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Abstract

In the context of Alien Invasive Species (AIS) assuming worldwide importance as being the second most important irreversible impact on landscapes next to habitat destruction, the paper assesses their threat to the forests of Kerala. Based on field surveys and using a risk assessment protocol, the study identified 38 alien invasive species in the forests of Kerala. Of them, 10 are of high risk, 12 pose medium risk , 10 pose low risk and 6 insignificant as per the risk assessment conducted. There are 5 trees, 11 shrubs, 4 subshrubs, 12 herbs and 6 climbers among the alien invasives found in the forests of Kerala. The land of origin of the alien invasives happens to be America for 11 species, South America for 10 species, Central Ameriaca for 6 species, Central and South America for 4 species, and Asia for 3 species. One each of the alien invasives is from Africa, Australia, West and Central Africa and the West Indies. Most of the introductions into the forests of Kerala was intentional (31 species). Measures which would restore habitats from alien invasives and eradicate them which are in the establishment phase and prevent incursions of new invasives into the forest areas are discussed.

Key words: Alien invasive species, Risk assessment, forests of Kerala, habitat restoration

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Are Alien Invasive Plants a Threat to Forests of Kerala?

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Introduction

Species which cross over their of natural distribution and get introduced to new habitats are known as alien species (Saxena, 1991). When in a new locale, the species almost always gets released from it's natural enemies which checked its population in the native land and thus get an opportunity to explode its population size, if other abiotic factors are favorable (Elton 1958; Williamson, 1996, Crawley, 1997, Keane & Crawley 2002). Those alien species which have thus increased its spread in the new location displacing the local biota are called as alien invasive species (Keane & Crawley 2002; Torchin et al. 2002, 2003; Mitchell & Power 2003).

Introduction of the species to the new location can either be accidental or intentional (Enserink, 1999; Van der Putten 2007). Accidental introduction happens by way of hitchhiking of the plant(Hughes, 2003), plant parts (Usher et al., 1988) or propagules as contaminants in food grains (Mack, 1991; Shimono & Konuma, 2008), fodder (Panetta and Scanlan 1995)., attached to vehicles (Carlton and Ruiz 2005) or through ballast water (Carlton, 1996; Ruiz et al., 1997). Intentional introductions are made for a variety of purposes like agriculture, horticulture (Reichard & Hamilton, 1997), forestry (Sankaran, 2002) and aesthetic values (Cremer 2003). When the species that are brought in are not screened for their potential to become invasive, there is every chance that

they can cross over the planted areas and impact on the local vegetation in a variety of ways (Mack and Lonsdale 2001).

Several characteristics of the species help them to be invasive. Most important among them is the large quantity of seeds they produce which are mostly very small so as to be carried away to long distances by wind and water (Khare, 1980; Enserink, 1999). These seeds would have a long gestation period and their sheer number increases the propagule pressure on the new habitat (Carlton, 1996). This means that the propagules of the native species will have to compete with a large number of seeds of the invasive species. Further, many alien invasive species are early colonizers which can thrive on resource poor habitats (Monaco et al. 2005; Funk & Vitousek 2007). With extremely fast establishment and fast growth rates (Grotkopp et al., 2002; Burns, 2004, 2006) they can make use of tree fall gaps (David Gorchov et al, 2005), degraded forests and forest fringes better than the native species (Rojas, Isabel et al, 2011). Most invasive plants produce allelochemicals which deter the native plants from establishing in its vicinity (Callaway & Aschehoug 2000). The phenotypic plasticity exhibited by these plants help them to adapt to a variety of habitats as evidenced by *Mimosa diplotricha* var. *diplotricha* which remains a shrub in open lands but turns into a climber when trees are close by (Sultan 2001, Griffith and Sultan 2005, Hulme 2008, Niklas 2008). Most invasives adopt both sexual and vegetative modes of reproduction making them amenable to spread all through the year (Silvertown 2008).

The impact of alien invasive species is by way of direct displacement of native plant species. This happens through change of soil chemical profile, rewarding pollinators better

than the native species thereby reducing the reproductive success of native species, changing hydrological regimes, making the new habitats fire prone, limiting the photosynthetic efficiency of the native species by reducing light availability, and by inviting the necessity of herbicide application thereby impacting both the flora and fauna of the area (Nilsson and Grelsson, 1996; Levin, 2003). Follow up impacts would be reduced availability of forest resources such as medicinal plants and timber from forest plantations. Increased financial resources would be needed for weeding forest plantations during the early establishment phase when the canopy is open paving way for increased presence of alien invasive species. As in the classical cases of Kaziranga national park wherein the movement of the one horned rhinoceros was limited by thickets of *Mimosa diploticha* var. *diplotricha* and *Lantana camara* in many other national parks, the impact on fauna would be critical (Vattakkavan, 2002; Singh, 1976). Indirect impacts occur by way of complete elimination of food plants of the fauna and by making the habitat prone to fire (CBD, 2010; Adam et al, 2010).

It was believed that the threat of alien invasive species would be much low in natural habitats as compared to disturbed habitats and forests were considered to be immune to large scale plant invasions. However, recent studies have shown that this is not true. The diversity of survival strategies exhibited by invasive species has been shown to help them adapt to natural ecosystems including closed canopy forests. It has been predicted that owing to the high adaptability of alien invasive species to new environments, their threat is going to increase in the context of global climate change and associated changes in local habitats. This study attempts to

review the threat by alien invasive plants to the forests of Kerala in the light of our understanding of invasion ecology and field studies in major forest tracts of Kerala.

Methods

The data on occurrence of alien invasive species (hereafter, AIS) in forests was obtained by on-road survey covering evergreen, deciduous and dry deciduous forests and grasslands in Kerala. A total of 655 point observations were made. At each location, information was collected on the AIS and the impacted native species and habitats. Each of the species recorded was then subjected to the Invasive Species Assessment Protocol (Morse et al., 2004) so as to calculate the invasive rank (I-Rank) of the species. Description of the invasive rank used in the study is given in Table 1. On the factors that influence the position of a species in the I-Rank, the assessment protocol describes that " … factors which can push a species' I-Rank upward (towards High) are the ability to change ecosystem processes; … invade relatively undisturbed ecological communities; … cause substantial impacts on rare or vulnerable species of ecological communities, or high-quality examples of more common communities; wide distribution and general abundance where present; ability to disperse to new areas readily; and difficulty of control. Conversely, species with minimal impacts on ecosystem processes, native species, and ecological communities will generally be assigned an I-Rank of Low or Insignificant. Other factors that can push a species' I-Rank downward are lack of potential to spread beyond a small existing range, stable or decreasing abundance within the current range, and ease of control".

Results

Of the 38 AIS found in the forests of Kerala, 10 are of high risk, 12 pose medium risk , 10 pose low risk and the rest, 6, are insignificant as per the risk assessment conducted (Table 2). There are 5 trees, 11 shrubs, 4 subshrubs, 12 herbs and 6 climbers among the AIS found in the forests of Kerala. The land of origin of the AIS happens to be America for 11 species, South America for 10 species, Central Ameriaca for 6 species, Central and South America for 4 species, and Asia for 3 species. Alien species, one each has also been from Africa, Australia, West and Central Africa and the West Indies. It is also important to note that most of the introductions into the forests of Kerala was intentional (31 species). Six species were accidentally introduced and the motive and mode of introduction of one species (*Alternanthera brasiliana*) could not be deciphered. Each of the species is discussed below as per the I-Rank.

High risk Species

a) Acacia mearnsii

Observed to be highly invasive in Mannavanshola, Pambadumshola, Eravikulam National Park; this species is a fast growing, evergreen, nitrogen fixing tree introduced to Kerala in 1980's for afforesting grasslands in the high altitudes. The cultivation of the tree is for the tannin it contains in the bark. The tree is an aggressive colonizer with the ability to invade moist tropical habitats and landscapes experiencing climatic regimes comparable to 'warm temperate'. The trees produce a large amount of long-lived seeds which are triggered to germinate *en masse* by fire. By producing strong allelochemicals, the

species deters the native species from establishing in its vicinity. The species has invaded into adjacent grasslands and invites forest fire as the bark contains tannin. The impact includes decrease in stream flow, loss of biodiversity, increased soil erosion and destabilization of river banks.

b) Chromolaena odorata

Accidentally introduced from Assam in 1940's, this fast growing, upright or scrambling perennial shrub has a wide distribution in most forests of Kerala. Having got naturalized in many parts, it still remains as dense stands wherein it can smother plants up to a height of 20 m due to its phenotypic plasticity. High reproductive efficiency of the species coupled with the dispersal of the seeds through wind, makes its control rather difficult. This is one species which requires re-establishment strategies wherein the removal of the species is to be supplemented with assisted regeneration of native plants so as to phase out the AIS.

c) Lantana camara

Intentionally introduced as an ornamental plant, it is a low, erect and vigorous shrub densely growing in open un-shaded habitats. It occurs as a dominant understorey species disrupting natural succession and depleting native biodiversity. The shrub-growth of the species can be so persistent that it can completely stall the regeneration of rainforests for several years. The species poses high threat to disturbed forests wherein large expanses of the forest area have been occupied by just this species. Mechanical removal of the plant and subsequent planting of

indigenous species is to be taken up so as to restore the habitats and to prevent the sites from functioning as source for further invasion deep into the forest.

d) Merremia vitifolia

Commonly found in forest fringes and gaps, this perennial climber has the ability to smother native flora completely cutting off the sunlight from reaching the native species underneath. It spreads aggressively and reproduces vegetatively and is extremely difficult to remove manually, particularly when the plant is a few years old and the stem thick. In situations where it grows up to the forest canopy, cutting the main stem would desiccate the plant and increase the fuel load leading to canopy fires. Owing to this, any incursion of the plant should be dealt with at the earliest so as to prevent suppression of the native vegetation.

e) Mikania micrantha

A fast growing perennial climber intentionally introduced from South America as a cover crop for rubber plantations, has a wide distribution in Kerala. It can climb up to the canopy from forest fringes and spread over the canopy impacting the growth of trees in the forest and the herbs and, shrubs beneath. It aggressively colonizes tree fall gaps in natural forests. Many young teak plantations in moist habitats are heavily infested by *Mikania*. It reproduces both by sexual and vegetative means; vegetative propagation from fragmented herbage is more prolific in moist edaphic and atmospheric conditions. When in flowering it attracts a large number of pollinators including butterflies thereby creating competitive pressure on the

regeneration of native species. When the herbage dries up, this species too invites the dager of canopy fire and should be eradicated at the time of establishment.

f) Mimosa diplotricha* var. *diplotricha

Intentionally introduced as a nitrogen fixing cover crop for coffee plantations, it is a fast growing straggler which can aggressively smother native vegetation. Both spiny and spineless varieties are seen, the former being most aggressive. Scrambling vigourously over native plants and forming dense tangled thickets up to 3 m in height, it prevents regeneration, reproduction and growth of indigenous species. Owing to the presence of spines, this is one species that attracts herbicide application in place of mechanical removal. The species is rampant in non-forest areas and the possibility of invasion to forests is very high. Early detection and rapid eradication is the key to protect forests from this species.

g) Mucuna bracteata

A fast growing perennial, creeping and aggressively climbing vine intentionally introduced as a nitrogen fixing cover which is drought and shade tolerant. It can choke, smother and dwarfen native trees by its gregarious growth and climbing behavior. Propagation is mainly through seeds and fibrous roots which arise from nodes. It is one species which has escaped the confines of plantations and started to vigorously invade into the forests from the fringes. It is extremely difficult to remove the plant once it is established. This is one species which requires strict legislation to prevent its use in plantations near to forests.

h) *Prosopis juliflora*

A spiny, fast growing, small to medium sized evergreen tree with a short, crooked trunk and large crown has been a much debated species in India. While many consider it as a species which has catered to the fuel needs of people in arid zones, it has also been defined as a tough invasive species owing to its ability to reduce the carrying capacity of habitats. In Kerala, it is found in the dry deciduous forests of Chinnar Wildlife Sanctuary. If unchecked, it can form dense, impenetrable thickets which pose serious threat to native flora and fauna. It can also dry out the soil and compete for other plants for water especially in dry areas. This is one species which has to be carefully checked in the context of global climate change wherein the resilience of native species would be compromised.

i) *Pueraria phaseoloides*

Brought for use as cover crop in rubber plantations due to its nitrogen fixing and shade tolerance, this is a vigorous, deep rooted, twining and climbing legume adapted to different types of soils. It grows gregariously in vacant lands and forest fringes and has the ability to climb up the canopy and completely cover medium sized trees. The species warrants legislative control for its use in plantations adjacent to plantations.

j) *Sphagneticola trilobata*

A creeping, mat-forming perennial herb, native to the tropics of Central America is a widely planted ornamental species which has been mistakenly used even in gardens in fron of forest offices inside owing to its beautiful yellow flowers contrasting with the thick green leaves. It has a

wide ecological tolerance and can thrive well in open and shaded areas. It successfully displaces native species including many medicinal plants. Although very few viable seeds are produced, the flowers are rich in nectar and attracting pollinators from native species. Awareness about the threat of the species has to be widely so as not to introduce the species into forests since removal of the species requires long-term restoration strategies.

Medium Risk Species

Invasion is a dynamic process preceded by stages of introduction, establishment, spread and naturalization; hence at any given point of time, various invasive species would be at various stages as mentioned above. Even when risk assessment takes care of the possibility of a medium risk species to break off into a high risk species, these species need continuous monitoring. There are 12 AIS in Kerala which fall under the medium risk category. These include shrubs like *Cestrum aurantiacum*, *Hyptis capitata*, *Senna hirsuta* and *Tithonia diversifolia* which were intentionally introduced for ornamental purposes. While *C. aurantiacum* and *T. diversifolia* are seen invading medium to high altitudes, others are limited to lowland forests. The medium risk species which are subshrubs include *Ageratina adenophora*, *Hyptis suaveolens* and *Senna tora* which all intentionally introduced. The former is seen only in the high altitudes where it is showing aggressive invading behavior. *Ipomoea purpurea* is a medium risk climber, again introduced intentionally for its ornamental appeal and currently invading forest fringes. *Parthenium hysterophorus* and *Pennisetum polystachyon* are other medium risk AIS in Kerala, the former accidentally introduced and the latter intentionally

introduced. *Measopsis eminii* and *Senna spectabilis* are two medium risk tree invasives, which were intentionally introduced.

All medium risk AIS need monitoring and their spread into the forest areas can be checked if the eradication process is integrated with the regular fire-line works done along the forest boundaries and forest roads. This would need field guides and capacity building for the forest staff to selectively cull out the species.

Low risk Species

Low risk AIS are significant but are relatively of low risk to the forest ecosystems of State, now. Ten species belong to this category of which 4 are herbs, 3 shrubs, and one each a sub-shrub, a climber and a tree. The tree *Leucaena leucocephala* is seen in open lands outside forests and is seen within the forests at Thattekkadu and Muthanga. The climber *Centrosema molle* has been introduced as a cover crop and has invaded forest fringes. *Alternanthera brasiliana* is an ornamental plant which spreads fast on the ground vegetatively. The herbs include naturalized species like *Mimosa pudica, Ageratum conyzoides, Amaranthus spinosus* and *Erigeron karvinskianus* which have caused little or no impact on native flora.

It can be seen that there are two groups of plants which come under low risk species. Most of the species have been naturalized and should not pose serious threat to the habitats while species like *Alternanthera brasiliana* have been seen invading only recently which warrants monitoring as to its invasive traits.

Insignificant Species

Insignificant species observed in the study have been found restricted to forest fringes and are easily manageable. Most of them are characterized by low rate of vegetative reproduction and low rate of spread. Except for *Jatropha gossypifolia*, all others are susceptible to drought. Owing to these reasons, the insignificant species are of least concern.

Discussion

The study has identified 38 AIS in the forests of Kerala which fall under high risk, moderate risk, low risk and insignificant categories. All high and moderate risk species warrants immediate attention and those species in other categories need constant monitoring. The approaches towards this can be classified under the following four categories:

a) Assessment and Preventive Measures

Since none of the forest areas visited during the study was devoid of alien invasive species and since notable direct and indirect impacts were noticed, it is important to undertake a comprehensive survey of AIS in all forest divisions of Kerala.

To prevent new incursion of AIS into the forests, the following measures steps needs to be adopted:

i. All plant and soil which move into the forests (for civil works, saplings from central nurseries, etc) need to be thoroughly monitored for the presence of AIS as saplings, plant parts or propagules.

ii. Since many of the AIS which are impacting the natural forests were brought in as cover crops for

plantations, it is important further import should be made only after quarantine procedures.

iii. Forest areas, especially those which are tourist destinations, need to have thorough check including the vehicle and tourist baggage . This would prevent the influx of AIS propagules into the forests.

b) Early Detection and Rapid Control

The most economically viable way to contain AIS is to establish a surveillance system in place so as to detect AIS and adequate infrastructure and resources to eradicate them at the earliest notice. The following steps could be adopted:

i. Tourist and pilgrimage routes and spots within forests should be put under regular surveillance to detect and eradicate new AIS.

Adequate capacity building workshops should be undertaken for the field staff with field guides to identify AIS so as to equip then to take up proactive measures to contain the establishment of AIS.

c) Prevention of spread

For AIS which have already established and when immediate eradication is difficult, efforts should be focused on preventing its spread by:

ii. Restricting the movement of soil and plant parts from AIS infested area to other parts of the forest.

iii. Management of weed infested area during the reproductive phase of the AIS so as to prevent the dispersal of seeds to un-infested areas.

d) Habitat Restoration

For those AIS which have established themselves in large tracts, removal would not be practical or sustainable. For those areas systematic restoration strategies should be taken up as follows:

i. Identifying probable uses of the AIS.

ii. Prepare a management plan which includes the use of the AIS, products which can be made, marketing structures and its economics.

iii. Prepare a site specific restoration strategy which involves the list of native species to be planted or for which assisted natural regeneration measures are to be adopted.

iv. Simultaneously implement both eradication and restoration programmes mentioned above in a time bound manner.

Conclusion

With their capability to impact native biodiversity and landscape level changes, AIS are an important concern in forests of Kerala which warrants immediate action. Forest protection efforts need to integrate the variety of measures which would restore habitats from AIS, eradicate AIS which are in the establishment phase and prevent incursions of new AIS into the forest areas. The impact of AIS is twofold. First is the diverse array of direct and indirect impacts which they cause and the second is the impact caused by herbicides used for their control. One of the key challenges in managing AIS in forests is thus to avoid the use the synthetic herbicides,

the use of which would be counterproductive owing to their impact on native flora and fauna.

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Table 1. Description of Invasive Rank used in the study

Rank	Description
High	Species represents a severe threat to native species and ecological communities
Medium	Species represents moderate threat to native species and ecological communities
Low	Species represents a significant but relatively low threat to native species and ecological communities
Insignificant	Species represents an insignificant threat to native species and ecological communities

Table 2. Alien Invasive species in the forests of Kerala and their risk classes.

Sl.No	Species	Family	Habit	Local name	Rank	Introduction	Native to	Purpose of introduction
1	*Acacia mearnsii* De Wild.	*Mimosaceae*	Tree	Karuva	High	Intentional	Australia	Afforestation
2	*Ageratina adenophora* (Spreng.) King & Robins.	*Asteraceae*	Subshrub	Neelagiri	Medium	Intentional	Central America	Ornamental
3	*Ageratum conyzoides* L.	*Asteraceae*	Herb	Appa	Low	Intentional	Central America	Ornamental
4	*Alternanthera bettzickiana* (Regel) G.Nichols.	*Amaranthaceae*	Herb	Cherucheera	Insignificant	Accidental	America	-
5	*Alternanthera brasiliana* (L.) Kuntze	*Amaranthaceae*	Subshrub	Choracheera	Low	Intentional	Central and South America	Ornamental
6	*Alternanthera philoxeroides* (Mart.) Griseb.	*Amaranthaceae*	Herb	Minnamkanni	Insignificant	Unknown	South America	Unknown
7	*Amaranthus spinosus* L.	*Amaranthaceae*	Herb	Mullancheera	Low	Accidental	South and Central America	-
8	*Asclepias curasavica* L.	*Asclepiadaceae*	Herb	Kammalchedi	Insignificant	Intentional	America	Ornamental
9	*Centrosema molle* Benth.	*Fabaceae*	Climber	Kattupayar	Low	Intentional	America	Cover crop
10	*Cestrum aurantiacum* Lindl.	*Solanaceae*	Shrub	-	Medium	Intentional	Central America	Ornamental
11	*Chromolaena odorata* (L.) King & H. Rob.	*Asteraceae*	Shrub	Communist pacha	High	Accidental	America	-
12	*Clidemia hirta* (L.) D. Don	*Melastomataceae*	Shrub	-	Low	Accidental	Central and South America	-
13	*Erigeron karvinskianus* DC.	*Asteraceae*	Herb	Pottu - poovu	Low	Intentional	South America	Ornamental
14	*Hyptis capitata* Jacq.	*Lamiaceae*	Shrub	-	Medium	Intentional	Central America	Unknown

Sl.No	Species	Family	Habit	Local name	Rank	Introduction	Native to	Purpose of introduction
15	*Hyptis suaveolens*(L.) Poit.	*Lamiaceae*	Subshrub	Naattapoochedi	Medium	Intentional	America	Unknown
16	*Ipomoea purpurea* (L.) Roth	*Convolvulaceae*	Climber	-	Medium	Intentional	Central America	Ornamental
17	*Jatropha gossypifolia* L.	*Euphorbiaceae*	Shrub	Chuvannakadalavana kku	Insignificant	Intentional	South America	Hedge plant
18	*Lantana camara* L.	*Verbenaceae*	Shrub	Kongini	High	Intentional	Central and South America	Ornamental
19	*Leucaena leucocephala* (Lam.) de Wit	*Mimosaceae*	Tree	-	Low	Intentional	America	Social forestry
20	*Merremia vitifolia* (Burm. f.) Hallier f.	*Convolvulaceae*	Climber	Vana vayara	High	Accidental	Asia	-
21	*Mikania micrantha* Kunth	*Asteraceae*	Climber	Dritharashtra pacha	High	Intentional	South America	Cover crop
22	*Mimosa diplotricha* var. C. Wight ex Sauvalle *diplotricha* C. Wight ex Sauvalle	*Asteraceae*	Shrub	Aanathottavadi	High	Intentional	South America	Cover crop
23	*Mimosa diplotricha* C. Wight ex Sauvalle var. *inermis* (Adelb.) Veldk.	*Asteraceae*	Shrub	Aanathottavadi	Low	Intentional	South America	Cover crop
24	*Mimosa pudica* L.	*Asteraceae*	Herb	Thottavadi	Low	Intentional	south America	
25	*Mucuna breacteata* DC. ex Kurz	*Fabaceae*	Climber	Thottapayar	High	Intentional	Asia	Cover crop
26	*Parthenium hysterophorus* L.	*Asteraceae*	Herb	Congress pacha	Medium	Accidental	South America	
27	*Pennisetum polystachyon* (L.) Schult.	*Poaceae*	Herb	Kothappullu	Medium	Intentional	Africa	Accidental
28	*Phytolacca octandra* L.	*Phytolaccaceae*	Herb		Insignificant	Intentional	America	Ornamental
29	*Prosopis juliflora*(Sw.) DC.	*Mimosaceae*	Tree	Vanni	High	Intentional	South America	Fuel wood
30	*Pueraria phaseoloides* (Roxb.) Benth.	*Fabaceae*	Climber	Thotta - payar	High	Intentional	Asia	Cover crop

Sl.No	Species	Family	Habit	Local name	Rank	Introduction	Native to	Purpose of introduction
31	*Senna hirsuta* (L.) Irwin & Barneby	*Caesalpiniaceae*	Shrub	Ponninthakara	Medium	Intentional	America	Ornamental
32	*Senna occidentalis* (L.) Link	*Caesalpiniaceae*	Shrub	Karinthakara	Low	Intentional	South America	Unknown
33	*Senna spectabilis* (DC.) Irwin & Barneby	*Caesalpiniaceae*	Tree	Manjakonna	Medium	Intentional	America	Unknown
34	*Senna tora* (L.) Roxb.	*Caesalpiniaceae*	Subshrub	Thakara	Medium	Intentional	America	Unknown
35	*Sphagneticola trilobata* (L.) Pruski	*Asteraceae*	Herb	Venappacha	High	Intentional	America	Ornamental
36	*Synedrella nodiflora* (L.) Gaertn.	*Asteraceae*	Herb	Mudianpacha	Insignificant	Intentional	West Indies	Unknown
37	*Tithonia diversifolia* (Hemsl.) A. Gray	*Asteraceae*	Shrub	Kaippan pachha	Medium	Intentional	Central America	Ornamental
38	*Measopsis eminii* Engl.	*Asteraceae*	Tree	Kuda maram	Medium	Intentional	West and Central Africa	Shade

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KFRI Tree Health Helpline

Kerala Forest Research Institute (KFRI) in its three decades of existence has emerged as a hub of tropical forest research. One of the leading branches of research which cut across subject disciplines was the effort to solve tree health problems. This includes problems faced at single tree level to those at nurseries and plantation levels. Thousands of queries have been attended to, problems diagnosed arid remedies prescribed. Various divisions of KFRI like Soil Science, Entomology, Pathology, Botany, Silviculture, Wood Science, Statistics and Wildlife and Physiology had actively Involved In either attending to the problems in both multidisciplinary and monodiscipilnary modes.

The comprehensive tree helpline can attend to all queries related to tree planting and management such as site selection, species site matching, planting thinning, soil testing, fertilization, pest, disease and weed management, multi-species interactions, landscape level afforestation programmes, tree/wood sample identification, preservative treatments and economic valuation. The clientele of the service will be the general public including students who participate in tree planting programmes and also private and public firms.

Services offered

1. **Site selection:** Identifying the right locales for tree pLanting species
2. **Site matching:** Identifying which tree species are suited for a given site
3. **Planting:** Recommendations on spacing and time of planting
4. **Thinning:** Information on when and how to thin woodlots
5. **Soil testing:** Quantifying soil nutrients
6. **Fertilizer application:** Recommendations on type, quantity and timing of fertilizer use
7. **Pest, disease and weed management:** Protocols for monitoring and recommendations on pest, disease and weed control with special focus on eco-friendly methods
8. **Multi-species Interactions:** Knowledge on species mixing and their planting protocols
9. **Landscape level / afforestation Programmes:** logistical support for large scale tree planting efforts
10. **Tree/wood sample Identification:** Identification of wood samples and their strength measurements
11. **Preservative treatments:** Timber seasoning protocols and preservative treatment methods
12. **Economic valuation:** Economic projection and valuation of woodlots

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