EFFECT OF DEFOLIATION ON THE GROWTH OF TEAK

M.W. Baksha

Forest Protection Division, Bangladesh Forest Research Institute, GPO Box 273, Chittagong 4000, Bangladesh

&

M.J. Crawley

Imperial College of Science, Technology and Medicine, Silwood Park, Ascot, Berkshire SL5 7PY, United Kingdom

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BAKSHA, M.W. & CRAWLEY, M.J. 1998. Effect of defoliation on the growth of teak. In a one-year-old teak (*Tectona grandis*) plantation at Kaptai, Bangladesh, manual defoliation (25, 50, 75 and 100%) in June, simulating the damage caused by the larvae of teak defoliator, *Hyblaea puera* Cramer (Hyblaeidae: Lepidoptera), was carried out. Four years of such defoliation caused significant losses of about 14 - 49% in height, 19 - 51% in basal area and 23 - 62% in volume increments depending on the intensity of defoliation as compared to the unsprayed control. However, the losses were about 28 - 57%, 53 - 72% and 58 - 79% respectively compared to the sprayed control. The sprayed control that excluded all potential herbivores afforded about 16% in height, 42% in basal area and 45% in volume increments against those of the unsprayed control. Loss of volume increment is a serious impact of defoliation. Protection during the early years would be advantageous because of the higher absolute increment of teak at this stage. None of the trees defoliated showed mortality or leading shoot dieback.

Key words: Defoliation effect - growth impact - teak - *Hyblaea puera* - Bangladesh

BAKSHA, M.W. & CRAWLEY, M.J. 1998. Kesan keluruhan daun terhadap pertumbuhan jati. Di ladang jati (*Tectona grandis*) berumur satu tahun di Kaptai, Bangladesh, keluruhan daun secara manual (25, 50, 75 dan 100 %) dijalankan pada bulan Jun, sama seperti kerosakan yang diakibatkan oleh peluruh daun jati, *Hyblaea puera* Cramer (Hyblaeidae: Lepidoptera). Keluruhan seumpama itu selama empat tahun mengakibatkan kehilangan yang bererti sebanyak 14 - 49% ketinggian, 19 - 51 % luas kawasan pangkal dan 23 - 62 % pertambahan isipadu bergantung kepada keamatan keluruhan berbanding dengan kawalan tidak disembur. Bagaimanapun, kehilangan didapati lebih kurang 28 -57 %, 53 - 72 % dan 58 -79 % masing- masing berbanding dengan kawalan semburan. Kawalan semburan yang tidak termasuk semua potensi herbivor mampu lebih kurang 16 % ketinggian, 42 % luas pangkal kawasan dan 45 % dalam pertambahan isipadu kepada yang terdapat dalam kawalan semburan. Kehilangan pertambahan isipadu merupakan kesan serius yang disebabkan oleh keluruhan. Perlindungan pada awal tahun merupakan satu kelebihan kerana pertambahan mutlak pokok jati lebih tinggi pada peringkat ini. Tidak ada pokok yang mengalami keluruhan menunjukkan kematian atau menyebabkan mati rosot pucuk.

Introduction

The effect of defoliation has been studied by various workers both on conifers (Linzon 1958, Kozlowski & Winget 1964, Lanier 1967, Kulman 1965b, 1971) and broad-leaved species (Kulman 1965a, Heichel & Turner 1976, 1984). Only a few workers have studied the effect of defoliation on teak. The effect of defoliation caused by *Hyblaea puera* Cramer (Hyblaeidae: Lepidoptera) and many other defoliators was suspected to be a loss of about one-third to one-half of the potential volume increment (Beeson 1928, Minchin 1929). Mackenzie (1921) estimated 8.3% loss of volume in Myanmar. Beeson (1931) calculated a loss of about 8.2%. Later Beeson (1941) revised his estimate to about 13%. Champion (1934) gave the loss figure of 65%. So, we do not have a reliable estimate of the loss in increment due to defoliation caused particularly by *H. puera*. A study was therefore undertaken to estimate the loss of growth under the normal plantation practice of Bangladesh.

Materials and methods

Simulated defoliation experiments were set up in a 1-y-old teak plantation situated situated at Kaptai in the Chittagong (South) Forest Division, Bangladesh. The plantation was raised at an initial spacing of 1.8 × 1.8 m. The experiments were laid out in three separate blocks of the plantation. Each block constituted 12 trees selected at random. The plantation was weeded annually.

Varying intensities of manual defoliation (0% + spray, 0%, 25%, 50%, 75% and 100%) were carried out. Each treatment was applied to six trees, two from each block. The defoliation was carried out in June each year, simulating a major *H. puera* attack in the season. The leaf blades were removed by hands, leaving the petiole, mid-ribs and major veins intact simulating the damage caused by *H. puera* larvae. In the treatment, 0% defoliation + spray, defoliation by herbivore fauna was controlled by prophylactic application of a mixture of systemic and contact (phosphamidon and malathion respectively) insecticides. When an infestation was present or imminent, the trees were sprayed until dripping of the insecticide solution occurred. A pedal sprayer was used for the insecticide to reach the tops of the trees when they were not approachable by a knapsack sprayer. In practice, not more than four insecticidal sprays were required. Data on height, diameter at breast height (dbh) and forking were taken at the beginning of the experiment in December 1988. The breast height (1.30 m above ground) of all the trees were marked, and the measurements were taken with a slide calliper. The trees receiving various treatments were marked differently with paints. The heights of the standing trees were measured with a tape attached to a bamboo pole.

Final measurements were taken in late 1992. Thus, the total experimental period encompassed four years. The increments in height, dbh and volume for each tree during the period were determined by subtracting the initial data from the final data. Data were also taken annually to make interim comparisons.

The primary measurements taken were dbh and height, from which the basal area (*BA*) and volume of timber were estimated. The basal area was calculated from the dbh using the formula:

$$BA = \frac{\pi \, (dbh)^2}{4}$$

The volumes of standing experimental trees were calculated from the following mathematical relationship (Latif *et al.* 1985):

$$\log_e V = 1.62116 \log_e D + 1.16483 \log_e H - 9.48076$$

where V = total volume over bark (m^3)
D = dbh (cm)
H = total height (m)

This model is based on the lowest Furnival Index, high multiple correlation coefficient and low standard deviation.

Results and discussion

The analyses of variance showed that the differences in height, basal area and volume increments in various treatments were hightly significant ($p < 0.01$). However, the block differences were not found significant.

Table 1 shows the comparison of treatment means. The height increment in the fully defoliated trees was about 49% less than that in the unsprayed control (undefoliated) trees (Table 2). However, the loss was about 57% in comparison to the sprayed control trees (Table 3).

Table 1. Comparison of treatment means in respect of increments in height, basal area and volume per tree

Treatment (% defoliation)	Height increment/tree (m)	Basal area increment/tree (cm^2)	Volume increment/tree ($cm^3 \times 10^3$)
100	2.06 cd	8.4 b	2.83 c
75	2.66 bcd	9.1 b	3.53 bc
50	3.10 bcd	13.5 b	5.15 bc
25	3.48 bc	14.1 b	5.74 bc
0	4.06 ab	17.3 b	7.50 b
0 + spray	4.84 a	30.0 a	13.53 a
$LSD_{0.01}$	1.13	10.02	4.05
CV (%)	12.93	25.15	24.53

Means followed by same letter(s) in a column do not differ significantly ($p < 0.01$).

Table 2. Loss in increment due to defoliation expressed as a percentage of the increment in the unsprayed control (undefoliated) trees

Treatment (% defoliation)	Height	Basal area	Volume
100	49.26	51.45	62.27
75	34.48	47.40	52.93
50	23.65	21.97	31.33
25	14.29	18.50	23.47
0 (unsprayed control)	0.0	0.0	0.0

Table 3. Loss in increment due to defoliation expressed as a percentage of the increment in sprayed control (undefoliated + sprayed) trees

Treatment (% defoliation)	Height	Basal area	Volume
100	57.44	72.00	79.08
75	45.04	69.67	73.91
50	35.95	55.00	61.94
25	28.10	53.00	57.58
0	16.12	42.33	44.57
0 + spray (sprayed control)	0.0	0.0	0.0

The basal area increments in the defoliated trees differed significantly from fully protected trees but not between themselves (Table 1). A loss of about 72, 70, 55, 53 and 42% in basal area increments were attributed to 100, 75, 50, 25 and 0% defoliated trees respectively in comparison to the sprayed control trees (Table 3). However, the corresponding losses were about 51, 47, 22 and 19% as compared to the unsprayed control trees (Table 2).

The volume increment in fully defoliated trees was about 62% less than that in the unsprayed control trees (Table 2). It was about 79% less in comparison to the sprayed control trees (Table 3).

Mortality or dieback of leading shoots was not observed in the experimental trees. However, dieback was prevalent due to unknown reasons in some trees in other places of the plantation.

The present estimate of about 23 - 62% loss of the potential volume increment is in striking contrast to Beeson's (1941) estimate of 13% loss, which somehow has come to be generally accepted and quoted repeatedly by various workers. On the other hand, Champion (1934) placed the loss at 65% based on three artificial defoliations on saplings in June, July and August. A study by Nair *et al.* (1985) at Nilambur, India, showed that the loss in volume increment was to the extent of 44%. They did not perform various levels of defoliation by artificial means, but maintained the 'control' by regular spraying of insecticides. However, the upper limit of the present estimate closely corresponds to the finding of Champion (1934).

The present estimate of loss is an average of a 4-y period of study. However, the exact loss during a year depends on the intensity, frequency and time of occurrence of defoliation and the interval between the consecutive defoliations. Thus, the present estimate may have general applicability, although not for every year in every locality.

One of the limitations of this experiment was that although it was carefully done, artificial or simulated defoliation is not equivalent to insect-caused defoliation (Kulman 1965b, 1971). Thus, a slightly higher estimate of loss of increments in the present study appears reasonable. However, simulated defoliation is valuable as it permits randomisation and exact measurement of defoliation intensity (Kulman 1971).

None of the artificially defoliated trees showed leading shoot dieback or mortality. This supports the observation of Heichel and Turner (1976) who failed to elicit mortality to red oak trees subjected to artificial defoliation for three successive years.

In the present study, the impact of defoliation was assessed in 2- to 5-y-old saplings. Now the question arises whether the assessment will hold good for all ages. Beeson (1941) suggested that the incidence of defoliation was not uniform throughout the period of rotation. Thus, the impact of defoliation in various ages needs to be studied. The effect of repeated defoliations in a year on the growth, phenology, branching pattern and fecundity of teak needs also to be studied.

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