



Farm level economic analysis of subsurface drip irrigation in Ontario corn production



David Jacques^{a,*}, Glenn Fox^a, Peter White^b

^a University of Guelph, Department of Food, Agricultural and Resource Economics, J.D. MacLachlan Building, Guelph, Ontario, Canada N1G 2W1

^b University of Guelph, Department of Plant Agriculture, Simcoe Research Station, Simcoe, Ontario, Canada N3Y 4N5

ARTICLE INFO

Keywords:

Subsurface drip irrigation
Stochastic capital budget
Corn
Norfolk County
Ontario

ABSTRACT

This paper examines the economic feasibility of a subsurface irrigation system for a representative corn producer in Norfolk County, Ontario, Canada. We use stochastic capital budgeting to generate a distribution of net present values for this investment. Future corn yields and corn prices were treated as distributions. Under our base assumptions, the subsurface drip irrigation system has a negative expected net present value, meaning that it would not be a worthwhile investment for a corn farmer at the present time. The system's ability to increase yields has the largest effect on its expected net present value. Attempts to improve the system's economic value should focus on increasing its effect on yields in years with typical agronomic conditions. With reasonable assumptions for other system parameters, the initial cost of a 40.5 ha system would have to be reduced to \$165,000 to have a positive net present value 50% of the time or the system would have to increase corn yields by 33% in years with typical growing conditions to achieve the same net present value outcome.

1. Introduction

Corn crops in the sand plains region of Ontario, Canada are not usually irrigated. But in 2012, after four months of drought conditions, and facing significantly lower yields, growers in the region were considering the merits of irrigating their corn crops (Government of Canada, 2012). By the next growing season at least one subsurface drip irrigation system had been installed and irrigation was still a topic of conversation at growers' meetings in the area.

Corn growers in the sand plains region have seen drought years in the past. In 2007, 2002 and 2001 seasonal precipitation was more than 15% below the 15 year average in the area (Government of Canada, 2017). Colombo et al. (2007) suggest that inadequate precipitation may be even more of a problem in the future as Ontario's climate changes. They projected that, in the warm season from April to September, the sand plains region will see between 0% and 10% less precipitation. This forecast prompted Morand et al. (2017) to propose that the provincial government fund demonstration projects to showcase the benefits of subsurface drip irrigation. But is installing a subsurface drip irrigation system a worthwhile investment for a corn grower in the sand plains region?

Considering the merits of a subsurface drip irrigation system is an issue that extends beyond a region of sandy soil in Ontario. Lobell et al. (2014) showed that in Iowa, Indiana and Illinois in the United States,

over the period from 1995 to 2012, corn yields became more sensitive to drought stress. They suspect that this occurred because water availability has become more of a limiting factor in yields as other hinderances to production have been mitigated.

In this paper we consider the economic value of a subsurface drip irrigation system from the perspective of a corn grower. To do that we use stochastic capital budgeting of a representative installation in the sand plains region of Ontario. We also explore how the budget parameters affect the system's value. And we compare the value of a subsurface irrigation system's technical efficiency to that of a centre pivot system.

Other research has examined the economic feasibility of subsurface drip irrigation systems, notably Camp (1998), O'Brien et al. (1998) and Heard et al. (2012). Camp (1998) looked at the economics of using a subsurface drip irrigation system to grow corn in the Great Plains region of the United States. O'Brien et al. (1998) reviewed the literature on the use of subsurface drip irrigation systems and touched on their economic viability. Finally, Heard et al. (2012) evaluated the economics of a subsurface drip irrigation system used to grow alfalfa pasture in Australia's Murray-Darling Basin. However, the economic feasibility of this technology has not been studied for corn production in southern Ontario, an area with agronomic and climate conditions that differ from those of past studies. Furthermore, and of importance to growers and agronomists beyond this particular region, past studies

* Corresponding author.

E-mail address: djacques@uoguelph.ca (D. Jacques).

have not taken into account uncertainty in corn prices and yields in their analysis of economic feasibility.

2. Material and methods

Our analysis is based on a representative subsurface drip irrigation system, similar to one installed in a commercial trial corn field in Norfolk County, Ontario, Canada. We assumed that our representative system has the same components and layout as the system in Norfolk County except that our analysis is scaled to a 40.5 ha (or 100 acre) field whereas the commercial trial system covers 32.37 ha.

We developed a stochastic capital budget for this representative situation, including equipment and installation costs as well as annual changes in operating costs and revenues. In our base results, given that this is a new technology for this region, we assumed a conservative useful life of 15 years for the installation. We consider a longer useful life in sensitivity analysis. We applied a real discount rate of 5% in calculating present values. The capital budget subtracts the initial equipment and installation costs from the present value of the annual changes in net revenues (changes in annual revenues minus changes in annual costs) to generate a net present value. A positive net present value indicates that the investment would be attractive to a farmer with a real rate of time preference of 5%.

Future corn prices and yields are modelled as distributions in our capital budget. We used stochastic simulation with these distributions to generate a distribution of net present values. The mean of the net present values indicates the expected value of the system and the standard deviation gives a sense of how sure we can be that the system will have a particular net present value. We can also calculate the probability that the system will have a positive net present value.

Corn prices were modelled as a normal distribution based on historical real Ontario corn prices. The distribution of corn yields in the absence of irrigation was modelled as a mixture distribution, based on previous work by Tolhurst and Ker (2013).¹ They found that past corn yields in the Haldimand-Norfolk census subdivision,² the area in which our representative field lies, can be characterized by a mixture distribution that is made up of two normal distributions.

Fig. 1 illustrates corn yields *without* irrigation for year 1 in our simulation. The mixture distribution consists of two normal sub-distributions, each with its own mean and standard deviation. One of the sub-distributions, which we call the typical years sub-distribution, applies to the case of yields in years with run-of-the-mill agronomic conditions, i.e. those that usually occur in the Haldimand-Norfolk census subdivision. It is this sub-distribution that created the taller and wider yellow portion of the histogram in Fig. 1. Tolhurst and Ker (2013) report that yields come from the typical years subdistribution 89.3% of the time. The rest of the time yields come from what we call the exceptional years sub-distribution. Which characterizes corn yields that occur in years with close to ideal agronomic conditions. The exceptional years sub-distribution produced the shorter orange portion of the histogram in Fig. 1. Yields come from the exceptional years sub-distribution 10.7% of the time.

In the stochastic simulation of net present values, randomly drawing one year's corn yield from the mixture distribution is a two-step process. In the first step we draw from a continuous uniform distribution defined over the interval from 0 to 1. If the value drawn is less than 0.893 then in the second step we draw a random value from the typical years sub-distribution. On the other hand, if in the first step a value greater than or equal to 0.893 is drawn from the uniform distribution, then in the second step we draw a random value from the exceptional years sub-

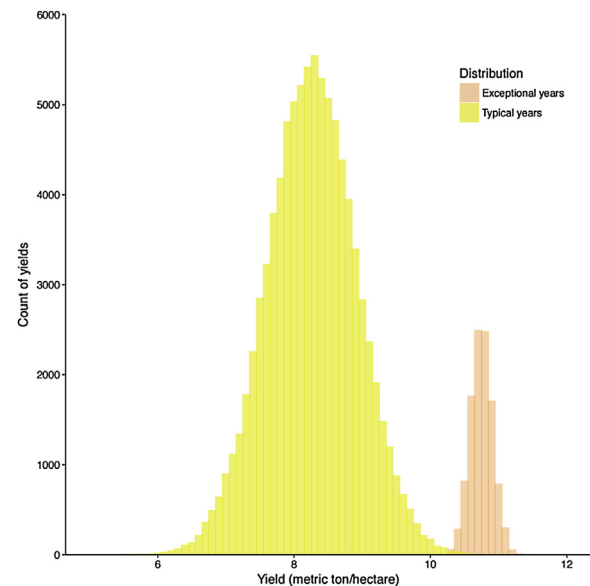


Fig. 1. Simulated corn yields on representative 40.5 ha field *without* subsurface drip irrigation system in first year of simulation. (For interpretation of the references to color in text, the reader is referred to the web version of the article.)

distribution. This process is repeated 100,000 times for each of the 15 years of the base scenario.

Tolhurst and Ker (2013) estimated that there has been an upward trend in corn yields in the Haldimand-Norfolk census subdivision. We incorporated their estimated trend into our mixture distribution by assuming that the mean of the normal years sub-distribution increased 1.02% per year and that the mean of the exceptional years sub-distribution increased 1.14% per year. Given these upward trends, in the last period of our simulation, in year 15, the mean yield in the typical years sub-distribution is roughly 13% higher than it is at the beginning of the simulation and the mean yield in the exceptional years sub-distribution is about 15% higher than it is at the beginning.

To account for the effect that subsurface drip irrigation has on corn yields, in each year of the simulation we multiplied expected corn yields without irrigation by a fixed proportion. We assumed the system would increase corn yields by 30% in typical years and by 10% in exceptional years.

Our assumption that the system would increase yields by 30% in typical years is based in part on the work of Powell and Wright (1993). In Table 4 of their paper one can see that over the four year study period the irrigated treatment plots averaged 28.8% higher yields than the unirrigated controls. Given this finding and the fact that in our yield distribution 89.3% of the corn yields are coming from the typical years sub-distribution, it seems reasonable to assume, at least as a starting point for our analysis, that the average yield in the typical years sub-distribution would be increased by 30%.

As for the effect the system has in exceptional years, we assumed that yields drawn from the exceptional years sub-distribution would be 10% higher. The argument for increasing the mean of the exceptional years sub-distribution by 10% is that even with ideal weather and crop management, on average corn grown with a subsurface drip irrigation system will have a higher yield than corn grown without a subsurface drip irrigation system. This is because a subsurface drip irrigation system affords a level of control over soil nutrients that is not possible on an unirrigated field. A subsurface drip irrigation system that has a liquid fertilizer pump, which is the case with our representative system, can be used to supplement macro nutrients in the soil. The relative simplicity of doing so means that even small deficiencies in macro nutrients can be corrected. This would not be the case on an unirrigated field. Therefore, a 10% increase in yields in exceptional years is

¹ Although the work by Tolhurst and Ker (2013) is unpublished, the algorithm they use to estimate the parameters of the Haldimand-Norfolk corn yield distribution is presented in Tolhurst and Ker (2015).

² Census subdivisions are geographical areas defined in Statistics Canada's Standard Geographical Classification.

Download English Version:

<https://daneshyari.com/en/article/8872977>

Download Persian Version:

<https://daneshyari.com/article/8872977>

[Daneshyari.com](https://daneshyari.com)