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Population Structure, Fruit Traits Variability and Pre-sowing Seed Treatment in *Hydnocarpus pentandrus* (Buch.-Ham.) Oken. in Central Western Ghats

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Abstract: *Hydnocarpus pentandrus* (Buch.-Ham.) Oken. is a medium-sized tree belonging to Achariaceae family and commonly called as Chaulmoogra. It is one of the threatened forest tree species of Western Ghats and IUCN categorized this species as Vulnerable. Growth structure of these trees varied among studied populations. The flowering and fruiting period was observed during February to May and fruit maturation period is about 12-13 months; hence, there is an overlap in different phenophases like flowering, initial fruit set and old matured fruits in a single tree. Fruit size also vary among populations, where fruits collected from Ladghar populations are comparatively bigger than Parule population, which showed small fruit size. Seeds treated with mixture of goat manure+cocopeat (76%) and mixture of goat manure+soil (68%) resulted in higher germination than rest of the treatments.

Keywords: *Hydnocarpus pentandrus,* Stand structure, Seed oil, Germination

Hydnocarpus pentandrus (Buch.-Ham.) Oken. (Family: Achariaceae) is one of the important rare medical tree species distributed in Western Ghats of India. It is also one of the important TBOs and ecologically this species is a component of moist deciduous and semi-evergreen forests of Western Ghats and also found to grow near moist and shady localities (Joshi and Harijan 2014). *Hydnocarpus* sp. are threatened world-wide; hence, they are known for their ecological and economic significance in the tropical evergreen forest (Majumdar et al 2019). Seed oil extracted from *Hydnocarpus* sp. is commonly known as Chaulmoogra oil and mainly used in the treatment of lepromatous leprosy (Effective in early cases), decreasing the size of nodules, anaesthetic patches and skin lesions. The oil is also recommended as local application in rheumatism, sprains and bruises, sciatica and chest affections. Its seeds have long been used in South India as a remedy for leprosy, chronic skin affections, ophthalmic and as a dressing for wounds and ulcers. In fact, *H. pentandrus* is one of the potential tree species for biodiesel as seed oil meets the specifications of biodiesel (Karthikeyan et al 2013). Tree grows up to 10-12 m tall and associated with mostly *Aporosa cardiosperma* and *Syzygium stocksii* and distributed in the Western Ghats of Maharashtra. In the case of Konkan region, *H. pentendrus* is mainly occurred in Deorai/Rahat of Ratnagiri and Sindhudurg districts; however, it is more abundant in private forests of Sindhudurg district. Normally these trees are located at higher altitude above 300 m MSL and largely distributed near the bank of river and canal. *H. pentendrus* tree had some mythological value in Konkan culture. In olden days, traditionally this oil was extracted from wooden dirt and used in *Deoghar* for lighting lamp. After oil extraction the remaining cake is used on wounds sustained while working in agriculture. Being an endemic species to southern India, forest degradation coupled with over exploitation of fruits from wild leads to decrease in the 40% populations over the last 60 years (About three generations). At present, the species is not found in the type locality and is surviving with only few individuals in the Sindhudurag and Ratnagiri districts. Mostly trees occur at the farms and beside the streams. Therefore, species is assessed as Vulnerable category. Information on ecology, community structure and natural regeneration of *H. pentendrus* in the Northern Western Ghats is scanty. Therefore, present study was carried out to understand the stand structure, phenology, fruit size variation of *H. pentendrus* in the Konkan region of Maharashtra. Pre-sowing treatments were also worked out to enhance seed germination in this species.

MATERIAL AND METHODS

The distribution, population size, habitat characterization of *H. pentendrus* was assessed by conducting field surveys, visiting herbaria, studying literature and interactions with botanists and local people. *H. pentendrus* specimens were

examined with the help of taxonomist in Jawaharlal Nehru Tropical Botanic Garden and Research Institute (TBGTI, Palode, Kerala). The geo-coordinates of different assessed populations (Plate 1) were recorded using global positioning system (GPS). For phenology study, monthly field visits were made and flowering and fruiting phenology were recorded. The variation in fruit quality was assessed by collecting ripen fruits during April-May, 2022. To study fruit morphology, 10 fruits were randomly selected and their length and width were measured. Weight of 10 fruits in ten replicates was determined using an analytical balance (Anamed, Model no-AA-2200DS). Apart from this, to enhance seed germination, seeds were exposed to eight different pre-sowing treatments *viz*., T_1- Scarification (Control), T_2- Soaking seed in water for 24 hours, T_3- Soaking seed in GA_3@ 300 ppm for 24 hours, T_4- Soaking seed in GA_3 @ 350 ppm for 24 hours, T_5- Soaking seed in H_2SO_4 1.0%, T_6- Soaking seed in H_2SO_4 2.0%, T_7- Goat manure + soil and T_8- Goat manure + coco-peat (Table 3) using bulk fruits collected from natural population. After collection, fruits are break opened and de-pulped by washing in normal tap water for three to four times and then seed were extracted. Later these seeds were air dried under shade for 12 hours and exposed different pre sowing treatment.

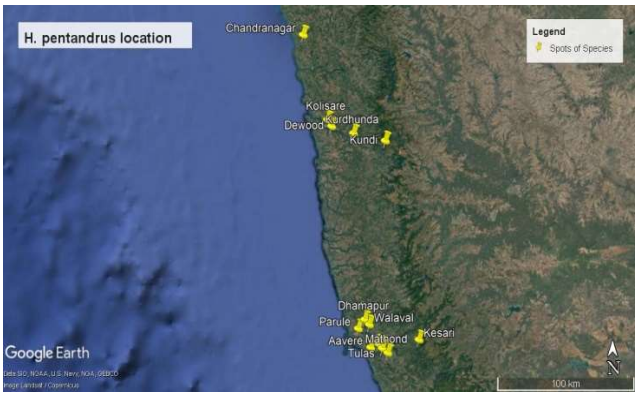

Plate 1. Location of different populations studied

RESULTS AND DISCUSSION

Stand structure and tree growth: The Konkan region of Maharashtra is highly dynamic and vibrant part of the Western Ghats and the region is divided into two agro climatic zones *viz.,* the south Konkan coastal zone with very high rainfall having lateritic soils (Ratnagiri and Sindhudurg districts) and the north Konkan coastal zone having very high rainfall zone with non-lateritic soils (Thane and Raigad districts; Haldankar et al 2014). The study was carried out in the south Konkan coastal agro-climatic region, which covers total 19 field surveys in different forest areas of Sindhudurg and Ratnagiri districts. Total eight populations of *H. pentendrus* were identified through survey. All population are found near the streams in private farms and scared grooves. The trees were located at a low elevation of 8m MSL in Dhamapur region and also at higher elevation of 283 m MSL in Kesari village of Sawantwadi region. Nearly all trees were found in the plains and hilly region with 0º to 47º slopes. However, only two identified sites were located in a moderately sloping region which had a 21º slope with a W268º aspect at Parule and a 19º slope with an S190º aspect at Dhamapur. The survey resulted in the discovery of all trees more than 140 cm GBH with 30-80 age groups. Average GBH of tree varied among population (Table 1). The highest GBH of 480 cm was at Math in Kudal and a minimum GBH of 64 cm at Kesari in Sawantwadi. The tallest trees were measured at Kalambat village in the Dapoli district with a height of 11 m with large crown spread among adult individuals (Table 1). Trees with a maximum crown spread of 37.63 m were recorded at Math, Kudal area and was minimum of 11 m in

Table 1. Population structure of *H. pentandrus* in Cenral Western Ghats

Population	Tree density (Number trees per population)	Tree height (m)	GBH (cm)	Crown spread (m)
Kalambat	04	8.25	141.25	20.83
Ansur	05	7.20	122.23	16.50
Math	06	9.50	318.66	37.63
Mathond	15	7.43	132.67	15.75
Andurle	03	7.00	105.20	11.00
Kashari	14	6.95	110.00	13.02
Ladghar	04	7.90	142.50	17.67
Parule	07	8.75	143.00	15.07
Mean	-	7.87	152.02	18.43
SD (±)	-	0.05	0.47	0.05
CV (%)	-	0.07	0.38	0.03
CD (p=0.05)	-	0.013	1.41	0.014

Andurle area. Study areas in Kesari and Parule show of 100 per cent and 70 per cent ground cover respectively, whereas Kalambat showed a minimum of 10 per cent ground cover.

Phenology and fruit size variation: The flowering and fruiting period was observed during February to May. Fruits began to ripe after the middle of April. Fruit maturation period is about 12-13 months. In this species, at a time, fruit maturation, flowering and new fruit-set were observed in same plant (Table 2). Significant variation in various fruit parameters among eight populations of *H. pentendra* was recorded and depicted in Figure 1. Fruit length varied from 70.1 (Parule population) to 84.3 mm (Ladghar population) among eight populations with overall mean of 74.10 mm. Similarly, significant variation among populations for fruit width (63.1 mm in Parule to 77.4 mm in Ladghar population), fruit thickness (9.50 mm in Parule to 14.8 mm in Ladghar population) and fruit weight (139.7g in Mathond to 325.2 gm in Ladghar population) was also recorded (Fig. 1). Among them, five genotypes recorded with smaller fruits and three genotypes recorded bigger fruits. Irrespective of populations, number of seeds per fruit ranged between 8 and 15 and a greater number of seeds per fruit was in Kalambat population and a smaller number of seeds per fruit was recorded in Ansur and Mathond populations. Seed oil per cent varied among the identified populations of *H. pentendra* and ranged from 37.83 to 40.99 per cent. Such kind of variation in fruit size and seed oil content was also reported in *H. pentendra* by Dhantri (2014) among seed sources of Uttara Kannada district of Western Ghats, where seed oil content varied from 32.35 to 49.49 per cent. Such kind of inferences in terms of variation in population structure, phenology and fruit attributes are also worked out for different forest species; further, geoclimatic variation coupled with genetic attributes resulted in great population variation in most of the morphological traits (Mirgal et al 2013, Gunaga et al 2015, Patwardhan et al 2017, Hegde et al 2018b, Gunaga et al 2020, Sukhadiya et al 2021). Similarly, population variation in fruit & seed traits and seed oil content was also documented in various TBOs like *Pongamia pinnata* (Raut et al 2011), *Garcinia talbotii* (Bansude et al 2013), *Calophyllum inophyllum* (Shinde et al 2012, Rahul and Gunaga 2017) and Mahua (Hegde et al 2018a).

Seed germination: Result showed that different pre-sowing treatments influences the seed germination and its attributes *viz.,* GRI, MDG, PV and GV in *H. pentandrus* (Table 3). Among these eight treatments, seeds treated with mixture of goat manure+cocopeat (76%) and mixture of goat manure+soil (68%) resulted in higher germination than rest of the treatments. Further these treatments also recorded higher GRI, MDG, PV and GV than rest of the treatments. Vidyasagaran (2017) observed that in *Hydnocarpus pentandra* , seed treated with 300 ppm GA_3 without seed coat, followed by 200 ppm GA_3 without seed coat shows highest germination percentage and growth attributes. In present study T8 (Goat manure + coco-peat) and T_7 (Goat manure + soil) are best for seed germination. Seed treatments are essential for orthodox types of seeds and species showing different kinds of seed dormancy. Influence of seed germination was also addressed in many forest species (Gunaga 2011, Nongmaithem et al 2018, Gunaga et al 2015). Hence, it is necessary to workout best pre-sowing treatment for each of the species for better germination and early seedling vigour.

Table 2. Maturity stages of fruiting and flowering at different population site of *H. pentandrus*

Population	Maturity stage						
	Dec-21	Jan -22	Feb-22	March -22	April-22	May-22	June -22
Kalambat	Pre-mature	Pre-mature	Pre-mature	Pre-mature + flowering starting	Pre-mature + Flowering peak period	Mature +peak flowering	New Fruit set
Ansur	Pre-mature	Pre-mature	Pre-mature	Pre-mature+ flowering starting	Pre-mature +Flowering	Mature +peak flowering	New Fruit set
Math	Pre-mature	Pre-mature	Pre-mature	Pre-mature+ flowering starting	Pre-mature+ Flowering	Mature +peak flowering	New Fruit set
Mathond	Pre-mature	Pre-mature	Mature	Mature+ flowering starting	mature+ flowering starting	Mature +peak flowering	New Fruit set
Andurle	Pre-mature	Pre-mature	Pre-mature	Pre-mature+ flowering starting	Pre-mature +Flowering	Mature +peak flowering	New Fruit set
Kashari	Pre-mature	Pre-mature	Pre-mature	Pre-mature+ flowering starting	Pre-mature +Flowering	Mature +peak flowering	New Fruit set
Ladghar	Pre-mature	Pre-mature	Pre-mature	Pre-mature+ flowering starting	Pre-mature +Flowering	Mature +peak flowering	New Fruit set
Parule	Pre-mature	Pre-mature	Pre-mature	Pre-mature+ flowering starting	Pre-mature +Flowering	Mature +peak flowering	New Fruit set

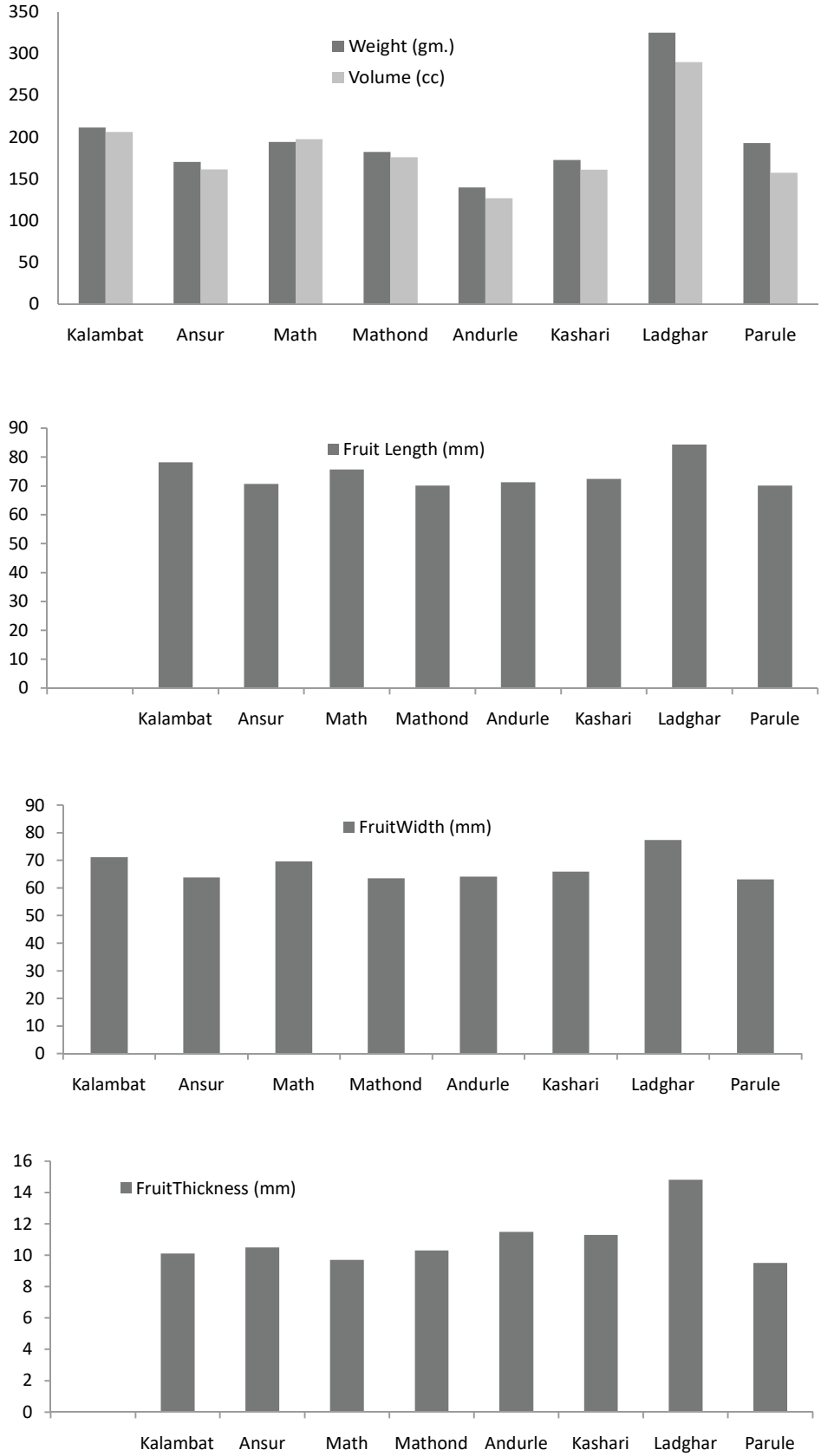

Fig. 1. Variation in fruit traits among eight populations

Table 3. Maturity stages of fruiting and flowering at different population site of *H. pentandrus*

Population	Maturity stage						
	DEC-21	JAN -22	FEB-22	MARCH -22	APRIL-22	MAY-22	JUNE -22
Kalambat	Pre-mature	Pre-mature	Pre-mature	Pre-mature + flowering starting	Pre-mature + Flowering peak period	Mature +peak flowering	New fruit set
Ansur	Pre-mature	Pre-mature	Pre-mature	Pre-mature+ flowering starting	Pre-mature +Flowering	Mature +peak flowering	New fruit set
Math	Pre-mature	Pre-mature	Pre-mature	Pre-mature+ flowering starting	Pre-mature+ Flowering	Mature +peak flowering	New fruit set
Mathond	Pre-mature	Pre-mature	Mature	Mature+ flowering starting	mature+ flowering starting	Mature +peak flowering	New fruit set
Andurle	Pre-mature	Pre-mature	Pre-mature	Pre-mature+ flowering starting	Pre-mature +Flowering	Mature +peak flowering	New fruit set
Kashari	Pre-mature	Pre-mature	Pre-mature	Pre-mature+ flowering starting	Pre-mature +Flowering	Mature +peak flowering	New fruit set
Ladghar	Pre-mature	Pre-mature	Pre-mature	Pre-mature+ flowering starting	Pre-mature +Flowering	Mature +peak flowering	New fruit set
Parule	Pre-mature	Pre-mature	Pre-mature	Pre-mature+ flowering starting	Pre-mature +Flowering	Mature +peak flowering	New fruit set

Table 4. Effect of different pre-sowing treatments on seed germination of *Hydnocarpus pentandrus*

Pre- sowing treatment		Day of first germination (day)	Day of highest germination (%)	Germination (%)	GRI (%)	MDG (%)	PV (%)	GV (%)
T1	Control	24	47	12	1.30	0.24	0.37	0.09
T2	Soaking seed in cold water for 24 hours	23	38	20	2.37	0.4	0.76	0.30
T3	Soaking seed in GA_3 @ 350 ppm for 24 hours	14	34	32	4.88	0.64	1.6	1.02
T4	Soaking seed in GA_3 @ 300 ppm for 24 hours	15	36	52	7.81	1.04	2.47	2.57
T5	Soaking seed in H_2SO_4 1.0%	16	36	39	6.14	0.77	1.61	1.25
T6	Soaking seed in H_2SO_4 2.0%	17	37	52	7.39	1.04	2.26	2.35
T7	Goat manure + soil	18	42	68	12.24	1.36	3.09	4.20
T8	Goat manure + coco-peat	17	41	76	12.96	1.52	3.61	5.49
Mean				63.76	6.89	0.88	1.97	2.16
SD				1.12	4.19	0.45	1.11	1.90
CV (%)				21.62	0.070	0.017	0.072	0.012

CONCLUSION

The distribution of *Hydnocarpus pentandrus* trees in a population is limited, clustered and showing less density. Population variation in terms of growth structure and phenology was also recorded. Significant variation in fruit attributes among studied populations was observed and there is scope for tree selection and tree improvement in this species. Pre-sowing treatments containing goat manure mixed with either coco-peat or soil enhanced seed germination in this species.

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