Using Shelterbelts to Maximize Economic Yield

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Mature field shelterbelts have been shown to increase crop yields within their protected zone (Lehane and Nielsen, 1961, Stoeckeler, 1962, Pelton, 1967, McMartin et al 1974). The magnitude of the increase has varied considerably among reports (van Eimern et al, 1964, Kort, 1988). This variability is likely due largely to climatic variability from region to region and from year to year (Kort, 1988). It is therefore important to use local multi-year studies as a basis for estimating the benefit of shelterbelts to crop yields on the Canadian prairies. Three studies from the Prairies and the Northern Great Plains were used as data for determining a representative yield response for spring wheat (Fig. 1.).

In constructing Figure 1 it was assumed that no crop was grown for a distance of 0.5 H from the centre of the shelterbelt (H is the height of the shelterbelt). Competition from the shelterbelt was assumed to reduce crop yield by 50% from 0.5 H to 1 H from the shelterbelt (Kort, 1988). Yield was increased from 1 H to 15 H due to reduced wind erosion, higher soil moisture from trapped snow, improved microclimate and reduced physical damage to the crop by wind and wind-blown soil. The area under this curve from 0 H to 15 H was found to be 3.5% greater than if there had been no shelterbelt (i.e. the area under the 100% line).

To calculate the economic benefit of field shelterbelts, a project was hypothesized which consisted of a north-south field, 400 m x 800 m (32 ha or 79 ac) in area which was protected on the east and west sides by mature green ash-caragana shelterbelts, 12 m in height. There was no crop to 5 m from the centre of the shelterbelts and they were competitive with the crop to a distance of 10 m. It was assumed that yield effects were the same from both shelterbelts (Lehane and Nielsen, 1961, Stoeckeler, 1962). Figure 2 was constructed to illustrate the project.

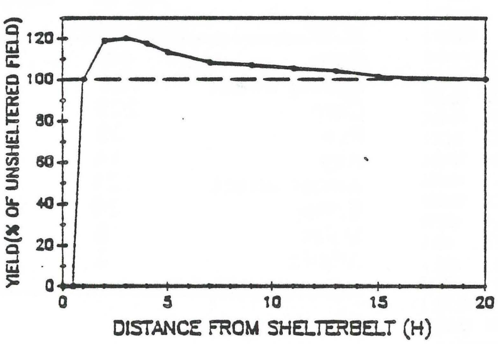

Fig. 1. The effect of a shelterbelt on the yield of adjacent crop of spring wheat (based on results of Lehane and Nielsen, 1961, Stoeckeler, 1962 and McMartin et al, 1974).

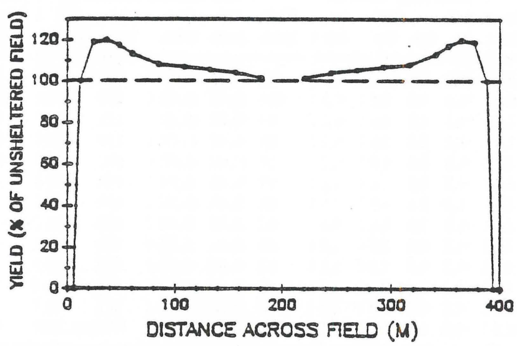

Fig. 2. Effect of 12 m high shelterbelts on yield of spring wheat across a 400 m field (based on Fig. 1).

Since shelterbelts require inputs for planting, establishment and renewal and since shelter varies with the age of the shelterbelt, a spreadsheet was designed in Lotus 1-2-3 by which an IBM PC/AT microcomputer calculated the economic benefits of the shelterbelts over their lifespan compared with an unsheltered field (Table 1). The effect of mature shelterbelts in this project on the economic yield would be about $325 annually in constant 1988 dollars under continuous wheat assuming an unsheltered yield of 1,700 kg/ha (25 bu/ac) and a price of $109/T ($3/bu). The 75-year accumulated present value of the shelterbelts was calculated, using an annual discount rate of 5%, to be $3278. Shelterbelts were therefore shown to be an economically viable enterprise. This spreadsheet can be used to calculate the values of shelterbelts under different conditions as it allows the user to change crop input costs, shelterbelt inputs, unsheltered yields and crop price. Farmers or agricultural professionals may therefore find it valuable in making decisions as to whether or not shelterbelts are viable under certain conditions.

Most crops are more responsive to shelter than spring wheat. Table 2 shows results of an extensive literature review of studies conducted in which world-wide yield responses of crops to shelterbelts were measured. Crops such as winter wheat and alfalfa are sometimes planted in a strip up to 40 m from the shelterbelts where they benefit from the winter snow cover. Corn benefits from the added heat units (Stoeckeler, 1962) while potatoes mature earlier in the sheltered zone (PFRA, 1986). Use of such crops takes maximum advantage of shelterbelt effects so that the shelterbelt value is further increased. Costly direct losses of fine soil fractions, organic matter, and associated nutrients by wind erosion (PFRA, 1983) are reduced by field shelterbelts increasing their value further.

Table 1. Partial Lotus 1-2-3 spreadsheet which calculates the net yield and economic benefits over 75 years in the hypothetical 32 ha project (assumes continuous spring wheat).

		Shelt. yield increase(%)*				Project economics (Constant $)**					Annual	Cum
Year	Tree Ht(m)	Land Occ.	Comp	Yield Incr	Net Incr	S'belt Inputs	Crop Inputs	Crop Return	Net Return	Diff (S-U)***	Present Value+	Present Value+
0	0.0	-1.3	0.0	0.0	-1.3	$13	$5,463	$5,853	$377	($18)	($18)	($18)
1	0.5	-1.3	0.0	0.0	-1.3	$110	$5,463	$5,853	$280	($115)	($110)	($128)
2	1.0	-1.3	0.0	0.0	-1.3	$29	$5,463	$5,853	$361	($34)	($31)	($159)
3	1.5	-1.3	0.0	0.0	-1.3	$58	$5,463	$5,853	$332	($63)	($55)	($213)
4	2.0	-1.3	0.0	0.0	-1.3	$29	$5,463	$5,853	$361	($34)	($28)	($241)
5	2.5	-1.3	0.0	1.6	0.3	$29	$5,463	$5,948	$456	$60	$47	($194)
6	3.0	-1.3	0.0	1.9	0.6	$13	$5,463	$5,967	$491	$95	$71	($123)
7	3.5	-1.3	0.0	2.2	0.9	$13	$5,463	$5,986	$510	$114	$81	($42)
8	3.9	-1.3	-0.2	2.5	1.0	$13	$5,463	$5,972	$516	$120	$81	$40
9	4.4	-1.3	-0.3	2.8	1.1	$13	$5,463	$5,998	$522	$127	$82	$121
10	4.8	-1.4	-0.4	3.1	1.3	$0	$5,460	$6,005	$545	$150	$92	$214
74	12.0	-2.5	-2.0	7.7	3.2	$0	$5,397	$6,117	$721	$325	$9	$3,312
75	12.0	-2.5	-2.0	0.0	-4.5	$1,200	$5,397	$5,663	($933)	($1,328)	($34)	$3,278

* Based on Figure 1.
** Assumes: Unsheltered yield= 25 bu/ac Price= $3.00 /bu
*** Assumes: Crop input cost= $70 /ac
Net return(unsheltered)=Crop return - Input cost ($395 /ac)
\+ Based on an annual discount rate of 5%

Table 2. Relative responsiveness of various field and forage crops to shelterbelt protection.

Crop	No. of field/years	Weighted mean increase(%)
Oats	48	6
Spring wheat	190	8
Corn	209	12
Rye	39	19
Hay	14	20
Winter wheat	131	23
Barley	30	25
Millet	18	44
Alfalfa	3	99

It is concluded that shelterbelts are generally effective in reducing wind erosion and increasing crop yields. Crop yields from fields protected by well designed mature field shelterbelts are increased by 3.5% or more, resulting in increased net economic returns. The accumulated net present value of two shelterbelts protecting a 32 ha (79 ac) field for 75 years was calculated to be $3278. The use of shelterbelts on the prairies should therefore be encouraged on the prairies.

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