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RESEARCH PAPER

Clonal variation in *Pongamia pinnata* for resistance to gall midge, *Asphondylia pongamiae* (Diptera: Cecidomyiidae): Important biofuel tree

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Abstract: Clonal variation for leaf gall infestation in *Pongamia pinnata* for resistance/susceptibility to gall midge, *Asphondylia pongamiae* (Diptera: Cecidomyiidae) was assessed during the year 2014-15 at college of forestry, Sirsi. Eleven clones belonging to Hassan provenance of Karnataka have been evaluated. The clones, Hariharapura, Sathenahalli, Muddanahalli and Baragaru were identified as Moderately Resistant (MR) and Karekere - LT was identified as Moderately Susceptible (MS). Clones Aladahalli, Karekare-1, Madenuru-2, Karekare, Alldahalli-1 and Madenuru-1 was identified as susceptible when compared to local check seedlings based on number of galls per leaf, per cent leaf infested with gall and growth performance. Among eleven clones evaluated none of the clones were found to be resistant.

Key words: Bio-fuel, Clones, Gall midge, Provenance

Introduction

Pongamia pinnata (L.) Pierre (Synonym: *Pongamia glabra* Vent.) is an arboreal legume, belonging to the family Fabaceae (Divakara and Rameshwar, 2011). Commonly known as Indian beech, in India, it is known by different names as pongamia, karanja, papar, kanji, karanga and pongamia. A medium sized tree, being indigenous to the Indian subcontinent and south-east Asia (Malaysia and Indonesia). Pongamia has been described as a "maritime species" since it tends to occur naturally along coasts and riverbanks in India, Bangladesh, Burma and Australia (Anon., 2000).The mature tree can withstand water logging, slight frost and highly tolerant to salinity. It prefers humid tropical and subtropical climates. However, it can tolerate a range of different conditions with mean annual rainfall between 500–2500 mm and temperatures of 0 – 16°C minimum and 27–50°C maximum, mature trees can cope with light frosts, but require a dry period of 2–6 months (Scott *et al.,* 2008).

Sundararaj *et al.* (2005) listed 53 insect pests on *P. pinnata* which includes six species of gall inducers. Among them gall midge, *Asphondylia pongamiae* (Diptera: Cecidomyiidae) is reported to induce a variety of galls on leaves, flowers, stem, rachis and on all different parts of plants. Phytophagous gall midge may have a deleterious effect on host plants by changing plant architecture, reducing leaf longevity, photosynthesis, seed production, and biomass (Devaraj, 2012).

Meager information is available with respect to clonal variation to leaf gall infestation for resistance/ susceptible in *P. pinnata.* In this context it is felt to investigate the occurrence of variation in different clones with respect to leaf gall resistance in pongamia based on the growth performance. Hence, present study was conducted to identify the resistant clones of pongamia by screening the clones of Hassan provenance against gall midge.

Material and methods

Two years old eleven clones of *Pongamia pinnata* clones belonging to Hassan provenances of Karnataka were evaluated at the college of Forestry, Sirsi, Uttara Kannada district during 2014-15 for their resistance against leaf gall midge. Eleven clones consisting of twenty ramets from each clone were maintained in field condition for one year.

Five randomly chosen ramets from the entire clone were tagged. All the ramets were exposed for natural infestation for gall insect under field condition. Observation for growth parameters *viz.,* plant height, number of infested leaves/plant and number of galls/leaf were recorded at monthly intervals from May 2014 to April 2015 and compared with pongamia seedlings raised with local seeds (Check). Monthly interval data recorded were pooled and represented season wise as rainy (May to August), winter (September to December) and summer (January to April). Data was subjected to statistical analysis of variance using Completely Randomized Design (CRD) by considering each ramet as replication. Susceptibility index for all the categories of the clones was calculated based on the mean number of galls per leaf which was multiplied with mean number of gall infested leaves per plant. Based on the number of galls/leaf, severity of the damage was determined as Damage Index (DI) as detailed below (Ogah *et al.,* 2012).

- Healthy = No galls (Resistant)
- Low = 1-5 galls/leaf (Moderately resistant)
- Moderate = 6-9 galls/leaf (Moderately susceptible)
- Severe = >9 galls/leaf (Susceptible)

Results and discussion

Number of galls per leaf

The pongamia clones screened against gall midge revealed significant differences among the clones. The mean number of

galls per leaf varied from 3.95 to 19.15 during rainy season. During winter, it varied from 1.35 to 9.55 where as in summer it was varied from 3.0 to 17.70. The overall mean number of galls among pongamia varied from 2.93 (Hariharapura) to 12.87 (Madenuru-1). The highest mean number of galls (15.47) was recorded in the check seedling. Based on the mean number of galls per leaf, four clones *viz.*, Hariharapura, Sathenahalli, Muddanahalli and Baragaru found as 'Moderately Resistant'. 'Karekere- LT' was categorized of 'Moderately Susceptible'. Six clones *viz.,* Aladahalli, Karekere-1, Madenuru-2, Karekere, Aladahalli-1 and Madenuru-1 were categorized as 'Susceptible'. The check seedling recorded highest number of galls (15.47) and found significantly different from the clones. Moderately resistant group's recorded very low number of galls per leaf (3.20) compared to moderately susceptible group (7.57) and susceptible groups recorded 12.0 mean numbers of galls per leaf (Table 1).

Per cent infested leaves per plant

Mean per cent infested leaves per plant varied from 5.51 to 43.39 during rainy season. During winter it varied from 5.36 to 29.38 where as in summer it varied from 5.93 to 29.54. The overall mean percent of infested leaves was varied from 5.72 (Hariharapura) to 33.84 (Karekere). Moderately resistant clones *viz.,* Hariharapura, Baragaru Sathenahalli and Muddanahalli recorded 5.72 to 6.98 per cent infested leaves. Karekere- LT recorded 23.38 percent infested leaves (Moderately susceptible). Susceptible clones *viz.,* Aladahalli, Madenuru-2, Karekere, Madenuru-1, Aladahalli-1 and Karekere-1 recorded overall mean percent infested leaves from 21.80 to 33.84. Moderately resistant groups of clones recorded 6.39 and moderately susceptible clones recorded 23.38 per cent leaf infestation followed by susceptible clones (25.40%) and check seedling recorded highest per cent leaves infested per plant (62.60) (Table 2).

Susceptibility index calculated based on average number of galls per leaf x number of infested leaves per plant revealed mean number of galls varied from 14.5 to 379. Among the clones, moderately resistant groups recorded 16.42 infestation index and infestation index in moderately susceptible clones recorded 139.7. Infestation index was 244.25 in susceptible clones. Check seedling recorded 379.0 infestation index under susceptible category (Table 3). Devaraj and Sundaraj, (2014) reported, cecidomyiid gall midge which induce a variety of galls on leaves, flowers, stem of plants with deleterious effect on host plants by changing plant architecture, reducing leaf longevity, reducing photosynthesis, seed production, and biomass.

Per cent increment in height

The height recorded at six and twelve months after initial height of the pongamia clones revealed the mean increment in height from 10.48 to 15.66 and 22.58 to 32.48 per cent respectively. Moderately resistant category of clones (Haripurapura, Muddanehalli Baragru and Sathenahalli) recorded 10.48 to 12.52 and 22.58 to 25.66 per cent increment in height after six and twelve months after initial height. Mean per cent increment of height in moderately resistant clones was 24.34. Karekere –LT recorded 12.98 per cent and 29.89 per cent increase in height after six and twelve month exhibited moderately susceptible clone. The susceptible category of clones (Karekere-1, Madenure-1, Aladhahalli, Karekere, Madenuru-2 and Aladhahalli-1) recorded to 11.36 to 15.66 per cent and 21.70 to 32.48 per cent increases in height after six and twelve months of initial height. Susceptible groups of the clones recorded mean increment height of 26.19 per cent. Local seedling registered only 9.88 and 18.60 per cent increases in height after six and twelve months after initial height and significantly found different from the clones (Table 4). Paul *et al.*(2013) reported gall midge (*Chilophaga virgati*) known to produce economically significant reductions in seed and gross biomass productivity in switch grass causing malformation of the inflorescence and reduction of growth.

In the present study, eleven clones of *P. pinnata* belonging to Hassan provenance of Karnataka along with local seedling as susceptible check were assessed for their resistance to leaf

Table 1. Mean number of galls per leaf recorded in clones of *Pongamia pinnata* of different resistance category

Sl No.	Clonal ID	Seasons			Mean	Mean of the group	Resistance category
		Rainy	Winter	Summer			
1	Hariharapura	4.45	1.35	3.00	2.93	3.20	MR
2	Sathenahalli	4.25	1.45	3.35	3.02		
3	Muddanahalli	3.95	1.40	3.75	3.03		
4	Baragaru	5.90	2.05	3.55	3.83		
5	Karekere –LT	9.00	5.70	8.00	7.57	7.57	MS
6	Alladahalli	9.00	4.75	14.05	9.27	12.00	S
7	Karekere - 1	14.40	7.55	14.80	12.25		
8	Madenuru – 2	15.10	7.85	14.45	12.47		
9	Karekere	15.35	6.30	16.30	12.65		
10	Alladahalli – 1	16.40	6.35	15.25	12.67		
11	Madenuru – 1	15.00	8.00	15.60	12.87		
12	Check	19.15	9.55	17.70	15.47	15.47	
	Mean	11.00	5.19	10.82			
	S.Em±	0.68	1.81	4.30			
	C.D. (0.01)	1.94	5.18	12.34			

MR = Moderately Resistant S = Susceptible MS = Moderately Susceptible Check = Local seedling

Table 2. Variation for per cent leaves infested per plant in different clones of *Pongamia pinnata*

Sl. No.	Clonal ID	Seasons			Mean	Mean of the group	Resistance category
		Rainy	Winter	Summer			
1	Hariharapura	5.87(13.94)	5.36(13.44)	5.93(14.06)	5.72(13.81)	6.39(14.65)	MR
2	Sathenahalli	6.11(14.30)	6.76(15.12)	6.20(14.42)	6.36(14.54)		
3	Baragaru	5.71(13.81)	7.64(16.00)	6.23(14.42)	6.53(14.77)		
4	Muddanahalli	5.51(13.56)	7.37(15.79)	8.06(16.54)	6.98(15.23)		
5	Karekere –LT	23.91(29.27)	21.26(27.49)	24.98(29.93)	23.38(28.93)	23.38(28.93)	MS
6	Aladahalli	19.66(26.35)	20.29(26.78)	25.44(30.26)	21.80(27.83)	25.40(30.26)	S
7	Madenuru – 2	22.02(27.97)	23.82(29.20)	19.76(26.35)	21.87(27.90)		
8	Aladahalli – 1	27.31(31.50)	20.06(26.64)	22.58(28.38)	23.32(28.86)		
9	Madenuru – 1	25.38(30.26)	24.62(29.73)	25.83(30.53)	25.28(30.13)		
10	Karekere – 1	26.70(31.11)	22.73(28.45)	29.54(32.90)	26.32(30.85)		
11	Karekere	43.39(41.21)	29.38(32.83)	28.76(32.39)	33.84(35.55)		
12	Check	61.40(51.59)	55.84(48.33)	70.56(57.17)	62.60(52.30)	62.60(52.30)	
	S.Em±	4.22	2.55	4.31			
	C.D. (0.01)	12.11	7.33	12.35			

Figures in the parenthesis are the arcsin transformed value

MR = Moderately Resistant S = Susceptible MS = Moderately Susceptible Check = Local seedling

Table 3. Variation in the susceptibility of the clones based on susceptibility index (average number of galls per leaf x number of infested leaves per plant) of the different clones of *Pongamia pinnata*

Sl No.	Clonal ID	Seasons			Mean	Mean of the group	Resistance category
		Rainy	Winter	Summer			
1	Hariharapura	28.0	2.6	12.8	14.5	16.42	MR
2	Sathenahalli	27.8	3.2	14.7	15.3		
3	Muddanahalli	24.5	3.2	22.1	16.6		
4	Baragaru	38.6	5.0	14.4	19.3		
5	Karekere -LT	239.0	47.9	132.4	139.7	139.7	MS
6	Aladahalli	224.1	34.4	250.8	169.8	244.25	S
7	Madenuru - 2	405.4	63.2	237.0	235.2		
8	Karekere	416.8	47.6	308.9	257.7		
9	Karekere 1	447.8	57.0	281.9	262.0		
10	Madenuru - 1	451.5	64.0	276.1	264.0		
11	Aladahalli - 1	524.8	50.8	263.1	280.0		
12	Check	688.4	99.3	349.6	379.0	379.0	
	Mean	293.1	39.9	180.3			

MR = Moderately Resistant S = Susceptible MS = Moderately Susceptible Check = Local seedling

gall midge, *Aspondylia pongamiae* infestation. The clones were categorized as 'resistant' and 'susceptible' based on number of galls per leaf/ number of leaves infested as well as adopting a novel index.

The different provenance of the clones exhibited variation with respect to number of galls due to their natural genotypic characters. No literature is available with respect to the screening of Pongamia clones against gall midge, *Asphondylia pongamiae.* However, Archana *et al.* (2012) screened local rice varieties against gall midge. Out of 81 varieties, eight were found highly resistant, forty-eight were moderately resistant, twenty three were moderately susceptible and none of the varieties found to be resistant and highly susceptible. Devaraj (2012) reported in his findings that flower and leaf gall inducer, *Asphondylia pongamiae*, produced 61, 46, 47, 41, 32 and 55 per cent mean incidence of flower galls in Kolar, Hassan, Mandya, Mysore, Udupi and Tumkur districts, respectively.

Clear differences were observed for the mean number of leaves infested per plant and mean number of gall insects per leaves among different clones. The susceptible local check was 'worst' affected with a mean of 22 infested galls leaves per plant and recorded nearly 63 per cent of leaves infested per plant. The seasonal variation for infestation was evident. The gall infestation was highest during rainy season than in summer and winter seasons. Highest mean number of infested leaves was recorded during rainy season (21.68) followed by summer season (13.51) and winter (6.18). The more number of fresh leaves was noticed during the month of May and subsequently these leaves were infested with the gall midge during rainy season, hence more number of infested leaves was recorded during rainy season compare to summer and winter. The present findings can be comparable with the result of Devaraj (2012) who reported that Pongamia trees give new flush of leaf and flowering at the end of February, March and April in Karnataka. At this the time, Pongamia flowers were found infested in its budding stage by the flower gall inducer. Similarly, Agyeman *et al.* (2009), worked on *Milicia excelsa* which was hampered by the gall forming Psyllid, *Phytolyma lata* (Homoptera: Psyllidae) and reported that the infestation

Table 4. Growth performance of *Pongamia pinnata* (Height increment in per cent) as influenced by gall midge infestation

Sl. No.	Clonal Id	Initial Height (cm)	3MAI	6MAI	Increment in height (%)	9MAI	12MAI	Increment in height (%)	Mean	Resistance category
1	Muddanahalli	66.48	69.98	74.76	12.45	79.01	81.49	22.58	24.34	MR
2	Hariharapura	60.38	63.65	66.71	10.48	70.24	74.73	23.77		MR
3	Sathenahalli	79.54	83.46	88.78	11.62	93.70	99.71	25.36		MR
4	Baragaru	76.54	80.54	86.12	12.52	90.71	96.18	25.66		MR
5	Karekere -LT	66.20	69.25	74.79	12.98	79.69	85.99	29.89	29.89	MS
6	Karekere - 1	71.56	75.41	79.69	11.36	82.99	87.09	21.70	26.19	S
7	Madenuru - 2	80.20	84.08	89.40	11.47	94.01	100.03	24.73		S
8	Aladahalli	69.00	73.01	78.17	13.29	82.18	88.15	27.75		S
9	Aladahalli - 1	65.10	68.55	73.39	12.73	78.61	84.99	30.55		S
10	Karekere	60.62	64.55	69.52	14.68	73.59	79.99	31.95		S
11	Madenuru - 1	54.78	58.63	63.36	15.66	67.18	72.57	32.48		S
12	Seedling	48.18	50.26	52.94	9.88	55.8	57.27	18.60	18.60	S
	S.Em±	4.99	2.90	0.80		0.93	0.92			
	C.D. (0.01)	14.20	8.46	2.34		2.73	2.68			

MAI = Months After Initial

MR = Moderately Resistant S = Susceptible MS = Moderately Susceptible Check= Local seedling

was more during the rainy season and level of infestation declined progressively after August reaching its lowest level. Nasareen and Ramani (2014) reported eriophyid mite, *Aceria pongamiae* infestation was higher during May and the population showed a sudden decline in October and November months.

The relative resistance of clones according to the susceptibility/ resistance were similar. This provided a basis for the categorization of clones into classes of resistance. Using data on mean number of galls per leaf and number of infested leaves per plant and novel index to assess the resistance constructed. It provides a scale on which the clones could be categorized as 'Moderately Resistant', 'Moderately Susceptible' and 'Susceptible' categories. Higher the value of index, higher will be susceptibility. As shown in the Table 3 the susceptible seedling check showed a highest value of index (379.1). The mean of susceptible clones was at 244.25 and 'MR' clones showed very least mean index of 16.42. That means, the 'MR' clones were nearly twenty three times lower in score than the susceptible check. Here based on this index it was concluded that clones 'Hariharapura', 'Sathenahalli', 'Muddanahalli' and 'Baragaru' are "resistant" clones to gall infestation. This was corroborated by considering even the number of infested leaves also.

The results pertaining to the growth performance of different pongamia clones collected from Hassan provenance exhibited no significant differences due to infestation of gall midge with respect to height. Mean increment in height among moderately resistant clones recorded 24.34 per cent while moderately susceptible category of clones recorded 29.89 per cent mean increases in height. The susceptible clones recorded 26.19 per cent mean increase in height, twelve months after initial height. Local seedling registered only 18.60 per cent mean increases in height and significantly different from the clones. The height increment in pongamia was not influenced by the gall infestation. It may be due to high vigor in the growth characters of the clones. Nixon (2012) reported serious harm by leaf galls in oak tree caused by hedge hog gall wasp (Hymenoptera: Cynipidae). He found that leaf galls causes difference in growth, height and trunk diameter and kill heavily infested trees.

Agyeman *et al.* (2009), who worked on Milicia excels, was hampered by the gall forming *Psyllid, Phytolyma* lata (Homoptera: Psyllidae) and resulted in significant reduction in seedling growth, height, stem diameter and biomass growth. Similarly, study conducted by Nixon (2012) on leaf galls of oak tree caused by oak hedge hog gall wasp (Hymenoptera: Cynipidae) revealed serious harm to the tree. Nasareen *et al.* (2014) worked on eriophyid mite, *Aceria doctersi* (*Acari* : Eriophyidae) infesting and inducing varying numbers of pouched galls on the leaves, leaf petioles, inflorescence and the young shoots of *Cinnamomum verum i*n Kerala, result revealed a reduction in growth rate, leaf area and biomass of the plant and also a reduction in the economic utility of the plant.

Conclusion

Based on the susceptibility index four clones, Hariharapura, Sathenahalli, Muddanahalli and Baragaru were found to be Moderately Resistant (MR) Karekare LT found moderately susceptible and Madenuru-2, Karekare, Karekare-1, Modenuru-1 and Aladahalli-1 found susceptible in both open and polyhouse conditions.

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