MECHANICAL INJURY OF WIND TO RECENTLY TRANSPLANTED CACAO SEEDLINGS AS RELATED TO THE SHADE PROBLEM

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ABSTRACT

Experiments in which cacao (*Theobroma cacao* L.) seedlings were submitted to different combinations of treatments involving protection and exposure to sunlight and wind have shown that the beneficial effect of shading in young cacao areas is due not only to reduced exposure to solar radiation but also to reduced air movement around the plants.

Excessive wind caused severe mechanical injury, at the pulvinus level. Visible damage occurred only 24 hours following exposure to wind. Injury progressed rapidly, leading to intensive leaf fall if the plants were maintained under non-protected conditions.

It is suggested that wind-breaks on their own can give adequate protection to cacao plantations, by providing both lateral shade and wind shelter. This practice might permit the use of a wide range of economic trees for sheltering and would probably lead to higher yield due to higher photosynthesis.

INTRODUCTION

Several field experiments have shown that crop yields were increased considerably when wind-breaks were used (3, 6, 7, 8, 10). Yet, little is known about the plant response to wind or the influence of the wind, alone or in

Received for publication July 25, 1978 and in revised form February 23, 1979.

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combination with other environmental factors, on the physiology of crops. Moreover, present knowledge is almost entirely restricted to studies on the effect of wind barriers on micro-meteorological factors affecting annual crops.

There is also little information about the effects of solar radiation and wind on growth of cacao plants. Although it has been demonstrated that young cacao seedlings can thrive in the absence of shade when moisture stress is avoided by continuous watering (4), in most cacao areas it is virtually impossible to start a new plantation without shading the young plants during the first 2–3 years. This fact has been interpreted as an indication that cacao behaves as a true shade-loving species in its early stages of development. In places with very low light intensity or low potential evapotranspiration, as in some regions of Ecuador, or in areas exceptionally well protected against wind, as in the Colatina valley of Espírito Santo, Brazil, it has been possible to establish cacao plantations without shading the young plants. These, however, are exceptional cases.

After passing the juvenile stage, or when the leaf canopy is sufficiently developed to provide some self-shading, cacao growth and production are usually higher with little or no shade than when plants are shaded(1,2,5,9).

Cacao is very wind sensitive and, in areas exposed to frequent breezes, cannot be grown without wind-breaks. Wind sheltering is a common practice, for example, in Grenada and other cacao producing islands of the West Indies, particularly in places near the coast where strong winds are frequent.

The main effect of excessive wind is to cause defoliation or premature leaf fall. In Brazil, frequent defoliation by wind occurs in Linhares, Espírito Santo, particularly when cacao is grown without or with little shade. However in the nearby valley of Colatina, which is protected by mountains, cacao has been under cultivation without shade for several years and defoliation does not occur. Annual rainfall is about the same in both places (1200 - 1300mm), but in Colatina the mean wind speed is $1 m.s^{-1}$ compared with $4 m.s^{-1}$ in Linhares.

In some parts of Ghana and western Nigeria cacao yield is reduced by dry "harmattan" winds, which blow from the Sahara Desert between December and March. The duration and intensity of this wind vary from place to place, and are important factors in determining cacao productivity.

The present experiment is part of a larger investigation aiming to examine the effects of wind and solar radiation on cacao. Experimental wind-breaks and over-head shade were used in this work, in an attempt to evaluate the relative damages caused by each of these environmental factors on cacao seedlings.

MATERIALS AND METHODS

Cacao (*Theobroma cacao* L.) seedlings about 4 months old were used in three experiments in the present work.

In the first experiment, the seedlings were transplanted to an unshaded area and submitted to three treatments: (a) control plants fully exposed to sunlight and without any protection against wind, (b) lateral protection against wind provided by vertical clear plastic sheets, and (c) the same as "b" but using black plastic sheets. Each wind-break measured 2.0 x 2.0m and protected nine cacao plants spaced 50cm apart. A randomized block design with four replicates was used. The leaf area per plant and the number of dead plants were measured weekly.

The same procedure was adopted in the second experiment, with the difference that two of the four replicates in each treatment received over-head shade provided by a porous black "Saram" shading cloth intercepting 60% of the incident sunlight.

As it was observed that excessive wind caused severe mechanical injury at the pulvinus level, a third experiment was carried out to evaluate the time-course of this event. Seedlings previously growing under well protected conditions were transferred to the experimental area and exposed to the various treatments applied in the second experiment. Tissue rupture in the leaf pulvini was observed on three consecutive days.

RESULTS AND DISCUSSION

Although severe defoliation occurred in all plants used in the first experiment during the first 2 months, presumably due to absence of over-head shade, control plants were virtually decimated, whereas plants protected by the vertically oriented plastic sheets refoliated well (Figure 1). Plants surrounded by black and clear plastic sheets were equally defoliated in the first two months but those protected by black sheets refoliated better, probably because of the development of higher air temperatures around the plants.

The second experiment investigated whether or not the defoliation that occurred in the first experiment was due to the absence of over-head shade. The results (Figure 2) showed that over-head shade was effective in preventing leaf fall only when associated with the use of wind-breaks. Wind sheltering, on the other hand, furnished sufficient protection against defoliation even in the absence of over-head shade. Thus, the plants protected against wind and direct solar radiation did not differ significantly from those exposed to sunlight but surrounded by wind-breaks. In fact, no difference was observed when black plastic sheets were used as

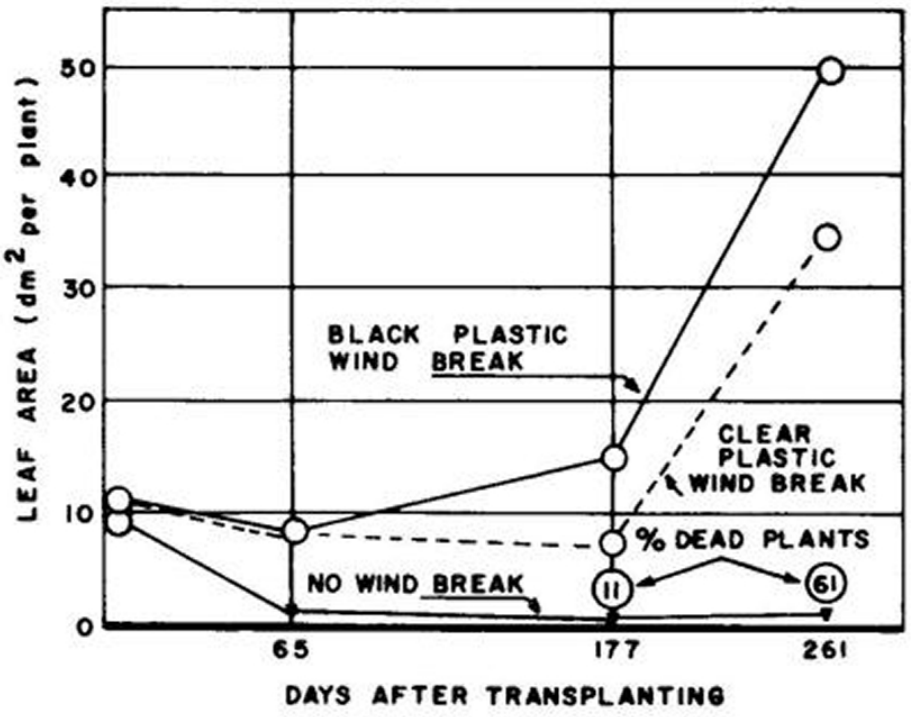

Figure 1 – Effect of black and clear plastic "wind breaks" on leaf area and percentage of dead seedlings, following transplanting to an unshaded site.

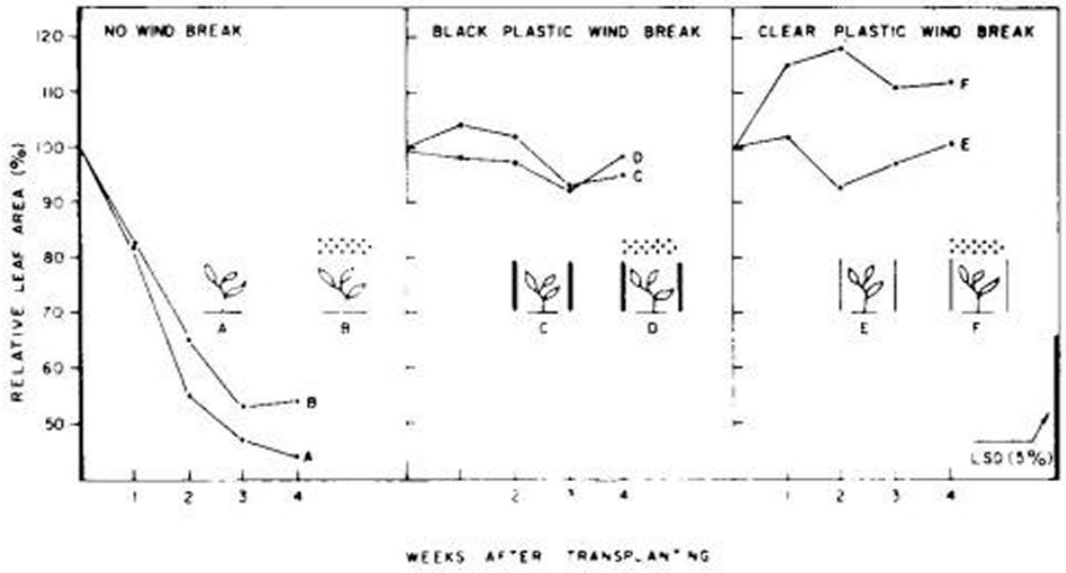

Figure 2 – Interacting effects of black and clear plastic wind breaks and over-head shade on leaf area of recently transplanted cacao seedlings. A – plants fully exposed to sunlight and without wind protection; B – over-head shade, no wind break; C – no shade, black plastic wind break; D – over-head shade, black plastic wind break; E – no shade, clear plastic wind break; F – over-head shade, clear plastic wind break.

wind-breaks. Though not significant, the differences found between wind-protected shaded and unshaded plants (F and E), as well as those observed between non-protected shaded and unshaded plants (B and A) may well be due to the possibility that the shading "Saram" cloth also afforded some wind sheltering.

The high defoliation rate that occurred in wind sheltered plants in the first experiment was probably due to less favorable climatic conditions following transplant.

As previously mentioned, the pulvini situated at the base of the leaf blades suffered severe mechanical injury when the plants were exposed to excessive wind. This tissue, formed by a mass of thin-walled cells, showed visible rupture in its outer layers only 24 hours following exposure to wind. The injury progressed rapidly, attaining the vascular strands within a few days and finally causing leaf fall if the plants were maintaned under non-protected conditions.

Figure 3 shows the percentage of damaged pulvini in the six environmental conditions employed in the third experiment. Control plants fully exposed to sunlight and without any

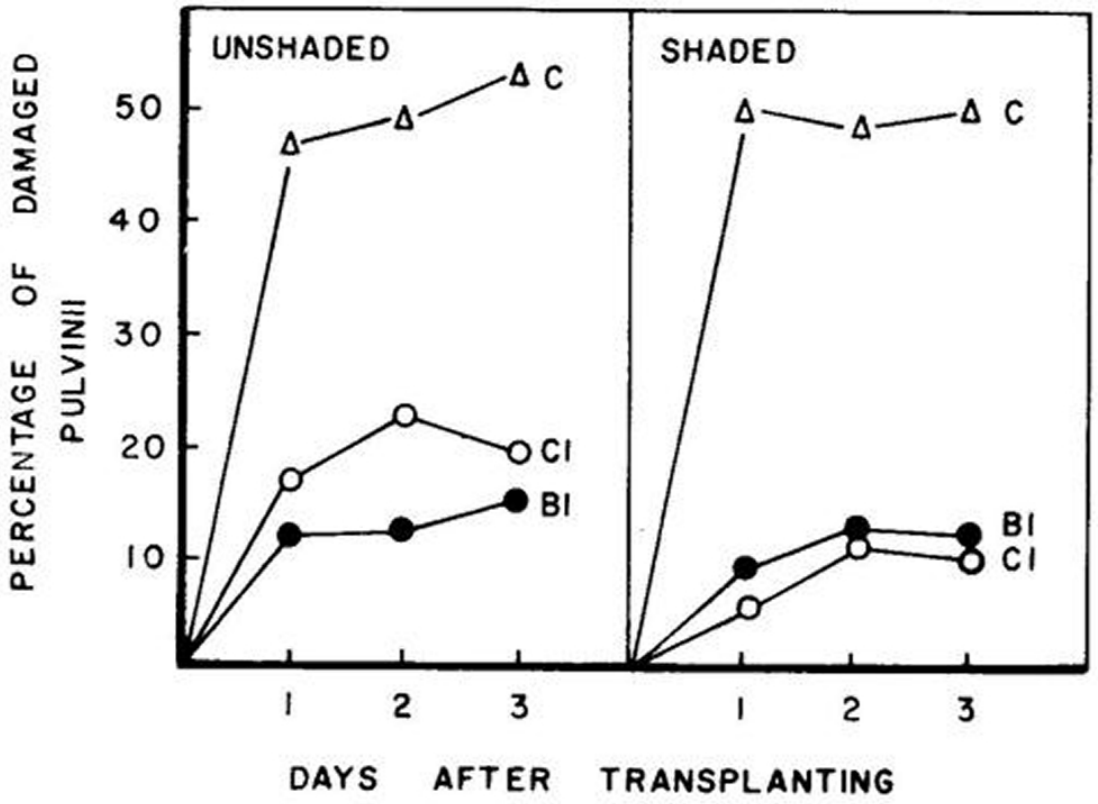

Figure 3 – Mechanical damages of wind to the pulvinii of cacao seedlings following transplanting to shaded and unshaded conditions (C = control plants with no wind break, Cl = clear wind break, and Bl = Black plastic wind break).

protection against wind had nearly 50% of their pulvini showing the initial epidermic rupture on the next day following transplant. When clear plastic sheets were used as wind-breaks, a significant difference in damage was found between plants growing with and without over-head shade, the former being more effectively protected, presumably due to an excessive water loss in the plants which were more exposed to sunlight.

This study indicates that the beneficial effect of shading in young cacao areas is due not only to reduced exposure to solar radiation but primarily to reduced air movement around the plants.

The results found in the present work suggest that wind-breaks on their own can give adequate protection to cacao plantations, by providing both lateral shade and wind shelter.

Through the use of wind-breaks it is foreseen that the cacao plants would grow faster and yield more due to higher photosyntesis. This might permit the use of economic trees for sheltering which had previously not been considered for over-head shading because of the undesirable shape of their canopy.

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RESUMO

Injúria Mecânica do Vento Sobre Mudas de Cacau Recém-Transplantadas com Relação ao Problema do Sombreamento

Experimentos em que plântulas de cacau (*Theobroma cacao* L.) foram submetidas a diferentes combinações de tratamentos, envolvendo proteção e exposição à luz e ao vento, demonstraram que o efeito benéfico do sombreamento de novas plantações de cacau deve-se não somente à exposição a baixas intensidades luminosas, mas também à redução da turbulência do ar em torno das plantas.

Ventos excessivos ocasionaram severa injúria mecânica na região do pulvinulus. Danos visíveis ocorreram apenas 24 horas após exposição ao vento. Os efeitos deletérios progrediram rapidamente, provocando intensa queda de folhas quando as plantas eram mantidas desprotegidas.

Sugere-se que uma proteção adequada pode ser oferecida a cacauais por barreiras periféricas que forneçam sombreamento lateral e redução na velocidade dos ventos, em substituição ao sombreamento de topo convencionalmente uti-

lizado. Tal prática permitiria selecionar maior variedade de espécies econômicas para a proteção ambiental de cacauais e provavelmente conduziria a produtividades mais altas, em decorrência de maior fotossíntese.

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