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RESEARCH ARTICLE

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Pod and seed trait variation studies in provenances of *Pongamia pinnata* (L.) Pierre. A potential agroforestry tree

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ABSTRACT

Screening of 40 candidate plus trees from naturally available *Pongamia pinnata* genetic resources was carried out to elucidate the variation of pod and seed traits on germination capacity to select the best planting material for higher productivity. The experiment was conducted at Regional Agricultural Research Station, Bijapur, Karnataka during 2005-2006. Variability studies revealed that, among the pod trait variability studies, highest 100 pod weight was recorded in CPT-20 (661.62 g), highest pod length in CPT-17 (7.0 cm) and more pod width in CPT-17 (3.1 cm). Among the seed traits, highest 100 seed weight was in CPT-18 (279.51 g), per cent seed oil content was highest in CPT-20 (42.79%), maximum seed nitrogen in CPT-10 (6.16%), seed phosphorus in CPT-30 (1.30%), highest seed potassium content in CPT-38 (1.33%) and among the seed sources highest seed germination was observed in CPT-11 (91%). In conclusion, the results revealed the existence of substantial genetic variation, which can be utilized for genetic resource conservation in gene bank and further tree improvement programmes of the species.

KEY WORDS : Pongamia, Seed source, Pod, Trait, CPTs

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INTRODUCTION

Pongamia pinnata (L.) Pierre, an arboreal legume, commonly known as Indian-beech. This medium-size tree is indigenous to the Indian subcontinent and south-east Asia (Malaysia and Indonesia), and has been successfully introduced to humid tropical regions of the world as well as parts of Australia, New Zealand, China and USA. It is drought resistant, nitrogen-fixing leguminous tree known to withstand water logging and mild frost, with high tolerance to salinity (Scott *et al.*, 2008).

P. pinnata is an excellent multipurpose tree with each and every part of the tree having specific use. Leaves are used as lactagogue fodder, especially in arid regions and also as green manure. Dried leaves are used in stored grains to repel insects. Leaves are active against Micrococcus; their juice is used for cold, cough, diarrhea, dyspepsia, flatulence, gonorrhea, and leprosy (Muthu *et al.,* 2006). Flowers are used to treat diabetes; roots for cleaning gums, teeth, ulcers and bark for bleeding piles. The wood is not durable, hence limited to cabinet making, cartwheels, posts and fuel. The ash of the wood is used in dyeing. The seed cake is used as cattle and poultry feed and biogas production. Furthermore, the waste pulp is used as an organic fertilizer (Shrinivasa, 2001). It is valued for its seeds consisting of 30-40% oil rich in triglycerides. The oil is also used as a lubricant, water paint binder, pesticide, and in soap and tanning industries. The oil is also valued as a folk medicine in enhancing the pigmentation of skin affected by leucoderma and used as a liniment to treat scabies, herpes and rheumatism.

Besides these advantages, pongamia seed oil as bio-diesel is fast emerging as a viable alternative to fossil fuel. In meeting the future demands for bio-diesel it will be important to establish extensive commercial-scale pongamia plantations. However, the progress will be hampered by several factors *viz*., shortage of elite planting material, low viability of the seeds and insufficient seed germination due to fungal damage and presence of a hard seed coat that reduces germination capability. Moreover, the constraint of plants established by vegetative propagation through stump cuttings are not deep rooted and are easily uprooted (Azam *et al.*, 2005).

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Hence, the challenging task, as of today is to screen the naturally available *P. pinnata* genetic resources to select the best planting material for higher productivity. Seeds from proven source or plus trees form the backbone of any successful tree improvement and afforestation programme. Seed parameter and germination behaviour are most important for afforestation programme and these characters are interdependent and polygenically controlled. Keeping all this in view, an effort has been made to evaluate the extent of variation and relationship of pod and seed traits on germination behaviour of Candidate Plus trees (CPTs) collected from various zones of Karnataka, India.

MATERIALS AND METHODS

An extensive wild germplasm exploration survey was conducted to identify the high yielding CPTs of *Pongamia pinnata* at fruiting stage from different predominant naturalized locations in Karnataka, India (Table 1). The selection was made on phenotypic assessment of economic interest characters *viz.,* yield potential, crown spread, total height, girth at breast height, age of the tree, free from pest and diseases *etc*. A total of 40 CPTs (morphologically superior trees) covering 10 agro-climatic zones of Karnataka were collected with 4 CPTs in every agro-climatic zone. From each CPTs 2 kg mature capsules were collected during February-March, 2005. The pods were cleaned and stored in muslin bags at ambient conditions. All lots were dried under similar temperature and humidity conditions to reach constant weight. A total of 100 healthy pods were collected from each CPTs to make three replications containing 25 pods per replication. Observations on three pod characters *viz.,* pod length, pod width and 100-pod weight were recorded. Pod length was measured from the tip of the pod to the point of attachment of the pod to the stalk and expressed in cm. Pod width was measured and expressed in cm. The weight of the 100-pods was recorded by weighing in electrical balance and average value was calculated and expressed in grams. The test seed weight of 100 seeds in each CPT with three replication was taken. Then the seeds were sown in polybags laid out in completely randomized block design and seed sources were assessed for germination per cent. The seed samples of 40 CPTs were sent to TERI, New Delhi for oil analysis and the seed nutrient analysis (Nitrogen, Phosphorus and Potassium) was conducted in the local laboratory of RARS, Bijapur. The data recorded on various characters during the course of investigation were subjected to Fisher's method of analysis of variance and interpretation of data was made as per the procedure given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The mean performance of pod traits (pod length, pod width and 100-pod weight) and seed traits (seed length, 100-seed weight, total oil content, seed nutrients and germination capacity) from 40 CPT's of *Pongamia pinnata* revealed the significant difference among the CPT's (Table 2). Among the pod trait variability studies, 100 pod weight varied from 163.75g to 661.62 g with highest weight in CPT-20 (661.62 g) followed by CPT-18 (640.95 g) and lowest was recorded in CPT-3 (163.75 g). The pod length varied from 3.1cm to 7.0cm with highest pod length in CPT-17 (7.0 cm) followed by CPT-20 (6.6 cm) and lowest was recorded in CPT-3. Similarly, the pod width varied from1.4cm to 3.1cm with more pod width in CPT-17 (3.1 cm) followed by CPT-35 and CPT-36 and lowest pod width was in CPT-3.

Among the seed traits, 100 seed weight varied from 56.11g to 279.51g with highest was in CPT-18 (279.51 g) followed by CPT-17 (266.03 g) and lowest was in CPT-2 (56.11 g). The per cent seed oil content varied from 28.98 to 42.79 with highest was in CPT-20 (42.79%) followed by CPT-2 (40.40%) and least seed oil was in CPT-34. Among the seed nutrients, per cent nitrogen varied from 3.08 to 6.16 with highest nitrogen in CPT-10 (6.16%) followed by CPT-14 (5.74%) and less seed nitrogen was recorded in CPT-36. The per cent phosphorus in seeds varied from 0.90 to 1.30 with highest seed phosphorus in CPT-30 (1.30%) followed by CPT-16, CPT-25 and CPT-36 (1.29%) and lease was in CPT-38.

Among the seed sources the seed potassium content varied from 0.43 per cent to 1.33 per cent with highest potassium content in CPT-38 (1.33%) followed by CPT-39 (1.29%) and less was in CPT-30. Among the seed sources highest per cent seed germination was observed in CPT-11 (91%) followed by CPT-12 and CPT-29 (87%) and least seed germination was observed in CPT-39 (17%).

Seed weight, depends on reserve food material, which is produced as a result of double fertilization (endosperm) and is dominated by the maternal traits, also influenced by the nutrient availability at the time of seed setting and environmental factors (Johnsen *et al.*, 1989). Embryo development and its physiological function are contributed by the maternal as well as by paternal (pollen grain) traits in the species. The occurrence of *P. pinnata* over a wide range of habitats with diverse geo-climatic conditions was expected to be reflected in the genetic constitution of its populations. In the present study, the

Table 1 : Details of *Pongamia pinnata* candidate plus trees

CPTs	Zone	Latitude	Longitude	Altitude (m)	Age in years	Height (m)	DBH (cm)	Appr. seed yield (kg/year)	Crown spread	
									E-W	N-S
1	I	16^{0} 12`N	76^{0}24`E	389.5	10	5.00	18.00	15	8.20	6.60
2	I	16^{0} 12`N	76^{0}24`E	389.5	15	7.00	22.00	20	8.00	7.00
3	I	16^{0} 12`N	76^{0}24`E	389.5	10	6.00	16.00	15	6.00	7.20
4	I	16^{0} 12`N	76^{0}24`E	389.5	12	6.00	20.00	25	6.00	5.00
5	II	16^{0} 12`N	76^{0}24`E	389.5	15	7.00	22.00	20	8.20	7.00
6	II	16^{0} 12`N	76^{0}24`E	389.5	15	6.50	18.00	20	8.20	8.00
7	II	16^{0} 12`N	76^{0}24`E	389.5	12	5.50	16.00	20-25	8.10	6.00
8	II	16^{0} 12`N	76^{0}24`E	389.5	25	8.90	24.00	30	9.00	8.00
9	III	15^{0} 55`N	75^{0}41`E	631	20-25	7.62	50.00	40-50	5.00	5.00
10	III	15^{0} 55`N	75^{0}41`E	631	10-12	5.48	30.00	25-30	4.50	3.50
11	III	15^{0} 55`N	75^{0}41`E	631	8-10	4.87	20.00	20-25	5.00	4.00
12	III	15^{0} 55`N	75^{0}41`E	631	7-8	3.65	12.00	20-25	3.00	5.00
13	IV	13^{0} 56`N	75^{0}40`E	650	25-30	7.50	30.20	50-60	8.20	10.20
14	IV	13^{0} 56`N	75^{0}40`E	650	25-30	8.00	30.20	50	8.20	8.20
15	IV	13^{0} 56`N	75^{0}40`E	650	20	6.00	30.20	30	8.20	8.40
16	IV	13^{0} 56`N	75^{0}40`E	650	25-30	6.200	27.00	50-60	10.10	6.40
17	V	13^{0} 56`N	75^{0}40`E	650	45-50	12.00	46.80	50-60	16.80	18.00
18	V	13^{0} 56`N	75^{0}40`E	650	50	12.00	54.80	60	19.80	15.10
19	V	13^{0} 56`N	75^{0}40`E	650	25-30	10.00	42.00	40	11.40	12.00
20	V	13^{0} 56`N	75^{0}40`E	650	25-30	11.00	38.00	40-50	14.30	12.70
21	VI	13^{0} 56`N	75^{0}40`E	650	20	6.00	30.60	30	7.80	8.00
22	VI	13^{0} 56`N	75^{0}40`E	650	20	5.50	27.40	25-30	7.30	6.00
23	VI	13^{0} 56`N	75^{0}40`E	650	30	6.50	31.00	35-40	9.70	7.30
24	VI	13^{0} 56`N	75^{0}40`E	650	18.20	4.70	23.60	25-30	7.90	7.10
25	VII	13^{0} 56`N	75^{0}40`E	650	25	11.00	42.30	50-60	12.60	15.00
26	VII	13^{0} 56`N	75^{0}40`E	650	15	6.00	26.00	35-40	5.00	6.00
27	VII	13^{0} 56`N	75^{0}40`E	650	15-20	6.50	28.20	30	8.00	8.00
28	VII	13^{0} 56`N	75^{0}40`E	650	15-20	6.00	26.70	25	5.00	7.40
29	VIII	15^{0} 26`N	75^{0}07`E	678	15	8.00	50.20	25-30	12.00	8.60
30	VIII	15^{0} 26`N	75^{0}07`E	678	25-30	9.00	52.40	20	11.5	10.40
31	VIII	15^{0} 26`N	75^{0}07`E	678	25	9.00	42.20	30-40	12	11.00
32	VIII	15^{0} 26`N	75^{0}07`E	678	12-15	7.00	24.10	20-22	10.60	7.60
33	IX	15^{0} 26`N	75^{0}07`E	678	25	11.00	46.30	50-60	12.60	13.20
34	IX	15^{0} 26`N	75^{0}07`E	678	20	9.00	44.50	40-50	14.8	11.80
35	IX	15^{0} 26`N	75^{0}07`E	678	20	7.00	34.00	40	9.00	10.00
36	IX	15^{0} 26`N	75^{0}07`E	678	25	9.00	44.10	40	8.60	9.40
37	X	13^{0} 56`N	75^{0}40`E	650	20	6.30	45.00	25-30	12.20	12.00
38	X	13^{0} 56`N	75^{0}40`E	650	15-18	7.50	26.80	25-30	9.10	8.30
39	X	13^{0} 56`N	75^{0}40`E	650	15	7.00	18.80	20	9.30	7.40
40	X	13^{0} 56`N	75^{0}40`E	650	25.30	6.00	32.40	40	9.40	9.80

Table 2 : Mean performance of selected CPTs for pod and seed traits in *Pongamia pinnata*

CPTs	Zone	Place	Pod traits			Seed traits					Germination (%)
			100 pod weight (g)	Pod length (cm)	Pod width (cm)	100 seed weight (g)	Seed oil content (%)	Nitrogen (%)	Phosphorus (%)	Potassium (%)	
1	I	Bidar	274.22	4.0	2.0	95.80	36.14	5.04	1.00	0.86	50
2	I	Bidar	199.74	3.3	1.7	56.11	40.40	3.36	1.08	0.73	69
3	I	Bidar	163.75	3.1	1.4	58.04	37.10	3.64	1.19	0.60	62
4	I	Bidar	188.92	3.3	1.6	97.15	38.78	4.20	1.20	0.51	83
5	II	Gulbarga	319.34	5.4	1.9	130.02	32.65	4.48	1.10	0.75	70
6	II	Gulbarga	266.41	5.3	1.8	126.60	38.95	3.64	1.15	0.62	80
7	II	Gulbarga	299.69	5.4	2.5	120.30	37.18	3.08	1.06	0.77	63
8	II	Gulbarga	212.10	4.5	1.9	69.81	37.71	5.04	1.00	1.21	41
9	III	Bijapur	332.42	4.8	2.4	142.38	37.68	5.32	1.25	0.54	37
10	III	Bijapur	308.28	4.9	2.5	140.48	36.64	6.16	1.10	0.83	32
11	III	Bijapur	261.48	4.0	1.7	94.81	36.19	3.64	1.15	0.63	91
12	III	Bijapur	530.04	5.0	2.5	226.72	36.24	4.76	1.00	0.83	87
13	IV	Chitradurga	286.80	4.2	2.1	153.25	35.63	5.04	0.95	0.86	79
14	IV	Chitradurga	256.78	4.7	2.0	119.78	34.46	5.74	1.01	1.22	83
15	IV	Chitradurga	229.71	4.7	1.9	112.84	36.63	4.76	1.14	0.63	61
16	IV	Chitradurga	208.28	4.7	2.0	83.26	34.77	5.88	1.29	0.58	36
17	V	Bangaluru	599.64	7.0	3.1	266.03	37.80	4.48	1.18	0.65	52
18	V	Bangaluru	640.95	6.5	2.8	279.51	40.33	4.48	0.98	0.90	67
19	V	Bangaluru	616.02	6.2	2.8	249.03	32.87	4.76	0.95	1.05	45
20	V	Bangaluru	661.62	6.6	2.9	270.70	42.79	3.78	1.15	0.76	58
21	VI	Hassan	400.35	5.9	2.5	145.74	33.40	3.36	1.10	0.66	55
22	VI	Hassan	275.71	5.7	2.6	110.00	32.46	5.88	1.13	0.70	51
23	VI	Hassan	275.38	4.0	2.1	104.75	33.94	3.36	1.10	0.81	50
24	VI	Hassan	279.90	5.4	2.7	106.40	36.52	4.20	0.99	0.95	67
25	VII	Shimoga	345.00	5.5	2.3	164.70	37.57	3.08	1.29	0.69	74
26	VII	Shimoga	311.80	5.3	2.0	144.19	34.91	3.36	0.91	1.04	58
27	VII	Shimoga	320.21	5.5	2.2	147.02	30.87	3.64	1.23	0.77	76
28	VII	Shimoga	321.30	5.2	2.1	149.00	35.87	5.60	0.99	0.90	81
29	VIII	Dharwad	338.99	5.5	2.2	159.74	35.62	4.48	1.14	0.70	87
30	VIII	Dharwad	360.75	5.5	2.3	166.95	36.52	3.36	1.30	0.43	64
31	VIII	Dharwad	252.12	4.9	2.0	103.30	34.84	4.76	1.05	0.72	83
32	VIII	Dharwad	338.51	5.5	2.1	147.12	34.46	5.74	1.01	0.83	73
33	IX	Sirsi	365.19	5.5	2.4	142.09	32.43	4.48	1.04	0.79	67
34	IX	Sirsi	407.25	6.1	2.7	163.91	28.98	3.92	1.08	0.75	37
35	IX	Sirsi	433.52	5.6	3.0	158.12	32.89	3.36	1.00	0.92	64
36	IX	Sirsi	390.76	5.7	3.0	145.72	36.75	3.08	1.29	0.57	27
37	X	Mangalore	475.96	5.9	2.9	204.33	31.38	3.36	1.05	0.72	20
38	X	Mangalore	442.96	5.8	2.9	187.77	32.22	4.20	0.90	1.33	21
39	X	Mangalore	460.16	5.7	2.9	200.52	31.90	3.36	0.98	1.29	17
40	X	Mangalore	422.39	5.7	2.9	182.55	36.35	3.08	1.08	0.80	20
S.E.±			5.04	0.55	0.30	3.92	1.63	0.28	0.05	0.06	3.16
C.D. (P=0.05)			14.39	1.57	0.87	11.20	4.66	0.80	0.14	0.17	9.03

seeds from various CPTs exhibited significant variability in pod and seed traits could be attributed to isolations that inturn influence gene flow. Significant variability of seed characters like; seed size and weight was observed in selected plus trees and among various provenances of *S. album* (Veerendra *et al.*, 1999). This type of variability in seed morphology and germination is attributed to the out-breeding nature of sandalwood. Genetic control of seed size traits has been observed in several tree species like *Faidherbia albida* (Ibrahim *et al.*, 1997), *Tectona grandis* (Jayasankar et al., 1999), *Dalbergia sissoo* (Gera *et al.*, 2000), *Tectona grandis* (Sivakumar *et al.*, 2002), *Strychnos cocculoides* (Mkonda *et al.,* 2003), *Juniperus procera* (Mamo *et al.*, 2006), and *Cordia africana* (Loha *et al.*, 2006).

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