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Induced Flowering in Young Hevea *Buddings*

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Observations were made over three years to assess the feasibility of using flower induced young Hevea *buddings for breeding. Among the stress and chemical treatments tested, fine girdling was the most effective in inducing flowering in the twenty-six – month-old buddings used in this study. Continuous flowering was maintained by repeated girdling for about three years. The girdled tress had been in flowering for about two years when flowering in the ungirdled controls was first seen. A cyclical pattern of flowering, in synchrony with that in mature trees, was evident in the girdled trees.*

Hand pollination was carried out on the induced female flowers. Fruit set success was comparable to that reported in mature trees. Seeds obtained from hand pollinated and open-pollinated flowers of girdled trees showed good germination success. Seeds were available in girdled trees almost throughout the third year.

Some of the advantages of flower induction are discussed. Adverse effects of girdling on young buddings and means of over-coming them are also discussed.

There is much scope for the use of young flowering plants in overcoming problems often encountered in plant breeding[1]. Though flowering has been successfully induced in young juvenile buddings of *Hevea*, the use of stressed flowering plants in *Hevea* breeding has not been adequately evaluated. Stress treatments, such as bending, girdling and water-logging are known to induce flowering in young *Hevea* buddings[1-6]. Of these, girdling appears to be the simplest and most effective[1]. The severe die-back often associated with girdling[7] limited the use of this technique in the past. Fine girdling, however, has been shown to prevent die-back while creating sufficient stress for induction of flowering[1]. This paper describes long-term flowering behaviour in plants induced to flower by fine girdling. The use of these plants for hand pollination from the ground and the degree of fruit-set success thus obtained are also described.

MATERIALS AND METHODS

Twenty-six-month-old buddings of RRIM 600, spaced 3.6 × 7.6 m apart, were used. The treatments studied included fine girdling, root pruning and application of chemicals to root systems as described previously[1]. The trees were girdled at a height of 1 m and girdling was repeated at the same height on the healed bark. Girdling was repeated at approximately one- to three-month intervals when healing was complete.

Observations on flowering were made once every two weeks. Besides observation of the number of trees flowering, the number of shoots bearing inflorescences in each tree was counted. Mature seeds arising from open-pollination were harvested from the trees before the pods dehisced. These were weighed and planted in sand beds covered with sawdust to determine germination success.

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For leaf-fall studies, hexagonal frames measuring 2 m diagonally were constructed around the bases of trees that were sampled. A 30 cm high polythene sheet enclosed the hexagonal frame. Leaves were collected weekly and counted.

Girth was determined to assess growth differences. Girth was measured at a height of 1 m in ungirdled trees, while in girdled trees girth was determined by the mean of measurements made 30 cm above and below the 1 m high girdles.

Hand pollination was carried out with the aid of ladders. Hand pollinations were also carried out from the ground without ladders on low branches. The developing fruits were bagged with cotton nets and harvested when mature, for seed germination studies.

RESULTS

Preliminary observations made for upto five months after application of various treatments have been reported[1]. *Table 1* shows the effects of various treatments at twenty months after application of the treatments. Girdling clearly continued to be effective in inducing flowering. Chemical treatment of the roots did not appear to induce flowering or promote flowering in the girdled trees.

Flowering was first observed in the ungirdled trees when they were about forty-seven months old. In contrast, flowering was first observed in the girdled trees less than two months after stress application *i.e.* when the trees were about twenty-eight months old. Flowering was continuous in the girdled trees once they had begun flowering. The intensity of flowering, as judged by the number of shoots bearing inflorescences per tree, appeared to be at the peak during April 1978 and 1979 and in February 1980. Secondary flowering was also evident between August and October *(Figure 1)*. Root-pruned trees flowered occasionally during the main flowering season, but flowering was not continuous as in girdled trees.

Girdling did not appear to alter the pattern of leaf-fall intensity, leaf-fall being highest during the month of January in both girdled and ungirdled trees in 1980 *(Figure 2)*. Flowering intensity in the same period was higher in the girdled trees even though leaf-fall was similar in both girdled and ungirdled trees.

Girth measurements indicated that girdling depressed growth *(Figure 3)*. Depression of girth was greater in 16 mm girdled trees. Though girth was depressed to a greater extent in 16 mm girdled trees, flowering intensity was higher in the 2 mm girdled trees during the second and third years of observation *(Figure 1)*. Trees that were stressed with 16 mm girdles appeared to be more prone to trunk-snap than 2 mm girdled trees *(Table 2)*. Trunk-snap occurred at the girdled region. Girth measurements 30 cm above and 30 cm below the girdled region were similar *(Figure 4)*. Girdled trees showed development of bark bursts on the main trunk above the girdle *(Table 2* and *Figure 5)*. The bark bursts appeared to be due to abnormal activity of the cambium, leading to outgrowth of woody tissue. The exudation of latex from the burst bark regions was often evident. There were no pads of rubber coagulum between the wood and bark as reported in bark bursts associated with puncture tapping in other clones[8]. Two of the 16 mm girdled trees and one ungirdled tree were affected by fungal root disease at the end of three years' observation *(Table 2)*.

Fruit set in the girdled trees, though not assessed quantitatively, appeared

TABLE 1. EFFECTS OF VARIOUS TREATMENTS ON FLOWERING IN BUDDINGS OF RRIM 600

Treatment	No. of trees flowered		
	Control (no girdling)	2 mm repeated girdling	16 mm repeated girdling
Control	0	9	6
Dressing with TIBA 1% (wt/vol)	0	8	8
Dressing with ABA 0.05% (wt/vol)	1	7	6
Dressing with coumarine 0.5% (wt/vol)	0	8	3
Dressing with ethephon 0.5% (wt/vol)	0	9	7
Dressing with CCC 1% (wt/vol)	*0*	8	5
Dressing with fungicide (Santa A)	0	5	6
Pruning off lateral roots	2	7	5
Pruning off main roots	0	8	6

Observations were made twenty months after treatment. Number of trees per treatment: 10

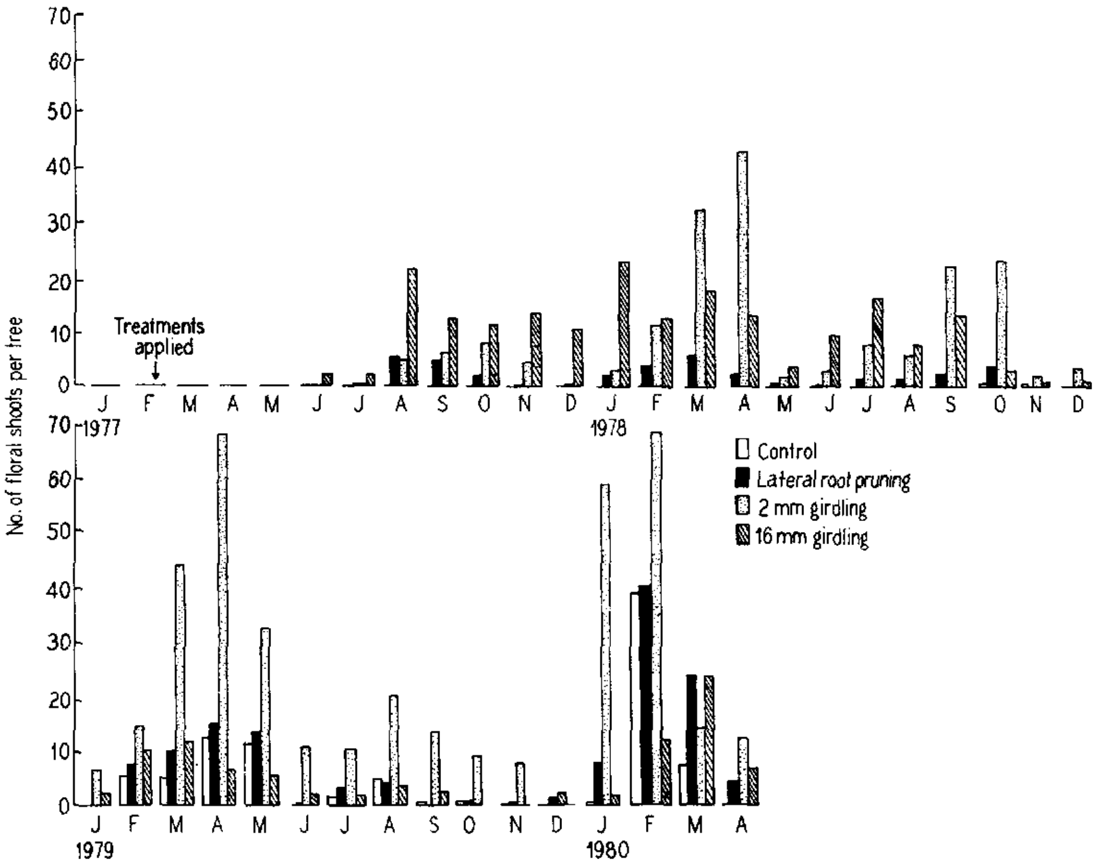

Figure 1. Effects of girdling and lateral root pruning on flowering in RRIM 600. Flowering was first observed in girdled trees in March 1977, but quantitative observations began only in July 1977. Initial number of trees per treatment: 10.

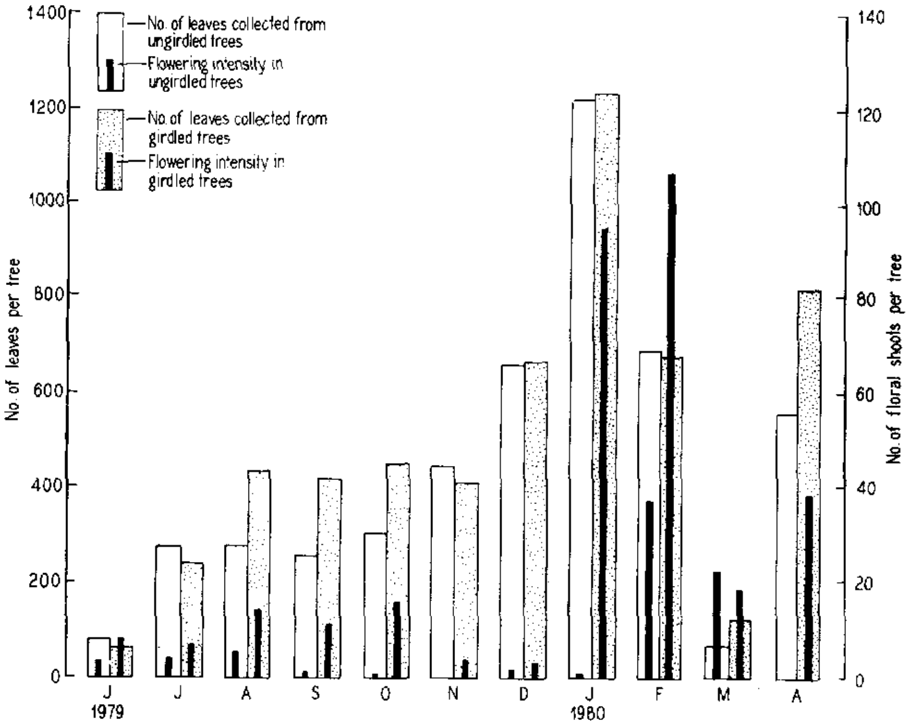

Figure 2. Leaf-fall in relation to flowering in girdled and ungirdled trees in RRIM 600. Number of trees per treatment: 10.

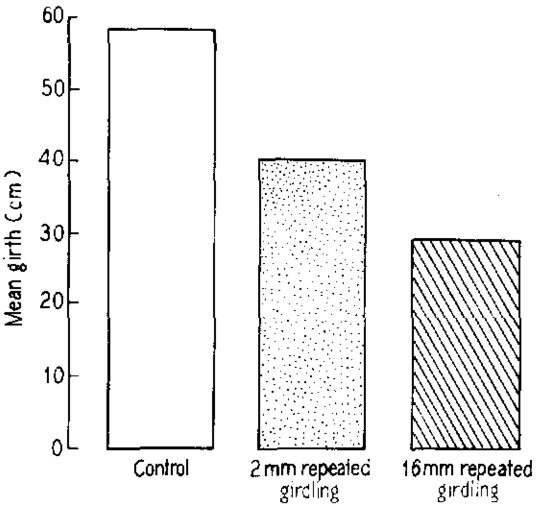

Figure 3. Differences in girth, three years after girdling. Number of trees per treatment: 10.

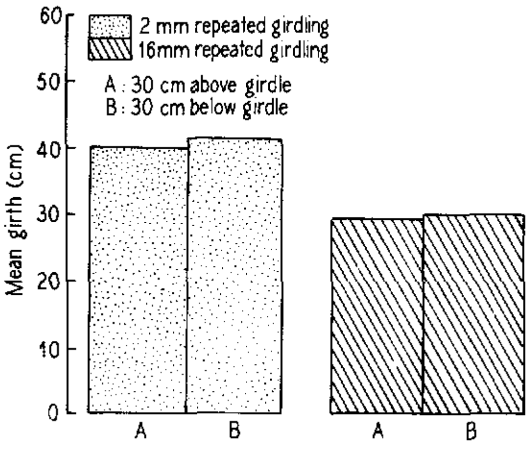

Figure 4. Girth measurements 30 cm above and below the girdle, three years after girdling. Number of trees per treatment: 10.

Figure 5. Bark bursts seen in a 16 mm girdled tree of RRIM 600.

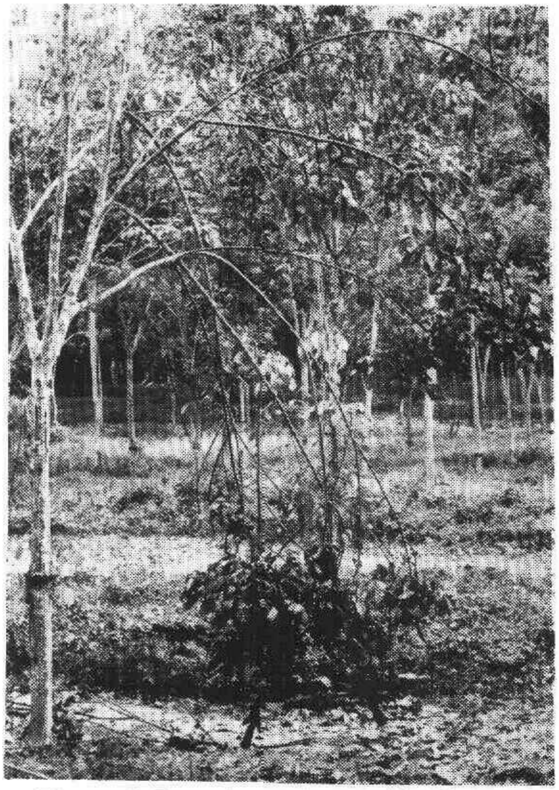

Figure 6. Branch-snap caused by heavy fruiting.

profuse in relation to that in mature trees of the same clone in neighbouring fields. Breakage of branches owing to heavy fruit set was sometimes evident *(Figure 6)*.

Seeds were available for most periods during the third year *(Figure 7)*, and seed viability appeared to be high. Germination of seeds from the girdled trees was com-

TABLE 2. EFFECTS OF GIRDLING ON BARK BURSTS, DIEBACK, TRUNK-SNAP AND ROOT-DISEASE OVER A PERIOD OF THREE YEARS

Item	No. of trees		
	Control	2 mm repeated girdling	16 mm repeated girdling
Bark bursts	0	2	3
Dieback	0	1	2
Trunk-snap	0	0	3
Root disease	1	0	2

Number of trees per treatment : 10

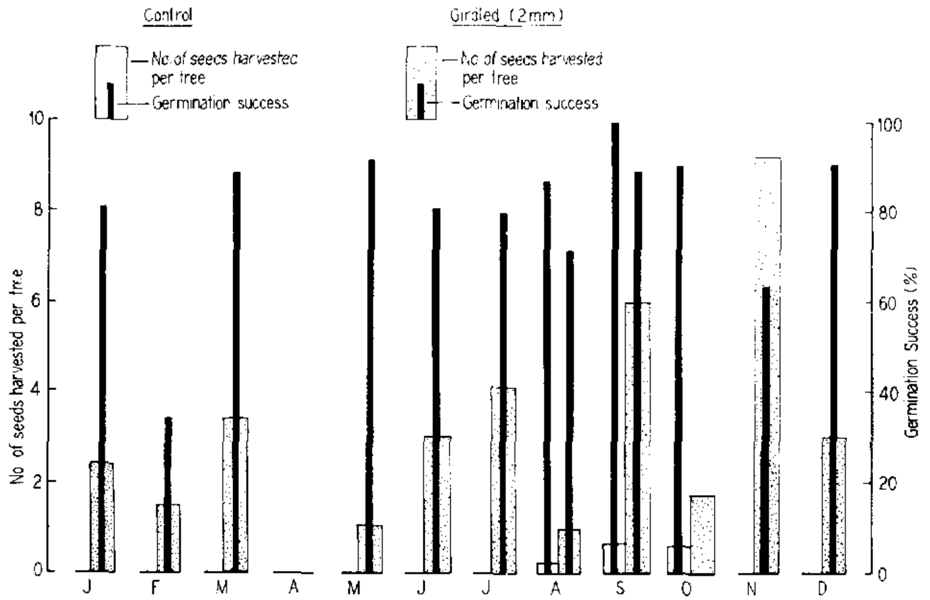

Figure 7. Seed availability and viability in 1979. Initial number of trees observed per treatment: 90.

parable with that of seeds, first available in the second half of the third year, from ungirdled trees. The mean weight of seeds collected during the third year from girdled and ungirdled trees was similar, being 4.3 g and 4.4 g respectively.

Hand pollination was attempted during the third year of flowering on both 2 mm and 16 mm girdled trees with the aid of ladders. The first attempt in September to November in the third year, using male flowers from clone RRIM 701 gave 8% success. A second attempt in January and February of the fourth year resulted in 4.3% success. Seeds that were harvested from the first hand pollination attempt showed germination success of about 50%.

DISCUSSION

The results of this study clearly suggest that it is feasible to use girdled buddings to overcome some of the problems faced in *Hevea* breeding. As induced buddings flower throughout the year it should be possible to overcome problems created by lack of flowering synchrony. Hand-pollination from the ground is evidently also a feasible proposition. An added advantage of using flower-induced trees is that hand pollination can be staggered throughout the year. The hand pollination success on girdled trees compares favourably with that generally evident on mature trees[9]. Disease control, e.g. against *Oidium*, should also be easier on young buddings. Poor disease control on mature trees has sometimes led to lack of male flowers for hand pollination.

This study, though limited to one clone, did reveal some of the likely problems that may be encountered with girdled trees. As the girdled trees are prone to trunk-snap it would be desirable to site any nursery, intended for flower induction purposes, in a wind-sheltered area. To minimise trunk-snap it is evidently essential not to exceed 2 mm wide girdling. Besides, the 16 mm girdled trees showed poorer flowering. When branches are heavily laden with developing fruits it becomes necessary to provide mechanical support.

Despite significant depression of growth, as judged by girthing, girdled trees can evidently be maintained in a state of continuous flowering for at least three years. It appears remarkable that the root system, which can be expected to be severely deprived of photosynthetic assimilates, survived during this period. Intermittent flow of assimilates when the girdles had healed or movement of assimilates through wood parenchyma cells may have sustained the roots. This may also explain the similarity in girth above and below the girdle. Chua[10] observed that ring-barking a *Hevea* tree did not entirely prevent carbohydrates from entering the tapping panel.

The bark bursts that were observed in girdled trees did not lead to tree death. It therefore seemed unlikely that they were caused by micro organisms. The presence of bark bursts only above the girdle suggests that their formation is related in some way with disruption of phloem translocation or hormonal balance.

The cyclical pattern of flowering was evident in the girdled trees even when ungirdled trees had not flowered. This raises the prospect that the flowering rhythm is a reflection of endogenous rhythms which may also operate in later stages of the juvenile phase. Field observations suggest that the intensity of leaf-fall or flowering gradually increases with age. It may thus be plausible that the endogenous rhythm may be more marked with age. Seedlings have so far been relatively more recalcitrant to induction of flowering by girdling. Perhaps the development of the endogenous rhythm may be slower in seedlings than in buddings.

As this study is based on one clone, it would be desirable to extend observations made above to several other clones relevant to current breeding programmes to gain further insight into the degree of flowering and severity of the problems discussed above.

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