Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231-6345 (Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jls.htm
2014 Vol. 4 (2) April-June, pp.568-575/Amiri and Taei

Research Article

EFFECTS OF *ZIZIPHUS SPINA* TREE AS BIOTIC SHELTERBELT ON WIND SPEED FLUCTUATIONS IN AGRO ECOSYSTEMS

***Iraj Amiri and Javad Taei**
Agricultural and Natural Resources Department, University of Jiroft, Jiroft, Kerman, Iran
** Author for Correspondence*

ABSTRACT
Windbreaks have been used for centuries to shelter crops from wind damage and to protect soils from wind erosion. This study was performed in 5 steps to evaluate the effects of biotic and abiotic windbreaks on mean horizontal flow and turbulent velocity fluctuations under field conditions. These steps included of granolometery analyzing, determination of field threshold velocity of soil erosion, estimation of acceptable wind speed, optimizing windbreak distance and wind speed recording. Two kinds of windbreaks were used in this study, include of biotic windbreak (*Ziziphus spina christi*) with 85% density and abiotic windbreak (Mud wall) with 100% density. Results of field experiment showed that optimized distances for abiotic and biotic windbreak are respectively observed at 7.87h and 4.5h after windbreak. Finally mud wall is applicable for high decreasing wind speed at the back of windbreak but its high wind speed fluctuation and high turbulent were limited these windbreak in agro ecosystem. *Ziziphus spina christi* with 85% density is applicable for medium decreasing of wind speed and creating low turbulent after windbreak.

***Keywords**: Mud Wall, Ziziphus Spina Christi, Threshold Velocity, Windbreak, Wind*

INTRODUCTION

Windbreaks are barriers used to reduce and redirect as wind blows against a windbreak, air pressure wind. They usually consist of trees and shrubs, but builds up on the windward side (the side towards the may also be perennial or annual crops and grasses, wind), and large quantities of air move up and over the fences, or other materials. The reduction in wind speed top or around the ends of the windbreak. Artificial porous windbreaks are now in widespread use for many purposes. Several types of porous windbreak are available (e.g., wooden-slotted snow-fence, plastic mesh and mud wall), and without exception, these are manufactured so as to give a uniform distribution of porosity with height. That a windbreak should be porous in order to prevent the creation of an intensely turbulent wake is beyond dispute. However, even a very porous windbreak, while not causing a lee-side recirculation zone, does cause increased levels of turbulence in a region of the leeward flow as a result of advection and diffusion of kinetic energy away from a region of strong shear-production just above the fence (Raine and Stevenson, 1977; Cleugh, 1998). The interaction between the windbreak and the airflow is complicated by the turbulent characteristics of the wind and by the complex behavior caused by natural obstacles. Although much effort has gone into the measurement and characterization of wind flow in the lee of wind barriers and isolated obstacles at a range of scales, relatively little attention has been given to the direct interaction of the air with the individual plants that can be characterized by a drag coefficient. Our understanding of wind interaction with three-dimensional, porous obstacles, however, such as tree windbreaks and isolated trees and shrubs, is much less complete (Heisler and DeWalle, 1988). The consequence of this lack of knowledge results in the use of surrogate data in models. For example, Raupach (1992) and Raupach *et al.,* (1993), by necessity, use drag coefficients of solid roughness elements reported by Taylor (1988) to represent natural, porous vegetation. Furthermore, the very causes of wind-speed reduction, pressure perturbation related to width and structure, permeability and drag force, are largely unknown for three-dimensional, porous obstacles (Wang and Takle, 1996). Wind condition were measured around four different shelterbelts during an extensive measurement program carried out in jiroft (Iran) in 1997and 1998. The main purpose was to compare the shelter effect of different types of shelterbelts under the same weather conditions (Lindholm *et al.,* 1988). Besides windbreak height and porosity, the actual form of the wind

speed curve depends on other important characteristics of the airflow–windbreak system. These are the approach flow characteristics, such as wind speed, wind direction, turbulence intensity, and atmospheric stability, and external windbreak properties, such as windbreak shape, width, and length (Heisler and Dewalle, 1988). The effects of these factors are important but often contradictory, and they are seldom defined analytically (Cleugh, 1998; McNaughton, 1988; Heisler and Dewalle, 1988). The evaluation of properties of different windbreaks and its effects on turbulent velocity fluctuations is very important and necessary for designing suitable windbreak for agro-ecosystems in any climatic conditions. The choice of tree species and shrub species adapted to create a wind break should be used in ecological conditions.
Lotus due to low water needs, drought resistance, nitrogen fixation ability and hard and drought conditions are suitable for dry areas and can live as a suitable windbreak for the conditions used. This study was performed to improving agro ecosystems under arid climatic conditions. Windbreak could improve crop yields, soil stabilization, and evaporation but these effects related to kinds of windbreaks and its planning over the agro-landscapes. Windbreaks are barriers used to reduce and redirect wind. They usually consist of trees and shrubs, but may also be perennial or annual crops and grasses fences, or other materials. The reduction in wind speed behind a windbreak modifies the environmental conditions or microclimate in the sheltered zone. Mud wall as abiotic windbreaks with 100% density cause to create high turbulent in the back of the windbreak. This turbulent cause to increase the soil erosion. So we don't suggest this kind of wind break for sensitive soil in arid conditions. The objectives of this study were to determine: (1) Comparative Study of *Ziziphus spina* as biotic windbreaks against abiotic wind break with 0% porosity on wind speed changes (2) estimation of optimal distance between parallel windbreak to reduce soil erosion in the space between.

MATERIALS AND METHODS

Field Study

The case study was Jiroft catchment which located between 28° 33' N and 28° 85'N latitudes and between 57°43'E and 57° 85'E longitudes in East south of Iran. The climate of this region is sub humid with warm summer and moderate winter (UNESCO, 1979). In the Jiroft station average temperature is 25˚C, and annual rainfall is 150mm which 85% is concentrated in the winter and autumn seasons and 15% in the spring. Average of maximum velocity of dominant wind has been 54 km per hour. The forestry and rangelands covered 320000 and 1467517 hectares respectively.

Granolometery Analyzing

This step was performed in order to estimate threshold velocity of wind erosion. Threshold velocity is defined the minimum velocity which causes to move soil particles. For evaluation this parameter, the soil samples were collected from 0-20cm depth. Soil samples were powdered and categorized them according to ASTM (American Society for Testing and Materials International. GR (Graph software) was used to determine of granolometery index and soil texture.

Determination of Field Threshold Velocity for Soil Erosion

Threshold velocity was determined base on Ekhtesasi method (1993) using wind erosion meter (wind tunnel-Field Model W.E Meter), which made in Iran (Ekhtesasi, 1993). As this method described, 7 kilogram of powdered soil, was putted into wind tunnel (figure 1) then the minimum speed which able to raise soil particles was recorded as threshold velocity (Ekhtesasi, 1993). Von Karman method (1921) which described follow was used to converting tunnel threshold velocity of soil erosion to field threshold velocity of soil erosion.

$V_{2(\frac{m}{s})} = V_{1(\frac{m}{s})} \times (H2/H1)^{0.16}$ (equation1)

V1= tunnel wind speed; V2= field wind speed which estimated above 10 meters of ground surface; (H2= standard for field wind speed estimation that is 10 m (Ekhtesasi, 1993); H1= for wind erosion meter was 0.2 meter (Ekhtesasi, 1993).

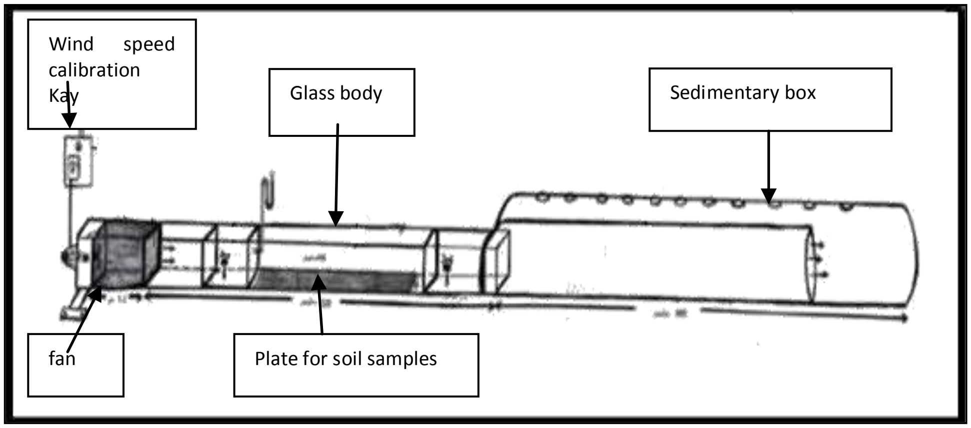

Figure 1: Wind erosion meter (wind tunnel-Field Model W.E Meter), Iran (Ekhtesasi, 1993)

Estimation of Acceptable Ratio of Wind Speed

In this step acceptable wind speed ratio was estimated using equation (2). Acceptable ratio of wind speed is defined as ratio of threshold velocity (which estimated in step2) to maximum velocity (which estimated from long term wind data of Jiroft climatology station). Acceptable ratio show how much of wind speed should be decease which will not cause to soil erosion (Amiri, 2007). This ratio was applied for each windbreak to determine acceptable ratio of wind speed. Base of equation (2) optimized parallel windbreak distance was estimated.

and means the amount of wind speed which

Acceptable ratio = $(V_e / V_m) \times 100$ *(equation2)*

V_e: field threshold velocity of wind erosion soil

V_m: maximum of wind speed

Optimizing Windbreak Distance

This step determines the location of the next rows of the windbreak base on soil texture, threshold velocity of wind erosion soil and acceptable wind speed. The next rows were located in distance from previous windbreak where wind speed increase above acceptable wind speed.

Wind Breaks Wind Recording

Two kinds of windbreaks were used in this study, include of biotic windbreak (*Ziziphus spina christi*) and abiotic windbreak (Mud wall) (table1). Wind velocity was recorded in front of windbreaks at -20, -1, 1, 2,3,4,6,8,10,11,12,16 and 18 times distances of its height and 1 meter above ground level. Wind speed was recorded in 3 replications using Digital Anemometer (General DAF. 2005. MDL).

Table 1: Characteristics of studied windbreaks

Windbreak	Height of windbreak	Density
abiotic wind break (Mud wall)	2 meter	0% porosity
biotic wind break (*Ziziphus spina christi*)	3/3meter	15% porosity

Figure 2: View of Mud wall wind break which used in this study as an abiotic windbreak

Figure 3: View of Ziziphus spina christi wind break which used in this study as a biotic windbreak

RESULTS

Results of step1 -4 are presented in table 2. Base on Ekhtesasi method (1993) the threshold wind velocity in the wind tunnel was recorded 4m/s. This velocity was converted to field velocity using Von Karman method (1921).

$4\text{m/s} \times (10/\ 0.2)^{0.16} = 7.5\text{m/s} = 27\text{km/h}$

So according to average of maximum wind speed which recorded in meteorological data (54km/h) the acceptable ratio of wind speed was calculated as follow:

$Ve/Vm = (27^{\text{km/h}}/54^{\text{km/h}}) \times 100 = 50$ percentage of maximum wind speed (Vm).

Table 2: Results of step1 to 4

Step1	Step2		Step3	Step4 for abiotic wind break	Step4 for biotic wind break
Soil texture	**Threshold velocity of soil erosion**	**Average of max wind speed**	**Acceptable ratio of wind speed (%)**	**Optimizing windbreak distance**	**Optimizing windbreak distance**
Medium sand	7.5 m/s	15m/s	50% of the initial wind speed	8h (16m)	3h (=12m)

Table 3: Some characteristics of the studied areas varied

Type carminative	percent And the concentration of density	Effective height	Wind	date	Harvest season	The time field	Temperature
Lotus	85% - density	3/3 m	South to North	20/06/13 87	summer	5pm	36 ° C

Mudwall windbreak distance was optimized according to acceptable wind speed (50% of the initial wind speed) and the field experimental result which presented in table 2. Wind speed decreasing in the distance of 6h and 8h was respectively 15.27% and 77.2% of initial wind speed. Using interpolation 50% wind speed decreasing of initial wind speed will occur in 6.87h (which approximately equal to7h). According to table3 the distance of 1h back of windbreak, the wind speed was lower than estimated threshold (50% of the initial wind speed) so this was added to 7.87h (1h+6.87h) for estimating the location of next windbreak (Figure 2).

Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231-6345 (Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jls.htm
2014 Vol. 4 (2) April-June, pp.568-575/Amiri and Taei
Research Article

Table 4: means and standard deviation of wind speed due to distance from wind break

Distance from wind break	*Ziziphus spina christi*	Mud wall
-20	100±2.64	100±2.7
-1	77.56± 2.55	48.9±2.8
1	41±3.51	13.7±4.24
2	43±3.1	8.65±4.26
4	71.6±2.02	38.9±3.88
6	79.2±3.1	15.3±3.81
8	86.21±3.2	77.2±4.03
10	88.8±4.03	50±2.41
12	94.86±4.02	59±2.40
14	100.9±5.02	75±2.85
16	103.46±3.01	86.98±4.03

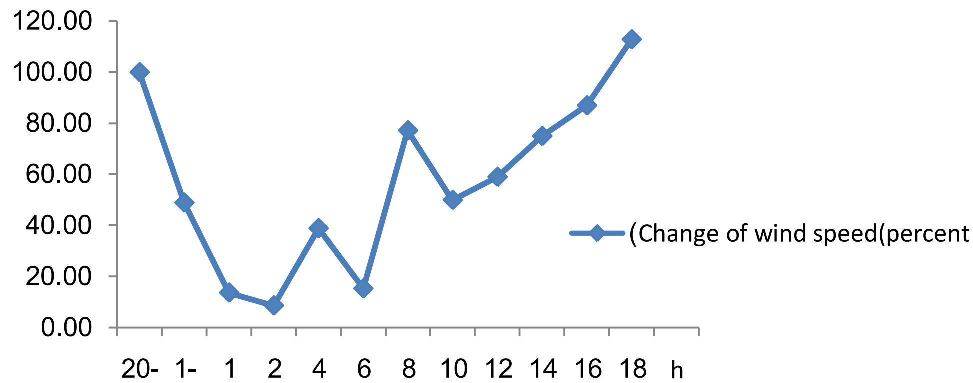

Figure 4: wind speed fluctuations around windbreak zone of Mud wall

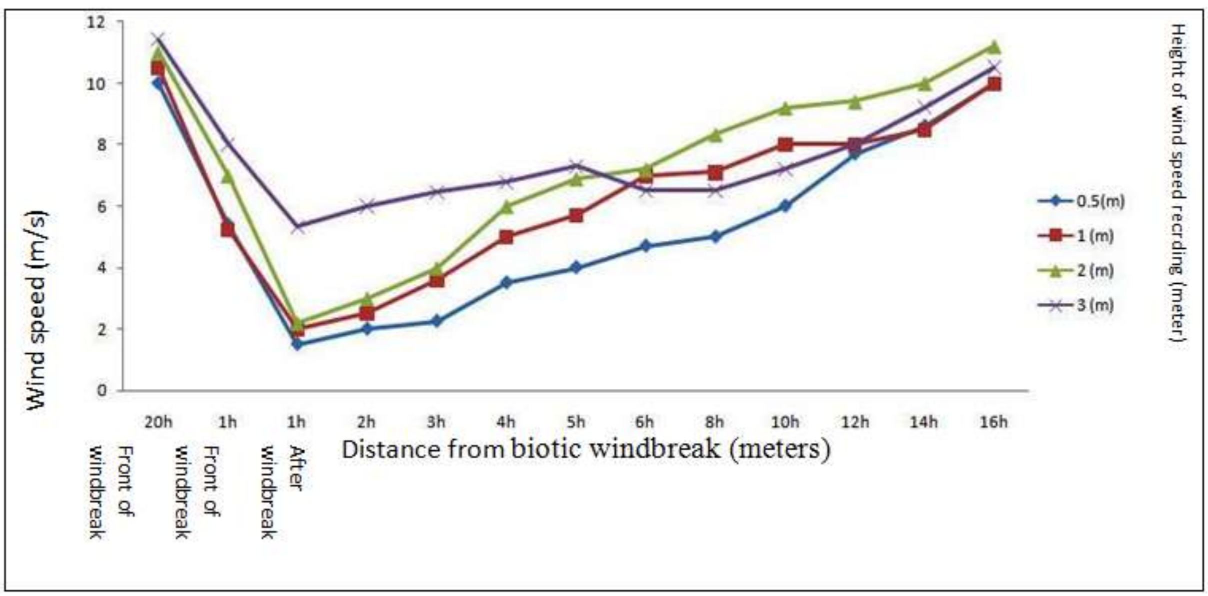

Figure 5: wind speed fluctuations around windbreak zone of *Ziziphus spina*.

So in order to control of soil erosion or decreasing wind speed under estimated threshold the next windbreak should be set in distance of 7.87h from previous windbreak. Turbulent velocity fluctuations of abiotic windbreak (mud wall) with density of 100% compressed was shown in figure 4 (table 3). *Ziziphus spina christi* was studied as biotic windbreak in this research. Windbreak distance was optimized according to estimated acceptable wind speed (50% of the initial wind speed) and the field experimental result which presented in Table 4. Wind speed decreasing in the distance of 2h and 4h was respectively 43% and 71.6% of initial wind speed. Using interpolation 50% wind speed decreasing of initial wind speed was estimated in 3.5h. According to Table 4, at the distance of 1h back of windbreak, the wind speed was lower than estimated threshold (50% of the initial wind speed) so this was added to 4.5h (1h+3.5h) for estimating the location of next windbreak. So in order to decreasing wind speed under estimated threshold the next windbreak should be set in distance of 4.5h from previous windbreak. Turbulent velocity fluctuations of biotic windbreak (*Ziziphus spina christi*) with density of 85.5 uncompressed was shown in figure 5 (table 3).

DISCUSSION

Evaluation of non-living mud wall as a carminative (Figure 4), between 1 and 2 times the maximum wall height, wind speed reduction has occurred. The results also Negli reports about non-living windbreak is different. This is probably due to the density difference of the mud wall. Wind speed at a distance of 4 times the height carminative rapidly increased and then decreased at a distance of 6 times the height. At intervals of 8, 10, 12, 14, 1 and 18 times the height of the wind break wind speed increased. This turbulence causes fluctuations and 100% density and roughness of the surface of the earth wall is carminative. It is noteworthy that the wind speed reversible compressed earth wall at a distance of less than carminative happened next. And this difference to the difference in density and lotus flower wall is carminative. Based on the results of these experiments (Figure 5), the largest drop in wind speed at a height of 1 m and at a distance equal to the height of an equivalent or next carminative (Ziziphus spina) happened. Negli reported the largest drop in wind speed at a distance of 4 times the height of the wind break occurs, It seems that the difference between the results of these tests and report Negli high density of trees along the bottom of the canopy (Canopy) is concerned. Striking parallel to the bottom dense carminative plant canopy and the wind speed dropped from a height of 1 meter in distance 2,3,4,5 and 6 times the height of the wind break, wind speed has increased. Of course, at a distance equal to the height of 10 varied levels of wind speed has shown a slight decline due to the density difference between the velocity fluctuations can also be a wind break at the bottom and top. Due to fluctuations in wind speed behind a wind break of study (Figure 4 and Figure 5), Drop in the wind speed at behind the wind break trees were alive with between 1 and 10 times equals the height of the wind break and mud wall to a height of between 1 and 6 carminative happened. In fact, these results are consistent with the results Negli, So that the drop in reported wind speeds of dense windbreak is more than Uncompressed carminative,while reversible wind speed happens at the non-jamming wind breaks. Another significant point is observed profiles of wind velocity fluctuations, at the carminative mud wall during the deceleration windbreak, along the windbreak was pretty smoothly, but at the lotus was non-uniform. It seems non- uniformity is due to non- uniform changes in wind speed over the alive wind break. Heisler and Dewalle (1988) report that studies of shelterbelts field that medium-porous barrier are the most effective in reducing the mean, near-ground wind speeds for the longest distances. The rate of wind speed recovery is faster in the near lee (between 0h and 10h), and slower afterwards, hence low porosity windbreaks are slightly less effective than medium porosity windbreaks (Wang and Takle, 1996). According to figure1 wind speed at 2h back of Mud wall windbreak was decreased fewer than 9 percent of its initial speed. So high density of windbreak created a zone at the back of windbreak which has a very low wind speed. Other researchers suggested this zone created at 2 to 10h back of windbreak (Guanming and Wenhu, 2003; Vigiak, *et al.*, 2003; Cornelis, *et al.*, 1997). A maximum wind speed reduction for biotic wind break was observed at 1h back of windbreak. The wind speed increasing after the minimum point has interesting pattern. This pattern shows the gradually change in wind speed and low fluctuations in contrast to solid windbreak. These findings are in qualitative agreement with simulations using the numerical model of Wilson (1985), Banzhaf *et al.*, (1992) and Olga (2003). Wilson (1987) reported differences in wind reduction and turbulence behind the two fences are fairly slight. Mean wind speed is reduced somewhat more effectively (an additional 10 to 15%) near ground in the near lee ($x/H = 7$) of the fence which is dense at the ground, with no apparent penalty in the turbulent field but with reduced effectiveness at larger distances relative to the uniform fence. Wilson (1985) examined the results of several relatively modem windbreak fence experiments and found that in these cases a more dense windbreak yielded not only a greater speed reduction, but also a greater range of shelter. This concurred with the prediction of the numerical model of windbreak flow which was the main subject of Wilson (1985). The maximum wind speed reductions, which occur close to the slat-fence windbreaks, ranged from 70 percent for the solid windbreak to about 50 percent for the 60-percent porous windbreak. However, average wind speed reduction over the leeward area was 5 to 10 percent larger for the 40-percent porous windbreak than that for any other windbreak (Heisler *et al.*, 1988). Finally we concluded that mud wall is applicable for high deceasing wind speed at the back of windbreak but its high wind speed fluctuation and high turbulent were limited these application in agroecosystems which laid in arid or semi arid regions. Ziziphus spina christi with 85% density is applicable for medium decreasing of wind speed over a larger zone after windbreak. So this biotic windbreak may be more useful for agroecosystems which laid in arid or semi arid regions. Growing of tree or other biotic windbreaks is interesting property for improving windbreaks, because its annual growth increases the windbreak zones (Bisal, *et al.*, 1964). Other benefits of biotic wind break are their applications to fuel, fruit production, forage and wild shelter in agro landscapes (Wojtkwski, 2003).

REFERENCES

Amiri I (2007). Comparative study of wind breaks effects on wind speed changes in Jiroft and Kahnooj region. MSc thesis, University of Zabol, Iran 100 (in farsi).

Benzhaf J, Leihner DE Buerkert A and Serafini PG (1992). Soil tillage and Windbreak Effects on millet and cowpea:Speed, evaporation, and Wind Erosion. *Agronomy Journal 84*(6) 1056-1060.

Bisal F and Nielsen KF (1964). Soil aggregates do n o t necessarily break down over winter. *Soil Science* **98**(5) 385-346.

Cornelis WM, Gabriels D and Lauwaerts T (1997). Simulation of windbreak for windbreak for wind-erosion Control in a Wind Tunnel. M.Sc. Thesis, University of Ghent, Belgium 96.

Ekhtesasi MR (1993). The method for classification and intensity determination of land desertification in Iran. *National Conferences of Desertification and Methods for Combat of Desertification* **1** 124-125 .

Georg Jaeggli B, Meinke H, Carberry PS, ade H, (1998). Variations in Wheat Yields Behind Windbreaks in Southern Queensland.

Gordon M, Heisle and David R.Dewall (1988). published by Elsevier Science B.Y,

Hagen TJ and Skidmore EL (1971). Turbulent velocity fluctuation and vertical flow as affected by windbreak porosity. *Transactions of the ASAE* **14**(4) 634-637.

Heisler GM and DeWalle DR (1988). *International Symposium on Windbreak Technology* reprinted from Agriculture, Ecosystems and Environment, (Elsevier Science Publishers BV, Amsterdam).

Honda Hitoshi (1974). Fundamental study on the planting and space effect sin public nuisance prevention in the city: 111. Dust catching ability of plant foliage. *The Technical Bulletin of Faculty of Horticulture, Chiba University* **22** 81-88.

Jensen M (1954). *Shelter Effect* (Danish Techn, Press, Copenhagen) 266.

Puri S, Singh S and Khara A (2004). Effect of Windbreak on the Yield of Cotton Crop Semi-arid Regions of aryana. Australia: Springer Link, I nc.

Van Eimern J, Karschon R, Razumova LA and Robertson GW (1964). Windbreaks and shelterbelts. *WMO Technical Note* **59** 188.

Vigiak O, Sterk G, Warren A and Hagen LG (2003). Spatial modeling of Wind spead around windbreaks. *CATENA* **52**(3- 4) 273-288.

Von Kármán T (1921). Uber laminare und turbulente Reibung. *Zeitschrift für Angewandte Mathematik und Mechanik* **1** 233-252.

Wang H and Takle ES (1996). On the shelter efficiency of shelterbelts in oblique wind. *Agricultural and Forest Meteorology* **81** 95–117.
Wojtkwski Paul A (2003). *Landscape Agroecology* (Food Product Press) 330. Englestan.
Wright AJ and Brooks SJ (2002). Effect of Wind breaks on Potato Production for the Atherton Tablelands of North Queensland. *Australian Journal of Experimental Agriculture 42*(6) 797 – 807.