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Morphometric Analysis of *Pongamia pinnata* L. Accession Across Distinct Regions of Karnataka and it Influence on Oil Content

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Abstract An ever increasing demand of fuels has been a challenge for todays scientific workers. The fossil fuel resources are dwindling day by day. Biodiesel is environmentally friendly and causes fewer CO_2, CO, HC and NO_X emission. *Pongamia pinnata* may be an emerging option for providing bio-oil for biodiesel production. The study was carried out in three climatic regions of Karnataka, viz., coastal, hilly and plain regions to evaluate the effect of environmental factors on physical parameters of pongamia trees, fruits and oil content in three regions. The seeds were collected from the Dakshina Kannada (coastal), Hassan (hilly) and Bengaluru (plain) districts of Karnataka. The survey has revealed that the trees were abundantly found in plain, coastal and hilly regions, but seed yield was found to be low in coastal region compared to plain and hilly regions. There was no variation with respect to height of plants between plain, hilly and coastal regions. But, with respect to trunk girth, canopy girth and number of branches there were significant variations between climatic regions. The research findings indicated that there were no significant differences between the three regions with respect to length, breath and thickness of pods and seeds. The results showed that the climatic regions did not significantly effect 100 pods and seed weight and seed/pod ratio. The results have shown that the percentage of oil varied with the location. The trees which are found in the plain region recorded the highest oil percentage and showed decreasing in hilly region and the least oil content recorded in coastal region.

Keywords *Pongamia pinnata*, Oil, Pod, Seed.

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Introduction

Self-sufficiency in energy is vital for overall economic development of India and other developing countries of the globe. India is using 3.5% of worlds total commercial energy, therefore India ranks 6th country in terms of consumption of energy. While the production of crude oil is less than the demand therefore there is enormous gap in demand and supply. Therefore, there is a need to import oil resulting in heavy burden of foreign exchange on the country. Lately, Indian Government started National Mission on Biodiesel a low-cost and renewable liquid fuel based on vegetables oils that can be considered as the finest replacement of diesel in the country. The biodiesel is the mono-alkyl ester of long chain fatty acids of animal lipids or vegetable oil (Meher et al. 2006).

The necessity to seek for alternative renewable, secure and non-polluting sources has been given top priority. Amongst the different non-edible oil seed plants, pongamia plant is considered as the promising resource that can provide the growing demand of biodiesel in India because of its great productivity and relatively short maturity cycle (Sangwan et al. 2010). The seeds of *Pongamia pinnata* have 25 to 40% oil (dense, reddish, brown oil representing good physico-chemical properties) (Natanam et al. 1989, Nagaraj and Mukta 2004) that can be transformed to biodiesel (fatty acid methyl esters, FAMEs) by transesterification by methanol in the presence of potassium hydroxide (KOH) (Konthe 2006, Konthe 2002). The whole saturated and unsaturated fatty acid composition was 20.5% and 79.4% respectively. The main mono unsaturated fatty acid was oleic acid (46%) whiles linoleic acid (27.1%) and linolenic acid (6.3%) forms the total poly unsaturated fatty acid. Low molecular weight fatty acids such as lauric and capric acids occur in very small amounts of about 0.1% each (Natanam et al. 1989, Nagaraj and Mukta 2004).

Materials and Methods

This study was carried out in three climatic regions of Karnataka, viz., coastal, hilly and plain regions. The seeds were collected from the Dakshina Kannada, Hassan and Bengaluru districts of Karnataka. The latitude and longitude of each place was noted using the GPS and detailed information about the trees were recorded. The harvested pods from three regions were sun-dried until they gained constant weight. The length, breadth and thickness of the pods and seeds were measured using the digital vernier caliper. 100 pod weight, 100 seed weight and seed/pod ratio were recorded.

Gerhardt soxtherm apparatus was used for estimating of oil content in seeds of pogamia. Sun-dried seeds were powdered and 10 g of powdered sample was weighed with precision to four decimal places. The powdered seed samples were taken in a cotton thimble and plugged with cotton and placed in preweighed soxtherm jars containing boiling stones. About 110 ml of petroleum ether solvent was added and placed in soxtherm apparatus. The oil was extracted by running the pre-programmed soxtherm apparatus for 3 h 18 min. After completion of extraction, the remaining petroleum ether and moisture present in the oil was removed by placing in hot air oven at 110°C for 1 h. Then, the jars were removed from the oven and placed in desiccators containing $CaCO_3$ for one night to remove moisture.

Results and Discussion

The investigation was carried out to know the oil content of *Pongamia pinnata* L. in coastal, hilly and plains of Karnataka. This part presents the results of the study in tabular and graphical form along with the discussion to interpret the outcome of the study.

Study area

A survey conducted has revealed that the trees were abundantly found in plains, coastal and hilly regions of Karnataka. This could be due to the fact that pongamia is a tree which is adopted to grow from mean sea level to an altitude of approximately 1200 m with an optimal annual rainfall of 500 to 2500 mm. *Pongamia pinnata* is regarded as both a saline and drought tolerant species. It is very tolerant of saline conditions and alkalinity (Sahni 1998). The seed yield was found to be low in coastal region compared to plain and hilly regions. It could be due to the effects of geographical and environmental factors specially rain fall and elevation from mean sea level.

The quantitative analysis has revealed that the oil yield was found to be highest in plains and very low in coastal regions. This could be due to the nature of the habitat where it is grown. Further, this suggests that the oil content may be governed by the environmental conditions. Similar findings were also reported by Pant et al. (2006), where they found that jathropa oil content varied depending on the type of species and climatic conditions, but mainly on the altitude where it is grown.

Physical parameters of *Pongamia pinnata* L. trees

The physical parameters such as approximate age, height, trunk girth, canopy width and number of branches were measured by using the standard meth-

Table 1. Physical characters of *Pongamia pinnata* trees. NS : Not significant at 5% level of significance, *Significant at 5% level of significance.

Region	Statistic	Height (m)	Trunk girth (cm)	Canopy width (m)	No. of branches
Plain (Bengaluru)	Mean	7.55	32.75	9.26	16.25
	Std Dev	4.06	22.19	2.79	6.96
	CV (%)	53.77	67.75	30.12	42.83
Coastal (Dakshina (Kannada)	Mean	7.28	18.75	6.07	12.87
	Std Dev	3.62	8.41	2.75	5.89
	CV (%)	49.72	44.85	45.30	45.76
Hilly (Hassan)	Mean	9.80	41.11	11.22	8.30
	Std Dev	0.98	15.87	1.94	1.89
	CV (%)	10	38.60	17.29	22.77
Significant (probability) value		0.17	0.02	0.0009	0.0122
Significant		NS	*	*	*
Mean		8.33	31.65	9.03	12.15
Standard Deviation		3.06	16.43	2.48	5.16
CV (%)		36.76	51.91	27.46	42.52

ods (Table 1). The results clearly indicate that there were no signficant differences between plains, hilly and coastal regions with respect to height of plants. But, with respect to trunk girth, canopy width and number of branches there were significant difference between climatic regions. Hassan showed the largest trunk girth (41.11 cm) followed by Bengaluru (32.75 cm) and Dakshina Kannada showed the least trunk girth (18.75 cm). Similarly, with respect to canopy width, Hassan showed the largest canopy (11.22 m) followed by Bengaluru (9.26 m) and the lowest trunk girth was recorded in Dakshina Kannada (6.07 m). The highest number of branches were recorded in Bengaluru (16.25) followed by Dakshina Kannada (12.87) and the least in Hassan (8.30).

The variations in trees trunk girth, canopy size and number of branches in different regions might be due to the age of trees, certain environmental factors and soil conditions. In the coastal regions nutrient leaching was more because of laterite soil and heavy rainfall in monsoon season. It could also be due to low organic matter in soil that may have affected the growth of plants.

Physical parameters of *Pongamia pinnata* L. pods

The physical parameters such as length, breadth and thickness of the pods were estimated by using digital vernier caliper and the results are presented in Table 2.

The results show that the samples collected from the coastal region had the highest length (47.40 mm), followed by hilly region (46.92 mm) and the lowest was recorded in plain region (46.74 mm). With respect to pod breadth coastal region showed the highest (24.60 mm) and the plains showed the lowest (22.93 mm). Hilly region showed the highest pod thickness

Table 2. Physical parameters of *Pongamia pinnata* L. pods. NS : Not significant at 5% level of significance.

Region	Statistic	Length (mm)	Breadth (mm)	Thickness (mm)
Plain (Bengaluru)	Mean	46.74	22.93	10.29
	Std Dev	8.02	2.58	0.77
	CV (%)	17.16	11.25	7.48
Coastal (Dakshina Kannada)	Mean	47.40	24.60	10.40
	Std, Dev	4.03	1.99	0.97
	CV (%)	8.50	8.09	9.32
Hilly (Hassan)	Mean	46.92	23.21	10.56
	Std Dev	6.91	3.12	1.52
	CV (%)	14.72	13.48	14.40
Significant (probability) value		0.97	0.41	0.88
Significant		NS	NS	NS
Mean		47.01	23.55	10.42
Standard Deviation		6.57	2.65	1.17
CV (%)		13.98	11.27	11.25

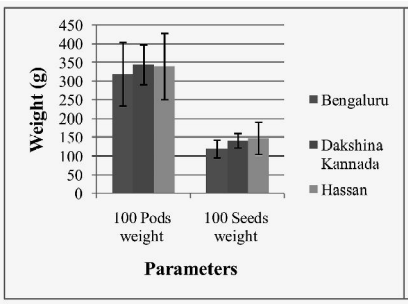

Fig 1: 100 seed and pod weight

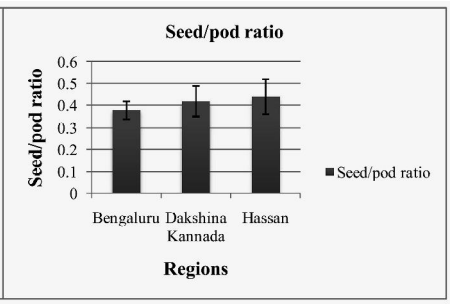

Fig 2: Seed/pod ratio

Fig. 1. 100 seed and pod weight.

Fig. 2. Seed / pod ratio.

(10.56 mm) followed by coastal region (10.40 mm) and the lowest was recorded in plain region (10.29 mm). But the differences were not significant between the three regions with respect to length, breath and thickness of pods.

Physical parameters of *Pongamia pinnata* L. seeds

The physical parameters such as length, breadth and thickness of the pods were also estimated by using digital vernier caliper and the results are shown in Table 3. The seed length, breadth and thickness were in the range of 17.55 mm to 26.92 mm, 11.51 mm to 18.29 mm and 5.45 mm to 9.46 mm respectively. With respect to physical characters of seeds, there were no significant differences among plains (Bengaluru), coastal (Dakshina Kannada) and hilly (Hassan) region.

These results are in confirmation with earlier results where they reported the seed length, seed width, and seed thickness among the accessions and ranged between 16.0 and 26.1, 10.5–18.0 and 4.5–10.2 mm respectively. The similar seed source variability in seed and pod characters have been reported for the same species (Narkhede et al. 2009).

100 pod and seed weight and seed/pods ratio

Hundred pod weight ranged from 318.74 g to 344.03 g. The maximum weight of pods was recorded in the samples collected from coastal region (344.03 g/100 pods) followed by hilly region (339.3 g/100 pods). The least pod weight recorded in samples collected from plains (318.74 g/100 pods). But the differences were not significant among the regions (Fig. 1). The results of the hilly region has recorded highest 100 seed weight (147.10 g/100 seeds) followed by coastal region (141.59 g/100 seeds) and plain region has the least weight (119.40 g/100 seeds). The differences were not significant between plains, coastal and hilly regions.

The hilly region has maximum seed / pod ratio (0.438)

Table 3. Physical parameters of *Pongamia pinnata* L. seeds. NS : Not significant at 5% level of significance.

Region	Statistic	Length (mm)	Breadth (mm)	Thickness (mm)
Plain (Bengaluru)	Mean	21.34	14.72	6.87
	Std Dev	2.04	1.05	0.95
	CV (%)	9.55	7.13	13.82
Coastal (Dakshina Kannada)	Mean	22.56	16.34	7.68
	Std Dev	2.77	1.30	0.49
	CV (%)	12.27	7.95	6.38
Hilly (Hassan)	Mean	23.61	15.69	7.28
	Std Dev	2.03	2.16	1.31
	CV (%)	8.59	13.76	17.99
Significant (probability) value		0.13	0.16	0.29
Significant		NS	NS	NS
Mean		22.59	15.59	7.28
Standard Deviation		2.28	1.63	1.01
CV (%)		10.12	10.51	13.92

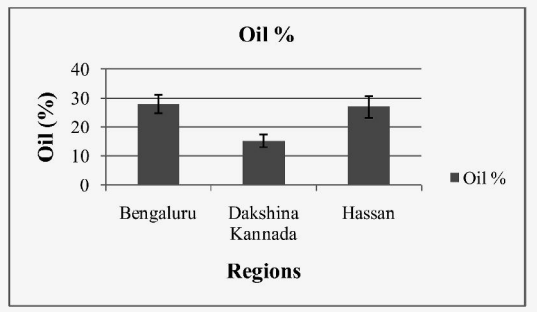

Fig. 3. Oil yield (%) in the seeds of *Pongamia pinnata* L.

followed by coastal region (0.418) and minimum seed/ pod ratio was recorded for plains (0.381). With respect to seed / pod ratio there were no significant differences between plains, coastal and hilly regions (Fig. 2). There was a strong association between pod characters and 100 seed weight. 100 seed weight, growth parameters (Rameshwar 2011) and seed germination and seedling traits (Police et al. 2011).

Oil content of *Pongamia pinnata* L. seeds

There were significant differences among the climatic regions, with respect to the oil content. The results clearly indicate that the oil yield was more in the samples collected from plains (Bengaluru) with (28.03%) and gradually reduced in the samples collected from hilly area (Hassan) (27.02%). The coastal region (Dakshina Kannada) showed very low oil content (15.25%) (Fig. 3).

Similar findings are reported where the oil content ranged between 15 and 47.2%. The percentage of oil varies with the location. The trees which are found in the plain region recorded the highest oil percentage and showed decreasing in hilly region and the lowest oil content was recorded in cooastal region. The environmental factors might affect the oil yield from one region to the other.

The formation of oil is a complex biochemical pathway in which the enzymes play a major role. The environmental conditions such as humidity, temperature and soil characteristics are important parameters which influence the oil content in seeds. The oil percentage ranged from 15.25 to 28.03%. It is higher than neem and rubber. Similar, findings were reported by Pant et al. (2006), where they found that jathropa oil content varied depending on the type of species and climatic conditions.

Conclusion

Owing to its versatile characteristics *Pongamia pinnata* is rightly called as abiodiesel plant being considered as an excellent source of biodiesel. This plant is a multipurpose tree with immense medicinal and economic value. Pongamia biodiesel is environmentally friendly and causes fewer CO_2, CO, HC and NO_x emissions as an alternative fuel to diesel. Pongamia trees are abundantly found in plain, coastal and hilly regions. The environmental and edaphic factors such as humidity, temperature and availability of nutrients in soil affects the seed yield and oil content of pongamia. The seed yield and oil content were found to be low in coastal region compared to plains and hilly regions.

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