teria will be done using GC–MS. Further studies are under way to characterize this isolate.

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PRACHI AWASTHI
ISHA SOOD
SUDHIR SYAL*

Department of Biotechnology and Bioinformatics,
Jaypee University of Information Technology,
Waknaghat,
Solan 173 215, India
**For correspondence.*
e-mail: sudhirsyal@rediffmail.com

Ingress of lantana in dry tropical forest fragments: Edge and shade effects

Invasion of native communities by exotic species is considered the second largest threat to global biodiversity[1]. Since the tropics are highly populated, they experience greater pressure of invasive species, as the process of plant species invasion gets exacerbated with increased anthropogenic interventions. Seasonal tropical forests are especially susceptible to invasion[2]. In India, dry tropical forest accounts for 28.6% of the total forest cover[3]. These forests are under immense anthropogenic pressure due to rapid industrialization and related land-use changes in the past few decades[4], leading to forest fragmentation[5]. Lantana (*Lantana camara* L.) had been introduced in India in the early 19th century as an ornamental plant[6]; but now it is growing densely throughout India. Field observations in the dry tropical forests of India indicated that lantana is spreading fast. However, it is not uniformly distributed across a forest fragment[7]. The objective of the present study was to assess the spread of lantana across forest fragments and to establish a relationship between lantana cover and tree canopy opening due to dry tropical forest fragmentation.

The study area lies on the Vindhyan plateau, Sonebhadra District, Uttar Pradesh (24°13′–24°19′N; 83°59′–83°13′E) and is 315–485 m asl[8]. Climate is tropical monsoonal, with mean annual rainfall of 821 mm. Soils are Ultisols and extremely poor in nutrients[9], and support tropical dry deciduous vegetation[4].

Nine forest fragments (sites), varying between >1 and 10 ha in size were selected to represent a range of canopy cover and vegetation conditions. At each site, ten quadrats (10 × 10 m) were sampled along a belt transect from the edge to the interior to measure tree canopy and lantana cover. The quadrats along the belt transects were segregated into edge, middle and interior in terms of species composition by the PCA ordination technique (data not shown here). At each site, three quadrats were selected from each of the above regions for soil sampling and collected soil samples were further analysed for physical and chemical characteristics[10].

Triplicate seedlings of lantana were exposed to different shade treatments in the Botanical Garden, Banaras Hindu University (BHU), Varanasi (25°18′N lat., 80°1′E long.) for assessing growth at 60 and 90 days per shade treatment. A separate set of three seedlings was used for recording the initial growth parameters.

Natural shades were imposed on the seedlings by placing pots under tree shades providing low (70–100% sunlight), medium (30–60% of full sunlight) and high shade (10–20% of full sunlight) regimes[11]. Light intensity at the low-shade level was 1600–1720 μmol/sq. m/s PAR at 11.00 am on a cloud-free day, as measured using LCpro portable photosynthetic system (ADC, UK). All the pots were maintained at 50% soil moisture.

Seedlings harvested at 0, 60 and 90 days were brought to the laboratory, washed and oven-dried (at 80°C) for biomass and relative growth rate (RGR) estimation as follows[12]:

$$\text{RGR (mg/g/d)} = \frac{\ln W_2 - \ln W_1}{t_2 - t_1},$$

where W_1 is the total plant dry weight at time t_1 and W_2 the total plant dry weight at time t_2.

Relationships between distance from the edge and tree canopy cover, as well as lantana cover were examined through regression analysis. ANOVA and Tukey's range was used to examine the effect of shade regimes on the relative growth rate of seedlings.

In the present study, tree canopy and lantana cover varied from 23 to 65% and from 1 to 52% from the edge to the interior of the fragment (Figure 1). Significant positive and negative relationship of tree canopy cover ($r^2 = 0.87$, $P = <0.0001$) and lantana cover ($r^2 = 0.89$, $P = <0.0001$) was observed with the distance from edge to interior respectively. Thus tree canopy cover and lantana cover were negatively associated with each other ($r^2 = 0.85$, $P = 0.001$). Being an opportunistic species, lantana is favoured by disturbance-induced structural changes in the community, such as the amount of biomass destroyed[13] or changes in soil characteristics or both[14]. In the dry de-

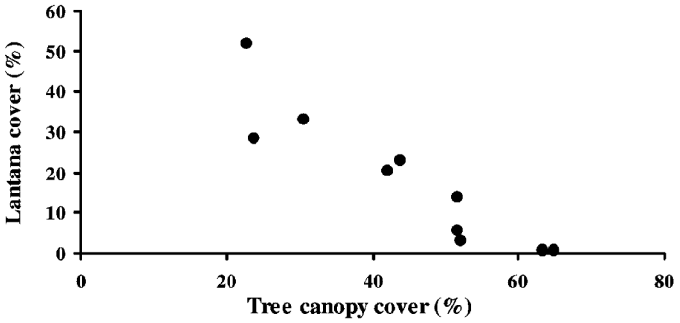

Figure 1. Variation in lantana cover in response to change in tree canopy.

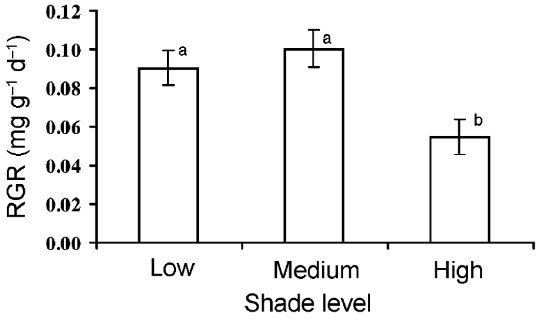

Figure 2. Relative growth rate (RGR) of lantana after 60 days of exposure to the different shade regimes. (Values suffixed with the same letter on bars were not significantly different from each other.)

Table 1. Soil physico-chemical characteristics of the edge, middle and interior of forest fragments

	Edge	Middle	Interior
Physical characteristics			
Moisture (%)	22.50^a	24.11^a	30.67^b
WHC	41.00^a	43.94^a	46.89^b
Bulk density	1.08^a	1.05^a	1.00^a
Soil texture (%)			
Sand	69.44^a	80.33^b	82.11^b
Silt	28.44^a	18.22^b	14.72^b
Clay	2.11^a	1.44^b	3.17^a
Chemical characteristics			
Carbon (%)	3.01^a	2.53^a	2.43^b
Nitrogen (%)	0.27^a	0.25^a	0.22^b

Values suffixed with the same letter in a row were not significantly different from each other.

ciduous forests of India, anthropogenic disturbance, particularly lopping of branches is greater at the edges due to easy accessibility. Disturbance-induced tree canopy opening acts as an invasion window[15], providing optimum light intensity for the establishment and colonization of lantana.

In order to test the hypothesis that canopy opening enhances lantana invasion due to increased light availability, its growth behaviour was monitored under controlled shade conditions. Biomass of seedlings grown at medium and low shade levels was 3.69 and 2.03 g respectively, whereas seedlings at high shade accumulated only 0.24 g after 60 days and could not survive beyond 60 days. Greater RGR was exhibited by seedlings at low-to-medium shade levels than high shade levels. RGR in medium shade level was 83 and 11% higher than high and low shade levels respectively, after 60 days of exposure (Figure 2). High RGR in the early phase of life promotes vegetative growth and it is reflected in the form of dense thickets of lantana on the forest edges. In addition to increased under-canopy light, canopy opening also increases nutrient availability at the disturbed edges[16] and temperature of the forest floor, enhancing germination and growth[14].

Lantana architecture promotes accumulation of litter under the shrub, resulting into build-up of organic carbon and nitrogen[7]. Lantana also has higher leaf nitrogen[17], which may favour faster litter decomposition in contrast to slower decomposition from the native species. Although there was no consistent pattern in physical characters of soil along the edge to the interior, we had observed significantly higher soil carbon and nitrogen in the edge region of the fragments compared to the interior locations (Table 1). Such behaviour has been observed for other invasive species also[18,19]. It leads to altered nitrogen dynamics in the invaded sites with increasing lantana cover[7]. Higher N turnover rates enable lantana to perform better than indigenous species[17], which are adapted for poor soil. Light has been recognized as an important plant resource[20] and below a certain threshold, light limitation can be critical for seedling survival[21]. Thus increasingly dense lantana cover may further reduce the intensity of light under its canopy, preventing the establishment of tree seedlings due to photosynthetically inactive light regimes at the ground level[22]. If this process of lantana invasion at the forest edges continues, the regeneration process of the tree species would be hindered[7], ultimately leading to the domination of the invasive species.

The present study indicates that shading by intact canopies may be an effective strategy for lantana control. Therefore, afforestation programmes and conservation measures as highlighted by Sagar and Singh[4] for dry deciduous forests of India, should be promoted to check further spread of lantana in core forest areas.

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PURNIMA RAIZADA[1]
GYAN P. SHARMA[2]
A. S. RAGHUBANSHI[1,*]

[1]*Department of Botany,*
Banaras Hindu University,
Varanasi 221 005, India
[2]*Centre of Excellence for Invasion Biology, Conservation Ecology and Entomology,*
University of Stellenbosch,
Matieland 7602, South Africa
**For correspondence.*
e-mail: raghubansh@gmail.com

A dichotomously branched fossil palm stem from the Deccan Intertrappean beds of India

Palms (family Palmae/Arecaceae) constitute a large assemblage of woody monocotyledonous plants distributed naturally in the Oceanic Islands and coastal areas in the tropics between 44°N and 44°S of the equator[1]. They play a significant role in human welfare and are ranked next to families Poaceae (Gramineae) and Leguminosae in providing the basic necessities like food, shelter and other minor necessities in the tropical countries[2,3]. There are 2364 species of palms embodied in 190 genera[4]. Palms usually have solitary or clustered, unbranched stems, each with a terminal crown of leaves. They are also known for a number of distinctive features in the plant kingdom, like tall woody axis built entirely by primary growth without physiological dormancy; continuous regeneration of adventitious roots throughout their life; massive leaves and inflorescences; longest stem, leaf and largest inflorescences and seeds[5].

Palms have a long geological history, originating in the Cretaceous period, if not earlier. Their geological remains are known in the form of permineralizations, impressions, compressions and casts of plant organs such as stem, root, leaf, inflorescence, flower, fruit, seed and pollen grains assigned to the number of organ genera from different parts of the world[6–8]. Permineralized pieces of stems or their parts are assigned to the organ genus *Palmoxylon* Schenk. There are more than 200 species of *Palmoxylon* described from the world, including 69 species from India. The Deccan Intertrappean beds of India are particularly rich in palm fossil remains[9,10].

In a recent field work in Central India, we procured a unique piece of permineralized palm stem having dichotomous branching with roots from the Deccan Intertrappean beds exposed at Silther (lat. 23°02′00″N; long. 80°38′20″E), Dindori District, Madhya Pradesh. The specimen was a massive piece of stem showing true dichotomous branching (*V*-shaped axis). One branch was 25.5 cm long and 14.5 × 17.0 cm in diameter, and the other 28 cm long and 12.5 × 16.5 cm in diameter. It appears that the dichotomous branching is of the first order, as both the branches at their joint are attached with thousands of adventitious roots. Both the branches are covered with a number of rings representing scars of the fallen leaf bases and roots. The roots are 4–8 mm in diameter, but thinner roots are also frequently seen. The stem exhibits fibrovascular bundles typical of palms distributed in the parenchymatous ground tissue (Figure 1 *a–d*).

Dichotomous branching in the extant palms has been reported in the genera *Allagoptera* Nees, *Chamaedorea* Willd., *Hyophorbe* Gaertn., *Hyphaene* Gaertn., *Nannorrhops* H. Wendl., *Nypa* Steck and *Vonitra* Becc. (now emended in *Dypsis* Naronha ex Mart.). However, the present correspondence is a first report of dichotomous branching in the fossils. The massive branching indicates its affinity possibly with the true dichotomously branched species of *Hyphaene* Gaertn. There are eight species in the genus *Hyphaene* distributed in Africa, Madagascar, the Red Sea, and the coasts of the Gulf of Eilat, coastal Arabia, Sri Lanka