# SUITABILITY OF *EUCALYPTUS GRANDIS* AND *E. MICROCORYS* AS WINDBREAK SPECIES IN TROPICAL NORTHERN AUSTRALIA

**D. Sun* & G.R. Dickinson**

*Queensland Forest Research Institute, Department of Primary Industries, P.O. Box 210, Atherton Q 4883, Australia*

*Received February 1995*

**SUN, D. & DICKINSON, G.R. 1996. Suitability of *Eucalyptus grandis* and *E. microcorys* as windbreak species in tropical northern Australia.** A study was conducted on the Atherton Tablelands of tropical north Australia to compare the suitability of *Eucalyptus grandis* and *E. microcorys* for forming windbreaks. Wind speed was measured at various distances from the leeward side of each of the *E. grandis* and *E. microcorys* windbreaks, both 13 years old and consisting of five rows of trees. The species were measured for their height, diameter at breast height (DBH), crown length (between the rows) and width (along the row), number of branches per tree, bole length (height to the lowest branch) and windbreak porosity. The *E. microcorys* windbreak had a uniform porosity both vertically and horizontally while the *E. grandis* windbreak had uneven porosity with some obvious gaps at the base (up to 8 m from the ground). *E. grandis* was significantly taller and longer in bole length but lower in number of branches per tree than *E. microcorys* at age 13 years. Wind speed was reduced more by the *E. microcorys* windbreak than by the *E. grandis* windbreak. *E. microcorys* appears to be a suitable species for windbreaks whereas *E. grandis* does not.

Key words: Windbreaks - *Eucalyptus grandis* - *Eucalyptus microcorys* - wind speed - tropical north Australia - tree growth

**SUN, D. & DICKINSON, G.R. 1996. Kesesuaian *Eucalyptus grandis* dan *E. microcorys* sebagai spesies penahan angin di kawasan tropika Australia utara.** Satu kajian telah dijalankan di Tablelands Atherton di kawasan tropika Australia utara untuk membandingkan kesesuaian *Eucalyptus grandis* dan *E. microcorys* untuk membentuk penahan angin. Kelajuan angin disukat pada pelbagai jarak daripada bahagian terlindung angin setiap penahan angin *E. grandis* dan *E. microcorys*. Kedua-duanya berusia 13 tahun dan mengandungi lima baris pokok. Spesies-spesies telah disukat ketinggian, diameter aras dada (DBH), panjang silara (di antara baris-baris) dan lebar (di sepanjang baris), bilangan dahan sepokok, panjang batang (ketinggian sehingga dahan yang terendah) dan keronggaan penahan angin. Penahan angin *E. microcorys* mempunyai keronggaan yang seragam pada kedudukan menegak dan mendatar sementara penahan angin *E. grandis* mempunyai keronggaan yang tidak sekata dengan jurang yang ketara pada pangkalnya (sehingga 8 m daripada tanah). *E. grandis* adalah ketara lebih tinggi dan lebih panjang di dalam kepanjangan batang tetapi lebih rendah di dalam bilangan dahan sepokok daripada *E. microcorys* pada umur 13 tahun. Kelajuan angin dikurangkan lebih oleh penahan angin *E. microcorys* daripada penahan angin *E. grandis*. Didapati bahawa *E. microcorys* merupakan spesies yang sesuai untuk penahan angin manakala *E. grandis* tidak.

**Present address: Bureau of Resource Sciences, P.O. Box E11, Queen Victoria Terrace, Parkes, ACT 2600, Australia*

## Introduction

It has been well documented that windbreaks could benefit agricultural production by reducing wind damage and hence, they play an important role in agriculture management systems (Marshall 1967, Sturrock 1981, Kort 1988, Sun & Dickinson 1994). On the Atherton Tableland of northeastern Australia, where winds are frequently strong throughout the year, establishing windbreaks on farm land has been considered as an effective agroforestry practice (Sun & Dickinson 1995).

It has been recognised that the effectiveness of windbreaks depends on correct species selection and appropriate design of the windbreak configuration (Sheikh 1988). For species selection, emphasis has been placed on species suitabilities for specific regions and their growth rates. Nicholas (1988) noted that a species suitable for windbreaks should have some of the following characteristics: fast growth; easy to establish; increases (or does not decrease) soil fertility; coppices well and is tolerant of cutting; and produces valuable by-products. Attention has also been paid to porosity distribution, a major factor determining windbreak effectiveness (Marshall 1967), between different species. Loeffler *et al.* (1992) indicated that compared with conifers, hardwood windbreaks are less effective due to their less uniform porosity distribution. They suggested that windbreak management for optimum shelter effect should be aimed to create relatively small pores evenly distributed across the windbreak. However, some characteristics which are likely to influence windbreak porosity such as crown diameter, number of branches per tree, and bole length to the lowest branch have attracted little attention. Information on the species response in such characteristics when planted in windbreaks is vital for species selection.

On the Atherton Tableland, *Eucalyptus grandis* and *E. microcorys* are the two most commonly used species planted to form single species windbreaks because of their fast growth and wood production value. *Eucalyptus grandis* is also a favourable species for windbreaks in other tropical and subtropical areas due to the same reason (Nicholas 1988). However, less is known about their suitability in terms of morphological characteristics and effectiveness when forming windbreaks. To gain this knowledge, we compared two existing windbreaks formed by *E. grandis* and *E. microcorys* in their morphology and effect on reducing wind speed.

## Methods

### *Study site*

The study site was on farm land located about 4 km from Atherton, a town on the Atherlon Tablelands of northeastern Australia (17° 12' S., 145°30' E., altitude 710 m). The site is flat with a red krasnozem soil. The prevailing winds in this area are southeasterly. The average daily maximum temperature in this region is about 32 °C for the hottest months (December, January) and the mean daily minimum temperature for the coolest month (July) is about 10 °C.

On this 500 × 400 m farm paddock, there were two 13-year-old windbreaks, one along the east boundary and one along the south boundary. The east boundary windbreak was orientated north-south and was 500 m long, consisting of five rows of *Eucalyptus microcorys* trees while the south boundary windbreak was orientated east-west and was 400 m long, consisting of five rows of *E. grandis* trees. In both windbreaks, the trees (seed sources unknown) were planted at a spacing of 3 m (inter-row) × 2.5 m (intra-row). Both windbreaks were oriented 45 degrees to the southeast, the prevailing wind direction on the Atherton Tablelands.

### *Measurements and data analysis*

Windbreak porosity was measured using the SCISCAN software developed by the Commonwealth Scientific and Industrial Research Organization . A photograph of the windbreak was taken and scanned into a PC computer using a HS-3000 scanner. The porosity was then calculated using the SCISCAN.

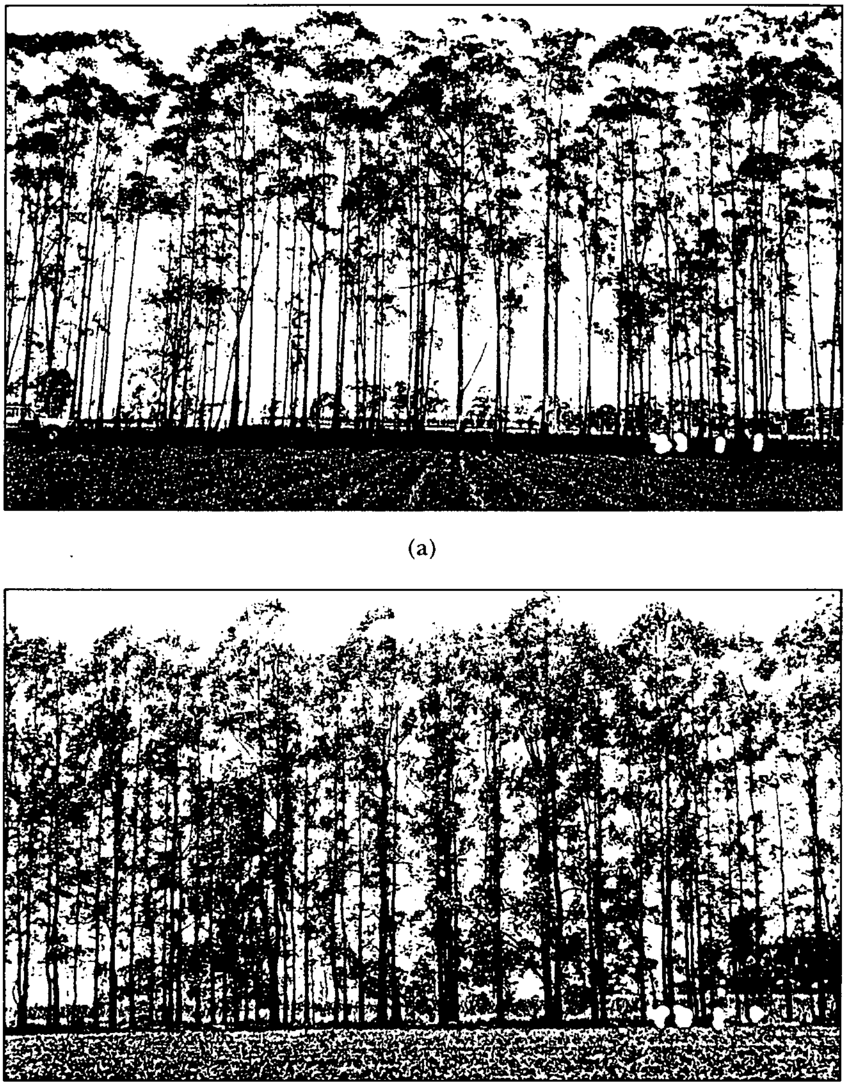
At the leeward sides of both windbreaks, wind speed was measured simultaneously at six positions along a transect perpendicular to the windbreak at 30 minutes intervals for two weeks. The measurements were performed using a GBL-8+8-128 datalogger at a height of 2 m above the ground. As there was only one set of such equipment, the measurements for each windbreak were undertaken at different times, the *E. grandis* windbreak in March 1993 and the *E. microcorys* windbreak in April 1993 . The six positions were at 0.3, 3, 6, 9, 13 and 16 times the windbreak height ($h$) respectively. Wind direction was measured at 13 $h$ every 30 minutes. It was believed that a windbreak could sometimes protect a distance up to 30 $h$ (Marshall 1967). The reason why we did not measure wind speed beyond 16 $h$ was because our main objective was to compare the effect of the two windbreaks, and because the size of the paddock made such measurements impractical.

In both the *E. grandis* and *E. microcorys* windbreaks, measurements of tree height, diameter at breast height (DBH), crown length (between the rows) and width (along the row), number of branches per tree and bole length (height to the lowest branch) were undertaken from 50 randomly selected trees, 10 trees from each row. These randomised trees were chosen in a section starting 50 m from both ends of the tree belts to exclude any possible edge effects. The data measured were statistically tested using the Student's *t*-test (Zar 1984).

## Results

### *Windbreak porosity and wind parameters*

The overall porosity of the *E. grandis* windbreak was 53.4% and that of the *E. microcorys* windbreak was 46.2%. While the base porosity (from the ground to the lowest branch) of the *E. microcorys* windbreak was the same as its overall porosity, the *E. grandis* windbreak had 70% base porosity. Figure 1 shows that there were no big gaps in the *E. microcorys* windbreak either vertically or horizontally while there were some obvious gaps at the base (up to 8 m from the ground) of the *E. grandis* windbreak.



(a)

(b)

**Figure 1.** Photographs of the 13-year-old windbreaks formed by (a) *E. grandis* and (b) *E. microcorys*

Throughout the period of the wind speed measurement, 92% of the wind came from the southeast. Wind speed which was averaged using only the southeast wind data, increased with the increase in distance from the windbreak (Figure 2). The data of wind speed at 16 *h*, the furthest position from the windbreak in the present study, indicated that wind strength was similar during both the *E. grandis* and *E. microcorys* windbreak measurement periods. Overall, wind speed was reduced more by the *E. microcorys* windbreak than by the *E. grandis* windbreak (Figure 3), particularly for the maximum wind speed which was reduced by 47% at 3 *h* by the former and 14% by the latter.

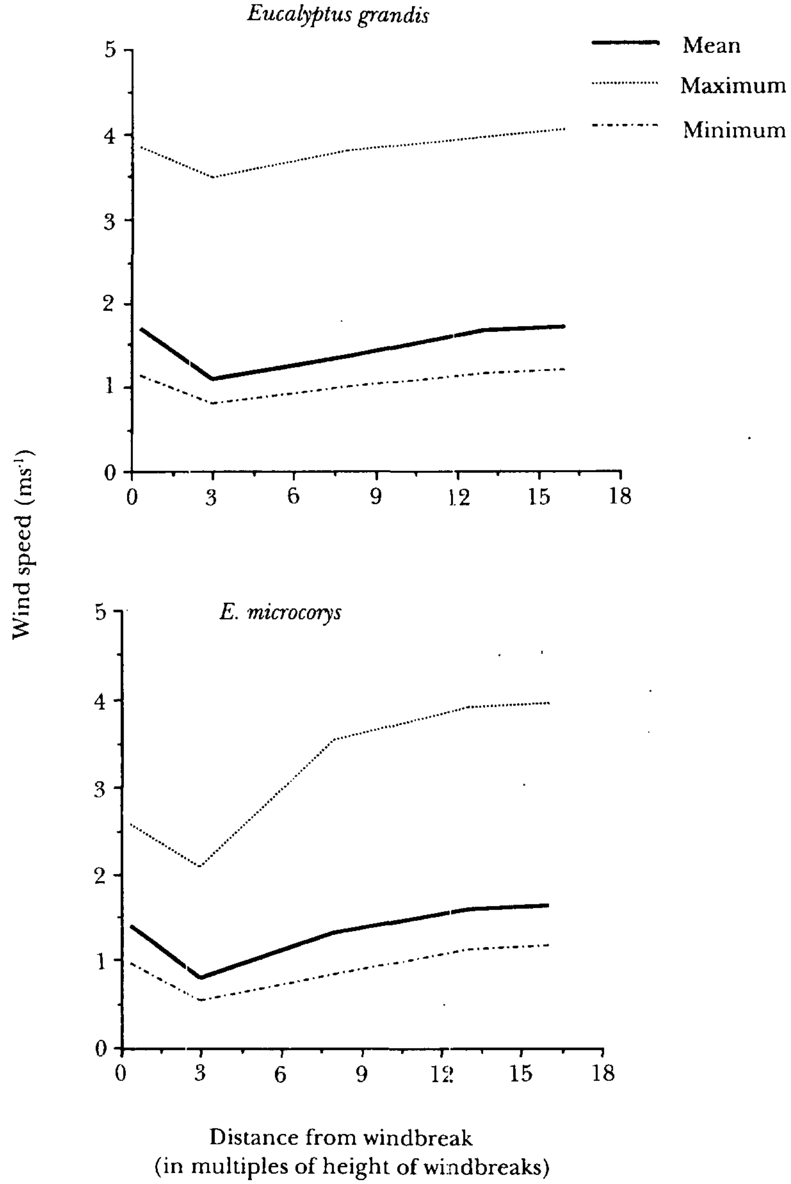



**Figure 2.** Wind speed (m s$^{-1}$) at a height of 2 m above ground versus distance along the perpendicular line from the windbreak on the leeward side

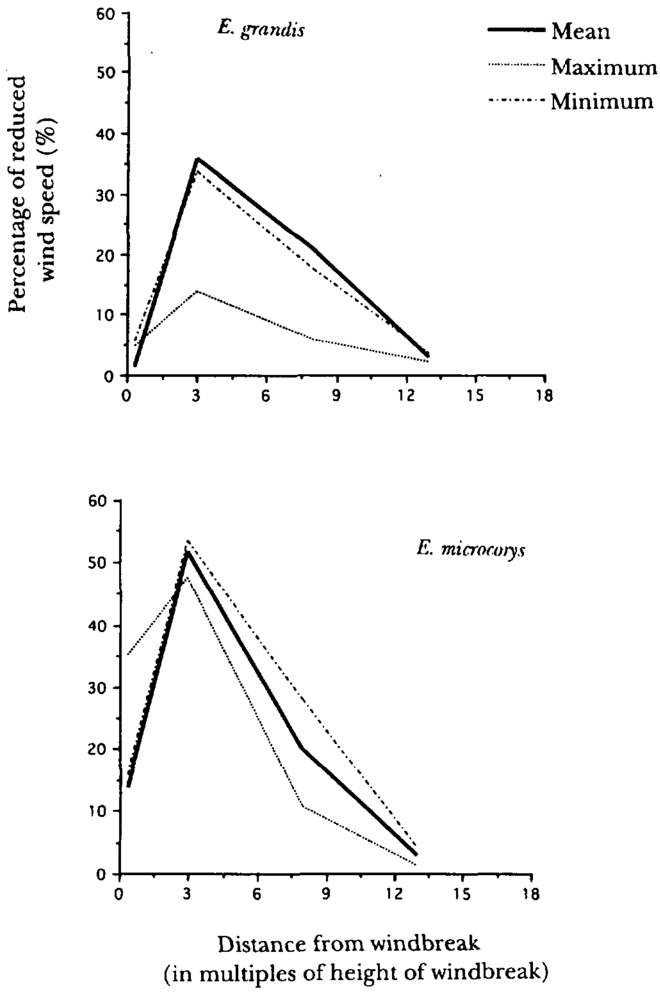



**Figure 3.** Percentage of reduced wind speed along the perpendicular line from the windbreak on the leeward side

## *Free growth*

Both species were >20 m tall at age 13 years with straight trunk and good tree form. *Eucalyptus grandis* was significantly ($p<0.001$) taller and longer in bole length than *E. microcorys* (Figure 4a). The ratio of bole length to tree height was 0.40 for *E. grandis* and 0.04 for *E. microcorys*. Compared with *E. grandis*, *E. microcorys* also had a significantly higher number of branches per tree, but a lower DBH (Figure 4b).

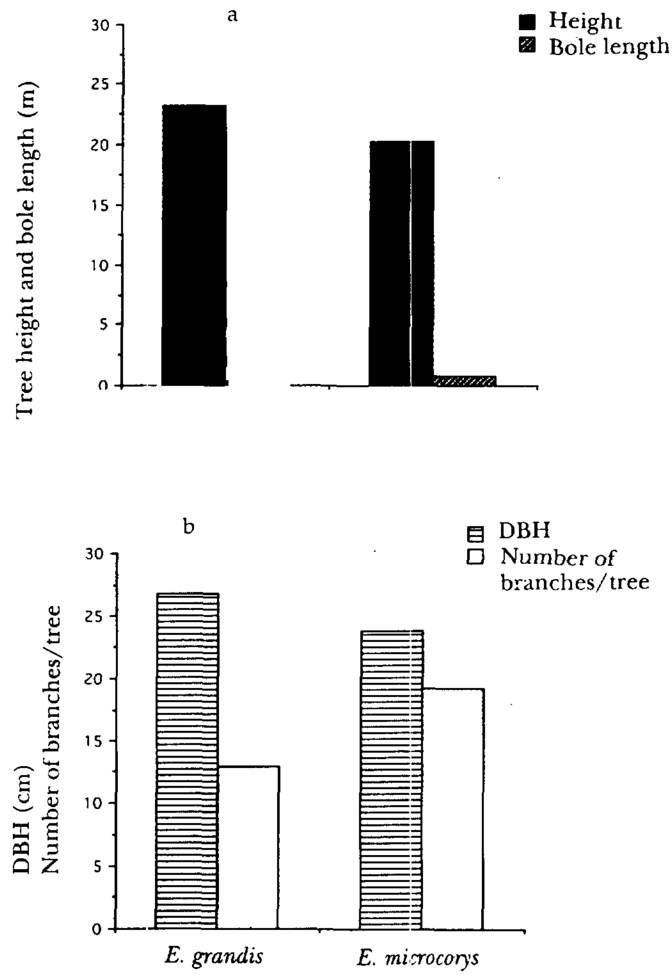



**Figure 4.** Tree growth of *E. grandis* and *E. microcorys* in windbreaks measured at age 13 years: (a) tree height and bole length, (b) DBH (diameter at breast height) and number of branches per tree

There was a significant ($p<0.05$) difference in crown length and width between the two species. Overall, the crown length and width of *E. grandis* were higher than those of *E. microcorys*, with the difference between the two species being the biggest for row 1 (leeward), compared with the other pairs of rows (Figure 5). For each species, trees in all rows had longer branches on the leeward side than on the windward side, and trees in row 1 had the significantly highest crown length and width among the 5 rows (Figure 5).

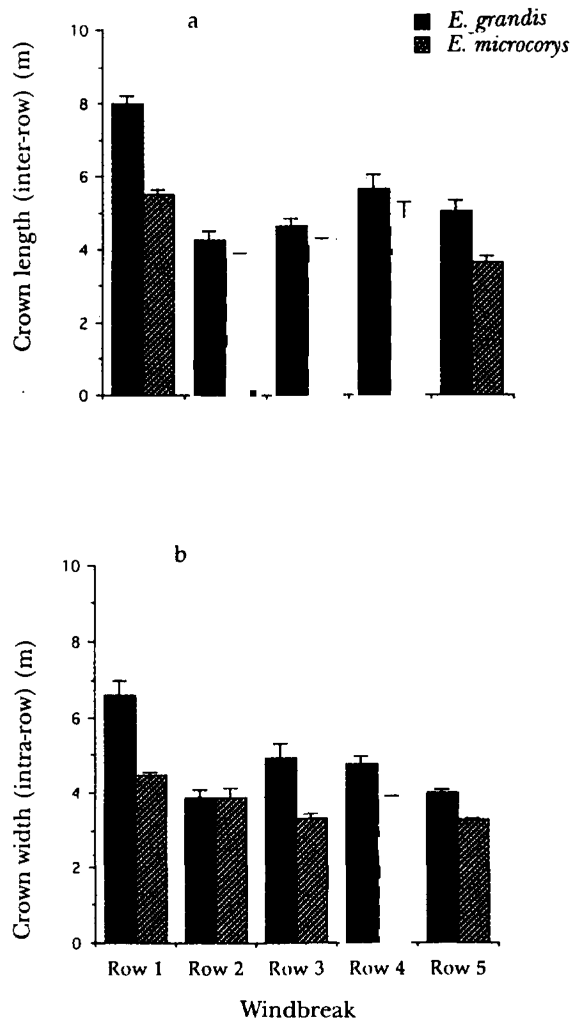



**Figure 5.** Tree crown growth of *E. grandis* and *E. microcorys* in windbreaks measured at age 13 years: (a) crown length (between rows), ( b) crown width (along the row). Bars are standard errors.

## Discussion

Both *E. grandis* and *E. microcorys* had a fast growth in height and DBH. As the shelter distance of windbreaks increases with the increased windbreak height (Marshall 1967), this fast growth habit can allow a considerably long shelter distance to be achieved within a shorter time than other slower growing species.

Although the overall porosity of the *E. grandis* windbreak in the present study was close to the optimum range of 40-50% as suggested by Marshall (1967), the porosity of the section from the ground to 8 m in height far exceeded the optimum range. The fact that *E. grandis* was unable to maintain low branches explains the reason for the large gaps at the base. According to Loeffler *et al.* (1992), large gaps at the base of a windbreak would result in increased windspeeds through and immediately behind these gaps, which would be more damaging than if no windbreak existed (Marshall 1967). The fact that for the *E. grandis* windbreak, wind speed at 0.3 *h* was similar to that at 16 *h*, may, to some degree, prove this. We, therefore, suggest that *E. grandis* is not suitable for single species windbreaks. It may, however, be planted in combination with other species. For example, the system of one or more rows of *E. grandis* with a row of species which have low branches would improve the windbreak uniformity of porosity distribution.

Compared with *E. microcorys*, *E. grandis* had a larger crown diameter which extended into the paddock on the leeward side with a greater distance. This indicates that *E. grandis* is likely to cause a larger shading effect on nearby crops than *E. microcorys*. Because tree belt shading is one of the main factors causing the reduction of the yield of nearby crops (Stoeckeler 1962, McMartin *et al.* 1974, Bird *et al.* 1984), *E. grandis* suitability even for multispecies windbreaks is questionable. In contrast, *E. microcorys* had a uniform porosity distribution both vertically and horizontally in the windbreak due largely to its capacity of keeping low branches. It is suggested that bole length to the lowest branch is an important criterion for windbreak species selection and species which are able to keep their low branches at maturity are more suitable for windbreaks than species with high branches.

## Conclusion

Although both species studied had similar growth rate and good tree form, *Eucalyptus microcorys* appears to be a suitable species for windbreaks while *E. grandis* does not. The height of the lowest branch and crown diameter should be considered as among the most important criteria for windbreak species selection.

## Acknowledgment

We would like to thank Ian Alan on whose property this study took place.

## References

BIRD, P.R., LYNCH, J.J. & OBST, J.M. 1984. Effect of shelter on plant and animal production. *Proceedings of the Australian Society of Animal Products* 15 : 270 - 3.

KORT, J. 1988. Benefits of windbreaks to field and forage. *Agriculture, Ecosystems & Environment* 22/23 : 165 - 90.

LOEFFLER, A.E., GORDON, A.M. & GILLESPIE, T.J. 1992. Optical porosity and windspeed reduction by coniferous windbreaks in Southern Ontario. *Agroforestry Systems* 17: 119 - 33.

MARSHALL, J.K. 1967. The effect of shelter on the productivity of grasslands and field crops. *Field Crop Abstracts* 20 : 1 - 1 4.

MCMARTIN, W., FRANK, A.B. & HEINTZ, R.H. 1974. Economics of shelterbelt influence on wheat yields in North Dakota. *Journal of Soil and Water Conservation* 29 : 87 - 91.

NICHOLAS 1988. Plantings in tropical and subtropical areas. *Agriculture, Ecosystem Environment* 22/23: 465 - 82.

SHEIKH, M.I. 1988. Planting and establishment of windbreaks in arid areas. *Agriculture, Ecosystem & Environment* 22/23 : 465 - 23.

SUN, D. & DICKINSON, G. R. 1994. A case study of shelterbelt effect on potato (*Solanum tuberosum*) yield on the Atherton Tablelands in tropical north Australia. *Agroforestry Systems* 25: 141 - 51.

SUN, D. & DICKINSON, G. R. 1995. Effect of wind effect on the early growth of five tree species planted to form windbreaks in northern Australia. *Journal of Tropical Forest Science* 7: 645 - 656.

STOECKELER, J.H. 1962. *Shelterbelt Influence on Great Plains Field Environment and Crops.* U.S.D.A, Products Research Report No. 62. 26 pp .

STURROCK, J.W. 1981. Shelter boosts crop yield by 35 percent: also prevents lodging. *New Zealand Journal of Agriculture* 143: 18 - 9.

ZAR, J.H. 1984. *Biostatistical Analysis.* Englewood Cliffs, N.J.