Wind Effect on Windbreak Establishment in Northern Australia

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Wind effects on the early growth of three species– Callistemon salignus, Eucalyptus microcorys, *and* Melaleuca armillaris *– planted to form windbreaks were examined in a field study on the Atherton Tablelands in north Queensland, Australia. Trees of these species were grown with and without wind protection using* Zea mays *(maize). Wind direction and speed were measured daily at intervals of 2 hours throughout the experiment. Tree angle to ground, height, and crown size were measured at age 5 months, when the maize was being harvested. Trees of each species leaned over as a result of wind. Tree height and crown growth were significantly reduced by wind. Using tall annual crops to protect windbreak trees during establishment is a useful technique.* Tree Planters' Notes 45(2):72-75; 1994.

It has long been recognized that wind causes physical and destructive damage to crops (Bates 1917, Caborn 1957, Bird et al. 1984). Kort (1988) noted that wind causes adjacent leaves to rub against each other, creating various kinds of damage. Strong wind may cause lodging of mature crops (Marshall 1967). Plant physiological processes are also influenced by winds, which cause changes in plant surface temperature and light interception by altering leaf angle (Grace 1988).

Many studies have shown that windbreaks can provide protection from wind and benefit crop growth (Marshall 1967, Kort 1988, Sun and Dickinson 1994). The benefits of windbreaks on livestock are also well documented (Reid and Bird 1990). Because of these benefits, windbreaks have become an important strategy for agriculture management in many areas of the world (Sturrock 1988).

Apart from windbreak design and assessment of the windbreak effect on crops using existing windbreaks, planting and establishment of windbreaks has also attracted some attention. Most of the establishment studies dealt with species selection, site preparation, weed control, and water requirements during the establishment period (Sheikh 1988). However, few studies have been carried out to examine the effect of wind on the establishment of the windbreak itself. Wind that can damage crops may also affect the growth of young trees and thus affect the establishment of windbreaks. It is important to know to what extent this effect would influence the growth of young trees and to develop techniques to improve windbreak establishment in windy areas. The work reported here was undertaken to further our understanding of techniques for establishing windbreaks that are subjected to wind.

Materials and Methods

Callistemon salignus, Eucalyptus microcorys, and *Melaleuca armillaris* were the windbreak tree species. Details of their seed sources are given in table 1. Maize *(Zea mays)* protected these trees with wind protection during their early growth.

The study site was in the middle of an 860- by 760-m (2,824by 2,493-ft) paddock, 2 km (1.2 miles) from Atherton, a town on the Atherton Tablelands in north Queensland (lat. 17/10' S., long. 145/28' E., alt. 710 m or 2,329 ft). The euchrozem soil is used to grow crops of maize, peanuts, and potatoes on a rotation system. The land is flat and exposed fully to winds. According to a long-term weather record from a local weather station, the prevailing wind in this area comes from the southeast and is frequently strong throughout the year.

Maize was planted on an 800- by 220-m (2,624 by 721 ft) rectangular site within the paddock on December 15, 1991. On both the south and north sides of the maize paddock, two windbreaks running east to west (figure 1) were planted on January 9, 1992. Because the prevailing wind was from the southeast, the northside windbreak would be protected by maize while the southside windbreak would not. It would be most ideal to set the maize site and windbreaks perpendicular to the direction of the prevailing wind (Oboho and Nwoboshi 1991), in this case, to the southeast. However, we were limited by the shape of the available study paddock.

Both windbreaks were made up of two rows of trees, one row of *C. salignus* and *M. armillaris* on the windward side and one row of *E. microcorys* on the leeward side (figure 1). The distance between these

Table 1– *Australian tree species used in this shelterbelt establishment study*

Species	Seed source	Lat.	Long.	Altitude (m)	Ann. rainfall (mm)
Callistemon salignus	Pomona	22°20'	152°54'	500	1,500
Eucalyptus microcorys	Connondale	26°47'	152°30'	500	1,000
Melaleuca armillaris	Beerburrum	26°56'	152°57'	32	1,500

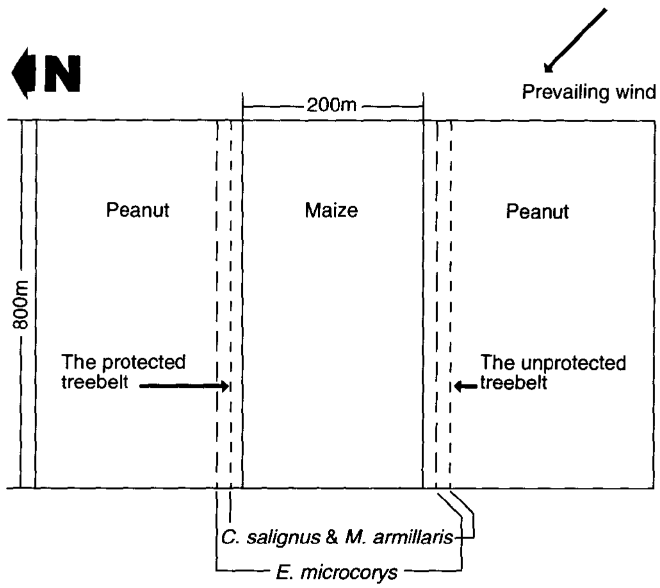

Figure 1—*Layout of the experiment.*

two rows was 2 m (6.5 ft). For each windbreak, 6-week-old seedlings of *C. salignus and M. armillaris* were hand-planted in sequences of 5 trees each, with a 2-m intrarow spacing; seedlings of *E. microcorys* were planted 4 m (13.1 ft) apart. There were 200 trees for each species in each windbreak. The soil was deeply ripped prior to tree planting.

An automatic weather station was located about 2.5 km (1.5 miles) from the study site. Because the study site and weather station were relatively close, with no undulating topography between them, wind direction and speed measured by the station were considered similar to those at the study site. Wind direction and speed were recorded daily at intervals of 2 hours throughout the experiment.

Maize height was observed and recorded during the experiment. Tree height, angle to ground, and tree crown size were measured at age 5 months, when the maize crop was being harvested. In both the protected and unprotected windbreaks, these measurements were taken from 40 randomly selected trees of each species. These randomized trees were chosen in the section starting at 50 m (164 ft) from the eastern boundary and ending at 50 m from the western boundary to exclude any possible edge effects. For each selected tree, two perpendicular cross diameters of tree crown were measured and the product of these two values was used as crown size (m^2). Tree angle to ground was measured using a protractor at 30 cm (1 ft) from the base. An angle of 0/ indicates a completely prostrate tree, whereas an angle of 90/ indicates a straight-standing tree.

The data were subjected to regression analysis (Zar 1984). For each species, tree angle to ground, height, and crown size were also calculated as a ratio by dividing the mean value measured in the unprotected windbreak by that measured in the protected windbreak. The ratio was used to assess quantitatively the protection effect of maize on young tree growth.

Results

Of the 150 days of the experiment, there were 116 days during which wind came from the southeast. Of these 116 days, there were 58 days when the wind reached maximum speeds greater than 20 km/hr, 49 days when it reached speeds from 10 to 20 km/hr, and 9 days when it was less than 10 km/hr.

The maize was 60 cm (23.6 in) tall when trees were planted and grew to 1.4 m (55.5 in) within 2 weeks. The maize attained its maximum height of 2.2 m (86.6 in) at 4 weeks after the trees were planted.

For each species, the mean angle to ground of the protected trees was greater than 80/ while that of the unprotected trees was less than 45/ (figure 2A), and the difference between the protected and unprotected trees was large. All trees leaned towards the northwest. At the end of the experiment, trees in the unprotected areas were straightened and tied to a stake that was inserted vertically beside the tree. This was undertaken to ensure that a good windbreak would be established.

The mean heights of *C. salignus, E. microcorys, and M. armillaris* when planted were 52 ± 1.7 cm (20.5 ± .67 in) (SE), 46 ± 2.2 cm (18.1 ± .87 in) (SE), and 51 ± 1.4 cm

(20.1 ± .55 in) (SE), respectively. At 5 months, the mean heights of the unprotected trees for each species were less than those of the protected trees (figure 2B). *E. microcorys* trees were taller than *C. salignus and M. armillaris* in both the protected and unprotected situations.

The protected trees of each species had a greater tree crown than the unprotected trees (figure 2C). For both the protected and unprotected trees, *E. microcorys* had a greater crown than *C. salignus and M. armillaris.*

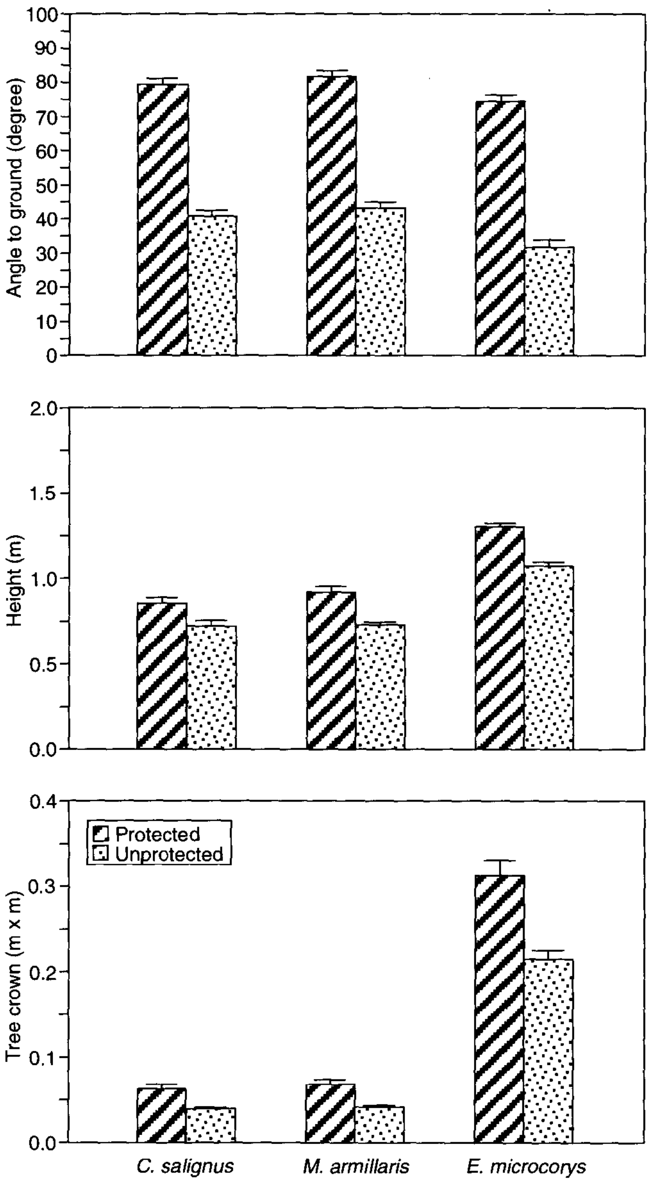

Figure 2—*Mean of tree angle to ground (A), height (B), and crown size (C) of each species in both the protected and unprotected windbreaks.*

No clear signs of physical damage to tree leaves were found.

For each species, the angle to ground of the unprotected trees decreased as plant height increased (figure 3). This negative correlation was statistically significant ($P < 0.001$). There was not a clear correlation for the protected trees ($P < 0.1$). No correlation was found between tree crown and angle to ground for each of the three species for both the protected and unprotected trees, except for *E. microcorys* in the unprotected situation.

Discussion

Because trees in this study leaned markedly in the direction of the prevailing wind, there was little doubt that tree inclination was caused by wind. Protected trees also showed some inclination, probably because they were not effectively protected during the first 2 weeks after planting, when the maize was not yet tall enough to provide effective protection. Wind also affected young tree growth in this experiment, as evidenced by the differences in plant height and tree crown growth between the protected and unprotected trees.

That the wind caused a reduction in plant growth suggests that the establishment of windbreaks in unsheltered areas is likely to be slowed down by wind effect. Because wind resulted in trees leaning towards the ground, the quality of the established windbreaks may be reduced if they are subjected to strong wind during establishment. It is interesting to note that for each species, the angle-to-ground ratio of unprotected trees to protected trees was much greater than the plant height and crown size ratios of the unprotected trees to the protected trees. This suggests that wind may cause a greater negative impact on the quality of the windbreak establishment than on the quantitative growth of trees, at least for the species studied.

Maize provided an important protection to young tree growth from wind effect. The faster growth of the sheltered trees in this experiment may be attributed to a more favorable microclimate provided by shelterbelts, as suggested by Grace (1988). Unlike the physical damage caused by wind on crop leaves (as reported by Kort 1988), the physiological stress caused by wind may be the most destructive for quantitative growth of trees, as suggested by the results for the young trees in this study.

For the same species, wind effect on tree leaning appears to vary with plant height. Taller plants are likely to lean more than shorter trees when subjected

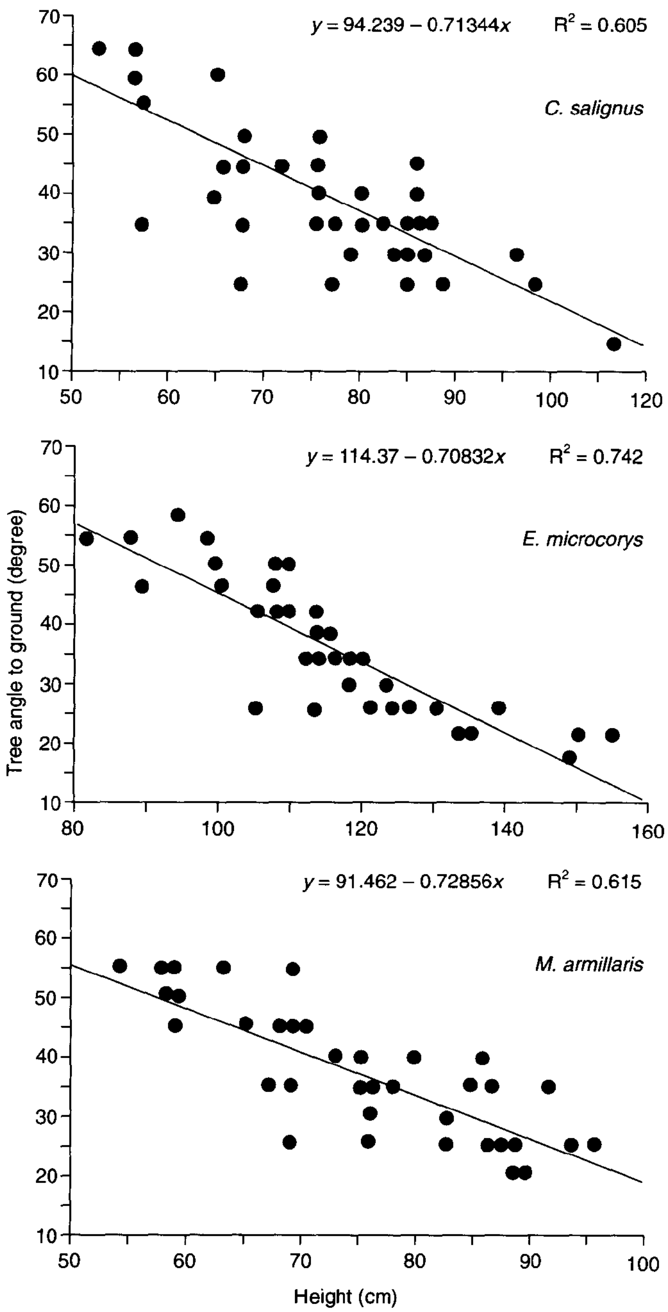

Figure 3—*Correlation of tree angle-to-ground to plant height of Callistemon salignus, Eucalyptus microcorys, and Melaleuca armillaris.*

to wind impact. This suggests that for the same tree species, fast growth may disfavor tree resistance to physical impact of wind. This contradicts the wish of farmers, who normally hope that trees will grow fast in their early stage, thus resulting in the quick formation of windbreaks and thereby reducing labor for maintenance, such as weed control. This controversy may be solved if trees are sheltered when young. Tree crown size of *E. microcorys* appears to be a factor affecting tree leaning when subjected to wind impact. This may be because trees with a greater crown had a bigger leaf surface to receive wind impact and a heavier weight on the tree top. Compared with *E. microcorys,* the tree crowns of *C. salignus* and *M. armillaris* were much smaller. This may explain why their crown size did not affect leaning. It is suggested that plant morphology may play an important role in resisting wind impact, and this idea deserves further studies.

Conclusion

Because windbreaks are generally planted on windy farm lands as shelterbelts, the young seedlings used for these windbreaks will often also be affected by wind. Using tall annual crops to protect windbreaks during their establishment appears to be a useful technique. These established windbreaks will in turn provide protection for crops from wind damage. This reflects a mutually beneficial effect between windbreaks and crop growth in agroforestry systems.

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