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VARIABILITY IN *Pongamia pinnata* (L.) Pierre GENOTYPES FOR SEED QUALITY AND STORABILITY CHARACTERISTICS

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ABSTRACT

An experiment was conducted during 2014 and 2015 at the Department of Seed Science and Technology, College of Agriculture, Rajendranagar, Hyderabad (India) to find out variability in sixteen seed storability characteristics of 24 *Pongamia pinnata* genotypes. All the traits showed comparatively higher phenotypic variance than genotypic variance. All the traits, except seedling length before storage which showed moderate coefficient of variability, depicted high coefficients of variability at genotypic and phenotypic levels, heritability and genetic advance. Among the traits, speed of germination, seedling vigour index-I, seedling vigour index-II and seed germination after storage reported comparatively higher genetic estimates. Among the genotypes of TOIL-5 (Tree Oils India Limited) gave maximum mean performance for five traits i.e. initial seed germination (100%), seedling dry weight (g) before storage (4.20) and after storage (3.45), seedling vigour index-I before storage (420) and after storage (266). TOIL-12 recorded higher values for seed germination after storage (85%) and seedling vigour index-I after storage (2896) followed by TOIL 21 with high initial seedling length (64.46 cm) and initial seedling vigour index-I (6140) and TOIL 4 with high speed of germination (42.39). These genotypes were superior on the basis of above traits, hence seeds of these TOILs may be considered for further tree improvement programme by selection for the enhanced seed storability for taking up of massive afforestation programme and for green energy biodiesel production.

Keywords: Genotypes, *Pongamia,* variability, seed quality, storability

INTRODUCTION

Pongamia pinnata (L.) Pierre is an indigenous plant to India and widely distributed on the Indian subcontinent, south-east Asia, Oceania, northern Australia, the East-African coast and southern China (Kazakoff *et al.,* 2011; Murphy *et al.,* 2012). It is cultivated along roadsides, canal banks and open farm lands. It is a versatile tree gaining importance as a potential source of biodiesel production (Hill *et al.,* 2006; Naik *et al.,* 2008; Scott *et al.,* 2008; Savita *et al.,* 2010) playing a major role in deciding the success of any renewable green energy production programme.

Pongamia is propagated only through seeds, hence storage behaviour is very important for taking up of successful plantation programme. Variability with regard to seed storability can be exploited for genetic improvement to evolve seeds with superior storage. 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. For a successful promotion of large scale plantations there is a need for carefully planned and well directed seed source research.

The most important factor for basic selective breeding is genetic variation in the characteristic of interest. The genetic estimates can be very useful tools in predicting the amount of gains expected in a shorter period. Marginal difference between PCV (phenotypic coefficients of variation) and GCV (genotypic coefficients of variation) and high estimates of heritability (broad sense) for all traits revealed the heritable nature of variability present. Relatively high value of genotypic variance resulted in high estimates of heritability, contributing to the high genetic gains in quantitative traits. To understand the causes of variation and apportioning of total phenotypic variance is of great utility as the heritable genetic variance could be exploited for future utility (Divakara and Das, 2011).

The level of genetic variation in a population is constantly changing and the gene pool of a population is always dynamic**.** The phenotype of a plant is determined by its genetic composition, the environment in which a plant is grown and the interaction of genotype with environment. The challenge that plant breeders face is to identify and select the plants that have genotypes conferring desirable phenotypes rather than the plants with favorable phenotypes due to environmental effects. The traits with greater heritability can be modified more easily by selection and breeding than the traits with lower heritability. Additive genetic variation makes proportionally a greater contribution to genetic variation than other types of gene action and is more easily captured by the commonly used methods of developing cultivars. Additive genetic variation is estimated by general combining ability. Traits can be classified as either qualitative, whereby variation occurs in discrete classes and often is controlled by one or a few genes, or quantitative, where variation is continuous and often is controlled by several genes, each having a minor effect. Quantitative traits can be influenced greatly by environment and thus have lower heritabilities than qualitative traits. Keeping in view of the importance of the crop and its propagation by seeds, the present study was designed to identify variability among *Pongamia pinnata* genotypes for good seed storability.

MATERIALS AND METHODS

The experiment was conducted at the Department of Seed Science and Technology, Seed Research and Technology Centre, PJTSAU, Rajendranagar, Hyderabad (India) during 2014 and 2015 to study the existence of variation among 24 genotypes of *Pongamia pinnata* and performance of seed quality parameters during seed storage. An extensive survey was under taken across forest areas of Adilabad and Ranga Reddy districts of Telangana in 2002 and 8700 genotypes of pongamia were collected. These genotypes were planted in August, 2003 in nursery and fields of Tree Oils India limited, Zaheerabad, Telangana (India). Based on characters like early maturity, seed oil content, crop canopy with less branching, less height and girth and good yield potential, 110 genotypes were selected and further screened. Finally based on their efficiency and performance 24 genotypes were screened. The individual tree was identified based on their phenotypical characteristics. Seeds were collected from candidate plus trees identified at farm of Tree Oils India Limited, Zaheerabad in February, 2014. Seed physiological studies were carried out during the reported period under study.

A laboratory experiment was laid out in a completely randomized design with four replications by storing 2 kg seed of each genotype in cloth bags. Seed physiological parameters were studied immediately after harvesting and six months after storage. Standard germination test was employed as per ISTA (2007) using sand method (Mariappan *et al.*, 2014) by placing hundred seeds in large germination trays in four replications and germination per cent was expressed using below formula at 21 days after sowing.

$$\text{Germination per cent} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds sown}} \times 100$$

$$\text{Speed of germination} = \frac{G1}{T1} + \frac{G2}{T2} + \frac{G3}{T3} + \text{-----} + \frac{Gn}{Tn}$$

Where, G1 = Number of seeds germinated on 1st day; G2 = Number of seeds germinated on 2nd day; G3 = Number of seeds germinated on 3rd day; T1 = Day one, T2 = Day two, T3 = Day three; Gn = Number of seeds germinated on nth day, Tn = nth day

Seedling vigour index-I and -II were estimated as per Abdul-Baki and Anderson (1973). The seedling length was measured from 10 randomly selected seedlings. The product of seedling length and germination percentage was tabulated for the estimation of seedling vigour index-I. Dry weight of 10 normal randomly selected seedlings from each replication was estimated by oven drying them overnight at 60°C. Seedling vigour index-II was calculated by multiplying seedling dry weight with germination percentage. The number of simple and trifoliate leaves with fully opened lamina was counted on the day of final count.

The data was analyzed statistically as per Panse and Sukhatme (1976). The data recorded as percentage were transformed to the respective angular (arc sine) values prior to analysis. The traits were analyzed using analysis of variance to understand the significant difference among the traits of TOILs under consideration (Gomez and Gomez, 1984). The components of variance were used to estimate genetic parameters like genotypic and phenotypic coefficients of variation as per the formula of Falconer (1981). Categorization of the range of variation was done as per Sivasubramanian and Madhava Menon (1973). Heritability (h^2) in broad sense was calculated as per Allard (1960) and heritability estimates categorized as per the suggestion of Johnson *et al.* (1955). From heritability estimates the genetic advance was estimated as per Burton (1952). In order to visualize the relative utility of genetic advance among the characters, genetic advance as percent of mean was computed and range of genetic advance of mean classified as per Johnson *et al.* (1955).

RESULTS AND DISCUSSION

The mean performance of genotypes involving a set of 24 genotypes for 16 quantitative traits namely seed germination, speed of germination, seedling length, seedling dry weight, SVI-I, SVI-II and the number of simple and trifoliate leaves before and after six months of storage is presented in Table 1 and Fig. 1. Genotype TOIL-5 showed high mean values for five traits *viz.*, initial seed germination (100%), seedling dry weight before (4.20 g) and after aging (3.45 g) and seedling vigour index-II before (420) and after aging (266). TOIL-12 gave higher values for seed germination after storage (85%) and seedling vigour index-I after storage (2896) followed by TOIL- 21 with high initial seedling length (64.46 cm) and initial seedling vigour index-I (6140) and TOIL-4 with high initial speed of germination (42.39), TOIL-13 with high speed of germination after aging (1.55), TOIL-18 with high number of simple leaves before aging (2.97) and TOIL-10 for high number of simple leaves after aging (2.83). Genotype TOIL-3 showed high mean value for the number of trifoliate leaves for both before (2.33) and after (2.00) aging.

Analysis of variance for 16 characters evaluated revealed that the mean sums of squares were highly significant for all characters indicating the greater variability among the pongamia genotypes for seed physiological and storability characteristics (Table 2). Genetic estimates of seed physiological and storability characters are presented in Table 3. There were fair differences between GCV and PCV for all traits. Comparatively higher phenotypic variances than genotypic

Table 1: Mean performance of selected genotypes for seed quality and storability traits in *Pongamia pinnata*

Pongamia genotype	Seed germination (%)		Speed of germination		Seedling length (cm)		Seedling dry weight (g)		SVI-I		SVI-II		No. of simple leaves		No. of trifoliate leaves	
	BA	AA	BA	AA	BA	AA	BA	AA	BA	AA	BA	AA	BA	AA	BA	AA
TOIL-1	90 (72)	32 (35)	27.36	0.35	48.60	34.22	3.95	3.30	4374	1118	355	105	1.50	1.00	1.65	2.00
TOIL-2	65 (54)	0 (4)	19.65	0.75	38.32	0.00	1.99	0.00	2498	0	131	0	2.00	0.00	1.45	0.00
TOIL-3	90 (72)	33 (35)	29.95	0.37	60.09	37.30	3.40	2.97	5408	1243	306	99	2.38	2.17	2.33	2.00
TOIL-4	75 (60)	53 (47)	42.39	0.60	55.88	32.18	3.10	2.73	4199	1695	233	144	2.63	2.50	1.91	1.50
TOIL-5	100 (86)	77 (62)	39.49	1.20	60.69	36.68	4.20	3.45	6069	2862	420	266	1.77	1.24	1.15	1.74
TOIL-6	85 (67)	75 (60)	31.62	0.80	45.02	35.09	3.11	3.28	3825	2619	266	245	1.90	1.29	1.00	1.58
TOIL-7	90 (72)	62 (52)	25.41	0.56	43.23	33.07	3.00	2.38	3890	2037	270	149	2.31	1.45	1.87	1.33
TOIL-8	60 (51)	48 (44)	17.73	0.53	47.03	30.53	2.81	2.47	2822	1476	169	119	1.50	1.75	1.50	1.65
TOIL-9	70 (57)	0 (4)	28.34	0.13	43.71	0.00	2.37	0.00	3059	0	166	0	1.82	0.00	1.37	0.00
TOIL-10	65 (54)	45 (42)	35.17	0.39	50.83	36.65	3.13	2.70	3309	1625	204	121	2.41	2.83	1.41	1.36
TOIL-11	75 (60)	47 (43)	25.14	0.52	55.13	29.13	2.77	2.17	4137	1359	209	101	2.62	2.30	1.5	0.93
TOIL-12	85 (67)	85 (67)	35.78	0.72	56.88	34.21	3.88	2.73	4847	2896	331	231	2.01	1.80	2.07	1.74
TOIL-13	85 (67)	65 (53)	20.47	1.55	43.80	32.90	2.52	1.95	3721	2117	215	127	1.30	1.60	1.51	1.65
TOIL-14	87 (69)	85 (67)	35.06	0.90	45.13	32.46	3.12	2.23	3915	2747	273	189	1.86	1.80	1.92	1.42
TOIL-15	30 (33)	0 (4)	7.78	0.18	48.52	0.00	0.61	0.00	1456	0	18	0	1.75	0.00	1.25	0.00
TOIL-16	75 (60)	36 (37)	20.51	0.25	50.88	31.36	3.50	3.00	3830	1139	264	108	1.75	1.75	1.71	1.75
TOIL-17	45 (42)	35 (36)	7.81	0.22	40.36	28.77	1.49	1.81	1822	978	69	63	1.75	2.66	1.50	0.50
TOIL-18	80 (63)	10 (18)	20.19	0.03	39.75	32.26	1.75	1.53	3180	323	140	15	2.97	2.05	1.12	1.25
TOIL-19	55 (48)	0 (4)	18.23	0.08	38.74	0.00	1.41	0.00	2140	0	79	0	1.96	0.00	1.56	0.00
TOIL-20	95 (78)	62 (52)	27.92	0.51	49.34	34.21	2.95	3.04	4674	2144	281	188	1.33	1.75	1.82	1.45
TOIL-21	95 (78)	80 (63)	32.79	0.90	64.46	35.87	3.94	3.04	6140	2870	375	243	2.38	2.63	2.01	1.13
TOIL-22	70 (57)	59 (50)	13.80	0.56	53.15	36.34	3.28	2.22	3720	2144	230	131	1.38	2.50	1.33	1.25
TOIL-23	95 (78)	50 (44)	33.72	0.35	51.08	32.36	2.89	2.74	4857	1586	277	138	1.94	1.46	1.55	1.50
TOIL-24	75 (60)	37 (37)	30.99	0.61	57.87	35.21	3.53	2.20	4350	1326	265	81	2.57	1.91	1.07	1.50
Mean	77 (63)	45 (40)	26.14	0.54	49.52	27.94	2.86	2.16	3843	1513	231	119	1.98	1.60	1.56	1.21
SEm±	2.28 (2.01)	0.70 (0.62)	0.80	0.11	1.67	0.30	0.23	0.08	215.43	33.94	21.77	5.19	0.28	0.44	0.27	0.28
$CD_{0.05}$	6.48 (5.73)	2.00 (1.76)	2.28	0.32	4.76	0.86	0.65	0.23	613.24	96.58	61.97	14.77	0.84	1.28	0.79	0.81
C.V%	5.17 (5.57)	2.72 (2.68)	5.31	21.17	5.85	1.88	13.80	6.43	9.71	3.89	16.31	7.53	20.53	38.93	24.51	32.50

BA = Before aging; AA = After aging; SVI = Seedling vigour index

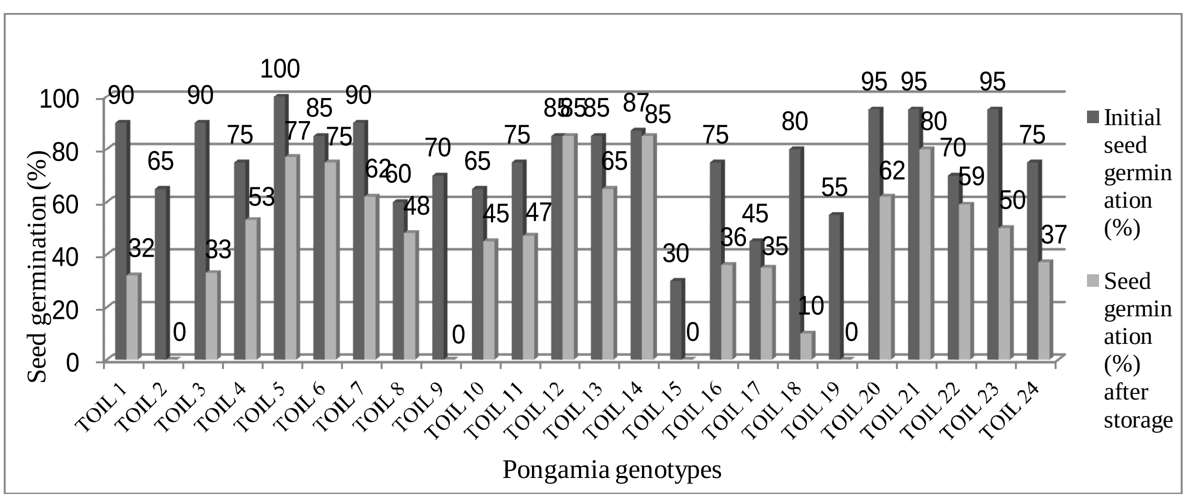

Fig. 1: Effect of storage period on seed germination in pongamia genotypes

Table 2: Analysis of variance for sixteen traits among *Pongamia*genotypes

Parameters	Treatments	Error	Total
DF	(23)	(46)	(71)
Seed germination (%) – BA	874.57**	15.56	293.40
Speed of germination – BA	42.32**	0.10	13.78
Seedling length (cm) – BA	162.99**	8.38	58.53
Seedling dry weight (g) – BA	2.37**	0.15	0.87
SVI-I – BA	4315128.00**	139223.80	1488620.00
SVI-II – BA	28826.71**	1421.48	10273.02
No. of simple leaves – BA	0.67**	0.07	0.27
No. of trifoliate leaves – BA	0.36**	0.03	0.14
Seed germination (%) – AA	2276.30**	1.48	739.47
Speed of germination – AA	0.08**	0.00	0.02
Seedling length (cm) – AA	504.24**	0.27	163.52
Seedling dry weight (g) – AA	3.62**	0.01	1.18
SVI-I – AA	2751447.00**	3455.60	893876.80
SVI-II – AA	19571.17 **	80.72	6440.77
No. of simple leaves – AA	1.77**	0.03	0.59
No. of trifoliate leaves – AA	1.05**	0.07	0.39

BA = Before aging; AA = After aging; SVI = Seedling vigour index

variances were observed. All the traits showed high coefficients of variation except seedling length before aging, which showed moderate coefficient of variation. Deebe *et al.* (2011) reported a significant variation among fifty-three candidate plus trees (CPTs) of *Pongamia pinnata* with respect to their pod and seed characters.

Higher estimates of PCV and GCV and high heritability values accompanied by high genetic advance estimates were also reported for seed thickness and 100-seed weight indicated additive gene action (Chillar *et al.*, 2002; Kaushik *et al.*, 2007; Thakur *et al.*, 2008; Ukey *et al.*, 2008; Sunil *et al.*, 2009; Narkhede *et al.*, 2009). The genetic variance which is heritable could be exploited for future utility (Divakara and Das, 2011). The variability in seed source is largely attributed to the heterogeneity of the genotypes and the genotype x environment interactions (Raut *et al.*, 2011).

Table 3: Genetic estimates of seed quality traits in relation to seed storability in pongamia

Parameters	Range	Mean	Coefficient of variability		Genetic component	
			GCV	PCV	h^2 (bs) (%)	GA (%) of mean
Seed germination (%)-BA	30 – 100	77	22.11	22.71	95	44.36
Speed of germination-BA	7.78 - 42.39	26.14	36.18	36.32	99	74.25
Seedling length (cm)-BA	38.32 - 64.46	49.52	14.50	15.63	86	27.70
Seedling dry weight (g)-BA	0.61 - 4.20	2.86	30.03	33.05	83	56.21
SVI-I-BA	1456 – 6140	3843	30.70	32.20	91	60.29
SVI-II-BA	18 – 420	231	41.36	44.45	87	79.27
No. of simple leaves-BA	1.30 - 2.97	1.98	21.99	25.65	74	38.85
No. of trifoliate leaves-BA	1.00 - 2.33	1.56	19.96	23.02	75	35.63
Seed germination (%)-AA	0 – 85	45	61.48	61.59	100	126.42
Speed of germination-AA	0.03 - 1.55	0.54	75.41	75.98	99	154.16
Seedling length (cm)-AA	28.77 - 37.30	27.94	46.37	46.41	100	95.45
Seedling dry weight (g)-AA	1.53 - 3.45	2.16	50.65	51.06	98	103.51
SVI-I-AA	323 - 2896	1513	63.27	63.39	100	130.10
SVI-II-AA	15 – 269	119	67.80	68.22	99	138.82
No. of simple leaves-AA	1.00 - 2.83	1.60	53.16	54.87	94	106.11
No. of trifoliate leaves-AA	1.13 - 2.00	1.21	50.70	56.47	81	93.77

BA = Before aging; AA = After aging; SVI = Seedling vigour index GCV= Genotypic coefficient of variation; PCV = Phenotypic coefficient of variation; h^2(bs) = Heritability broad sense; GA = Genetic advance

The genotypic coefficients of variation and genetic gain were comparatively higher for important traits like speed of germination after aging, seedling vigour index II after aging and seed germination after aging. The trait for seed storability may be changed considerably by selecting the superior 5% genotypes with high seedling vigour index-II and speed of germination. A significant amount of variability existed in different genotypes of *Pongamia pinnata*. The heritability values were high with only marginal difference. To understand the causes of variation, apportioning of total phenotypic variance has more utility. The similar results were reported by Divakara *et al.*, (2010), Divakara and Das (2011) and Patil *et al.* (2011).

Among the traits, highest heritability was recorded by seed germination after aging, seedling length-AA and seedling vigour index-I followed by speed of germination-BA, speed of germination-AA and seedling vigour index-II-AA (99.0) and seedling dry weight-AA (98.0). Speed of germination-AA showed high genetic advance (154.16) followed by seedling vigour index-II-AA (138.82) and seedling vigour index-I-AA (130.1). It suggests the role of additive gene action in the expression of these characters so could be considered as reliable indices for selection for improving the seed storability traits in *Pongamia pinnata*.

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