 13 (Bodi)	10°01'N	77°21'E	1207	5.82	0.19	5.79	39.28
FCRIPP 14 (Orathanadu)	10°38'N	79°15'E	121	7.08	0.29	6.85	40.93
FCRIPP 15 (Tanjore)	10°50'N	79°07'E	135	6.46	0.22	6.26	40.28
FCRIPP 16 (Pattukottai)	10°25'N	79°19'E	61	6.40	0.20	6.30	40.27
FCRIPP 17 (Mettupalayam)	11°17'N	76°57'E	108	6.64	0.23	6.37	40.61
FCRIPP 18 (Sirumugai)	11°19'N	77°01'E	991	6.35	0.19	6.13	40.17
FCRIPP 19 (Dharapuram)	10°43'N	77°31'E	807	6.00	0.19	5.98	38.78

FCRIPP 20 (Vedaranyam)	10°22'N	79°49'E	15	5.79	0.21	5.66	38.83
FCRIPP 21 (Arakkonam)	13°06'N	79°40'E	266	7.04	0.30	6.80	41.38
FCRIPP 22 (Thiruvallur)	13°15'N	80°00'E	113	5.48	0.19	5.30	38.70
FCRIPP 23 (Viluppuram)	11°55'N	79°30'E	134	6.69	0.26	6.58	40.38
FCRIPP 24 (Tindivanam)	12°13'N	79°37'E	148	6.29	0.23	6.17	40.21
FCRIPP 25 (Mannargudi)	10°41'N	79°25'E	61	7.19	0.31	6.96	41.54
FCRIPP 26 (Perundurai)	11°15'N	77°36'E	910	6.33	0.19	6.18	40.45
FCRIPP 27 (Sivagangai)	9°51'N	78°30'E	315	5.69	0.18	5.48	38.80
FCRIPP 28 (Manamadurai)	9°40'N	78°26'E	248	7.00	0.29	6.77	41.15
FCRIPP 29 (Nagercoil)	8°11'N	77°23'E	315	6.24	0.18	6.07	40.09
FCRIPP 30 (Pudycherry)	11°54'N	79°47'E	61	5.68	0.17	5.45	39.53

Table 2. Genetic parameters of growth traits and oil content

Characters	GCV	PCV	Heritability (%)	Genetic Advance(%) of mean
Tree Height	6.79	7.50	82.12	12.67
DBH	13.31	24.81	28.80	14.71
Crown Diameter	6.27	7.51	69.82	10.80
Oil Content	1.65	2.10	61.39	2.66

Among the growth and oil content, highest heritability was recorded by tree height (82.12) followed by crown diameter (69.82), oil content (61.39) and DBH (28.80). And Tree height (12.67), DBH (14.71), Crown diameter (10.80) and Oil content (2.66) showed that low genetic advance. It suggesting the role of additive gene action in the expression of these characters and could be considered as reliable indices for selection. Similarly, high heritability estimates for volume was earlier reported in Eucalyptus progeny trials (Balaji, 2000) in *C. equisetifolia* also reported high heritability for girth at breast height followed by girth at ground level. Jambulingam (1990) observed consistency in heritability and genetic gain for volume over growth stages in *C. equisetifolia*. Similarly, high heritability and genetic advance were reported for height in *Bambusa balcooa* at early stages of growth and Satheesh (2000) recorded high heritability for growth traits in *Bambusa bambos* and *Dendrocalamus strictus*, respectively.

High heritability coupled with low genetic advance as percentage over mean indicates predominance of non-additive gene action (Paramathma *et al*., 1997). In the present study, such phenomenon was observed for tree height which recorded highest values for heritability and low genetic advance as percentage. Hence, selection based on this character will be advantageous for yield improvement and future breeding programme in *Pongamia pinnata* seed source.

Correlation studies

The correlation study was employed using the data collected from the plus trees to throw light on the association of traits for oil content. This correlation studies will also provide information about the relatedness of association in the parental population to that of the progenies viz., clonal population performance.

Knowledge of the interrelationship existing among different growth, form and wood attributes is of crucial value to the tree breeder. If these were not known to the breeder, selection for one trait may cause an inadvertent change in the other (Zobel and Van Buijtenen, 1989). Some wood property traits are related but many are not (Zobel, 1971). In the current study, the magnitude of genotypic correlation coefficients between all growth and oil content studied were found to be higher than the corresponding phenotypic correlation coefficients. In phenotypic and genotypic correlation coefficient, oil content showed a positive correlation with tree height, DBH and crown diameter which are obviously the contributing characters to oil content (Tables 3 and 4).

Table 3. Genotypic correlation coefficient of growth

Characters	Tree Height	DBH	Crown Diameter	Oil Content
Tree Height	1.000	1.269	1.066	1.042
DBH		1.000	1.274	1.111
Crown Diameter			1.000	1.086
Oil Content				1.000

Table 4. Phenotypic correlation coefficient of growth

Characters	Tree Height	DBH	Crown Diameter	Oil Content
Tree Height	1.000	0.539	0.811	0.734
DBH		1.000	0.532	0.557
Crown Diameter			1.000	0.661

Positive phenotypic and genotypic correlations between growth and oil content have been reported in several genera like Pinus (Squilance *et al.*1997) and *Eucalyptus camaldulensis*.

Path coefficients for growth

The path analysis permits the separation of direct effects from indirect effects through other related traits by partitioning the genotypic correlation coefficients (Dewey and Lu, 1959). The maximum positive direct effect was exerted by Tree height (0.6188) on oil content followed by DBH (0.3498) (Table 5; Fig. 1).

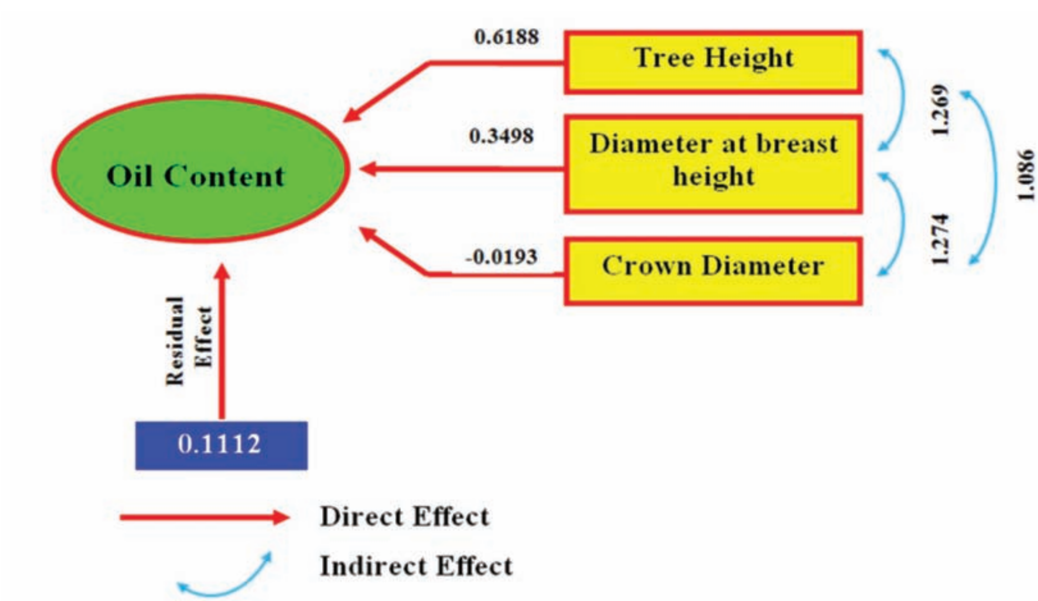

Fig. 1. Pathway co-efficient analysis in *Pongamia pinnata* genetic resource

Table 5. Path coefficient analysis for growth

Characters	Tree Height	DBH	Crown Diameter
Tree Height	<u>0.6188</u>	0.4439	-0.0206
DBH	0.7853	<u>0.3498</u>	-0.0246
Crown Diameter	0.6594	0.4457	<u>-0.0193</u>

The present investigation envisaged that high and positive association coupled with intensive direct effect of crown diameter on oil content indicated that the crown diameter could be the selection criterion in *Pongamia pinnata* improvement programmes and also for utilization in the industrial plantation programmes. From a comprehensive perspective, all growth traits were contributing directly to oil content. The crown diameter exercised its influence directly the available reports relate to path analysis of growth traits (Rathinam *et al*., 1981; Surendran, 1982). Therefore the growth attributes crown diameter may be considered important in the improvement in oil content per tree.

CONCLUSION

In the current study, among the growth, oil content and DBH moderate phenotypic and low genotypic variance in different identified *Pongamia pinnata* seed sources. Highest heritability was recorded by tree height (82.12). Tree height was recorded highest values for heritability and low genetic advance as percentage. In phenotypic and genotypic correlation coefficient, oil content showed a positive correlation with tree height, DBH and crown diameter which are obviously the contributing characters to oil content. The maximum positive direct effect was exerted by Tree height (0.6188) on oil content followed by DBH (0.3498). Hence, selection based on growth character will be advantageous for yield improvement and future breeding programme in *Pongamia pinnata* seed source. Therefore the growth attributes crown diameter may be considered important in the improvement in oil content per tree.

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