



AN ECONOMIC ANALYSIS OF THREE SOIL IMPROVEMENT PRACTICES IN THE COLUMBIA BASIN, WASHINGTON STATE

By

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Abstract

Soil improvement practices are ways to maintain or improve soil quality and thereby soil productivity. The objective in this research was to estimate the costs and benefits of three soil improvement practices in the Columbia Basin of Washington State: compost application, cover crops, and no-till/min-till. Focus group information formed the basis of three partial budgets to estimate changes in costs and returns due to the soil improvement practices. Partial budgets showed that two of the three practices generated positive changes in profit that were mostly due to savings in replant costs or reduced fumigation costs, and the third incurred a marginal negative value. Other non-cash benefits or costs not included in the partial budgets, but which could have a significant impact on the overall profitability of the cropping system, were increases in land value as soil productivity increased, the value of carbon sequestered, and learning and knowledge acquisition costs; all three can affect net returns. The challenge with these types of costs and benefits is how to incorporate them into a partial budget format.

Introduction

Global interest in the soil resource is currently increasing, as concerns about this resource and its ability to support food production are more widely recognized. Often, the terms “soil quality” or “soil health” are used to denote the importance of the physical, chemical, and biological aspects of soil, in contrast to the historical focus on chemical soil testing only. Soil improvement denotes activities taken in agricultural systems to optimize the function of soil for crop production. The published literature on the topic is vast due to the numerous types of practices, soil types and crops, and climatic zones in which these practices are used. The crop yield responses to the various experimental treatments or research reported in the literature, or changes in various soil quality measures (e.g., bulk density, soil organic matter, etc.) are usually the main focus of these reports. Very few publications focus on the economic costs or benefits of soil improvement.

Specific economic analysis of soil improvement practices is usually limited to a form of gross margin budget analysis or ad hoc approaches to measuring economic benefit (i.e., analysis based on a specific situation or set of assumptions about production practices). As an example, Wyland et al. (1996) used a budget approach; however, the economic component of their research contained very little information regarding differences in returns or costs.

As noted above, many soil improvement studies utilize an ad hoc approach to the economic analysis. This could be because the differences across soil improvement practices affect the economic data required to analyze the practice. For example, cover cropping systems utilize machinery and equipment that is typical across most farming systems, but additional variable inputs including seed and fertilizer for the cover crop are required and need to be included in the analysis. In contrast, reduced tillage systems require more specialized or heavier equipment suited to the system or soil type, incurring extra capital costs, but have similar seed or fertilizer requirements to a more “traditional” cropping system, thus an economic analysis may not need to include any additional variable input costs, except for fuel due to slower working rates.

Another problem is that many economic analyses fail to account for two subsets of costs or benefits. In most analyses, the researcher measures the direct costs (i.e., seed, fertilizer, fuel, chemicals, or machinery costs) that vary across soil improvement treatments. However, most analyses usually do not capture *indirect costs or benefits*, i.e., risk reduction related to crop productivity over time due to topsoil loss, or *non-priced costs or benefits* that cannot be valued directly, such as land rental changes due to changes in soil quality resulting from adoption or non-adoption of soil improvement practices, or the costs of learning about the improvement adopted. From an economic perspective, these costs or benefits may be critical to the success or failure of a soil improvement practice since failing to acknowledge either or both of these can under- or overestimate the costs and benefits of the practices.

The objectives in this research were to develop a tool to more fully measure the costs and benefits of common soil improvement practices and to test the tool on a set of three different soil improvement practices in the Columbia Basin of Washington State (Granatstein et al. 2017). The tool developed is a partial budget in Excel that can be applied to most soil improvement practices without significant alteration, has relatively simple data entry, measures net costs and benefits, and produces total change in enterprise profit. Information from three focus groups was used to validate and test the structure of the tool, and identify data requirements to complete the analysis.

Methodology

Partial Budgets

Unless a proposed change to a farm plan is extensive, one method of analyzing change is through a partial budget (Kay et al. 2008). As noted by Kay et al. (2008), partial budgets are a consistent method to calculate the change in profit from a change in the farm business. These authors emphasize the word “change”. In the context of the current research, the changes being studied are minor or major alterations in some inputs but are not system-wide changes, such as type of fertilizer, seed, or capital used in crop production, or potential changes in outputs from these production systems. The changes are not significant deviations in the cropping system, (i.e., no new cash crops are being introduced into the farm system). For these reasons a partial budget is a suitable framework for analyzing soil improvement practices.

Although partial budgets are relatively common, the data required to fully analyze a soil improvement practice can be difficult to identify and to put into a partial budget context. Partial budgets require a maximum of four different classes of data: additional costs, additional revenue, costs saved, or revenue foregone (Kay et al. 2008). Note that the data represent only the changes, not all revenues or costs. In the partial budget, the additional costs and revenue lost due to the change are summed together, then deducted from the sum of the additional revenue and costs saved in order to calculate the net change in profit. For a given soil improvement practice, profit will increase if the net change in profit resulting from adoption of that practice is positive — that is, when the total of additional revenue and costs saved is greater than the total of additional costs and revenue foregone. On the other hand, if the net change in profit is negative, profit will decline if a grower adopts the particular soil improvement practice.

Each soil improvement practice has its unique costs and revenues. In the tool designed, each of the four classes listed above is broken down into a number of sub-classes depending on the classification. For example, the costs saved and additional costs are broken down into: Inputs – including fertilizer, chemicals and water; Machinery and infrastructure – including machinery fuel and oil costs, capital purchases, and repairs and maintenance of machinery; and other costs saved/incurred – including soil testing, and additional management input.

One challenge of a partial budget analysis is that some costs do not fit directly or conveniently into the standard format. In the tool designed, these costs are listed as additional costs that need to be considered in the profitability of an improvement practice. One such cost is the time spent educating oneself about soil improvement and determining if a soil improvement practice would fit into the current farm system. This cost is scale neutral and so is difficult to incorporate into the budget. Other similar costs will be discussed later in the paper.

Costing Capital Items

Most costs included in the current study were changes to variable costs, which are costs that vary with the scale of operation, such as fertilizer, chemicals or fuel. However, in the case of the no-till/strip-till system, additional machinery or alternative specialized equipment (e.g., a no-till drill) purchases are necessary. In the context of a partial budget these are usually not included, except for the variable costs, that is, depreciation (Kay et al. 2008). One method to capture these costs for use in a partial budget is to use an amortized value for the capital costs. Amortizing a capital cost provides an annual cost of that capital investment; those costs can then be incorporated into an annual budget tool such as a partial budget.

Focus groups

One of the challenges with analyzing technology is that users sometimes adopt the technology into their system in different ways, thus leading to potentially different outcomes. To measure the outcomes of adoption it is possible to take different approaches, such as case study analysis, experimental analysis, or in the case of farm changes whole farm budgeting exercises. Each of these approaches has its own positives and negatives. For example, case study analysis assumes that the application of the technology in the case study system will be similar across all systems, and experimental analysis requires sufficient replicates to generate statistical power in the analysis.

In the following analysis, we chose to take a slightly different approach and in some ways combined case study analysis, expert opinion survey, and focus groups. The reasoning behind this approach was to reduce some of the impact that single case study data may have on the outcomes of adoption of a technology, due to factors such as the method or costs that may be unique to each situation, and to have producers validate the values reported. The latter is similar to an expert opinion survey, where recognized experts on the topic were identified – in our study, these were growers with known experience or reputation on the relevant practices and whose expertise were solicited for data validation and other supporting information. Obtaining data from focus groups is an approach that has been used by other studies to estimate costs and benefits of agricultural production practices, for example, Galinato and Miles (2013), Galinato and Tozer (2016), and Reganold et al. (1993).

To construct, calibrate, and validate the tool, three focus groups were convened covering three soil improvement practices: a group that used some form of bulk organic amendment (manure or composted manure), a group that utilized either strip-tillage or no-till, and a group that used some type of cover crop or green manure. These practices were selected because they were the most common soil improvement tactics used in the Columbia Basin (Granatstein 2014). Participants in the focus group were selected based on the following criteria: farmers must have similar characteristics in terms of location, size of farm operation, and similar mix of crops grown; and farmers could use only one approach or multiple approaches. Participants in the group were sent an initial questionnaire, adapted to their specific practice, asking questions that would aid in preparation for a face-to-face focus group meeting. The survey included questions such as number of years farming, size of farming operation, crops produced, number of years adopting a particular soil improvement practice (i.e., ranging 3-20 years among all the cooperators), and costs and benefits of the soil improvement practice.

Each focus group consisted of three to five farmer participants and four observers and recorders. One of the observers served the role as lead interviewer and asked all questions with observers allowed to ask questions to clarify information provided by the producer participants. A set of standard questions was developed before the focus group meetings to ensure that similar data was collected in all meetings.

The data collected from the grower questionnaires included area on which the soil improvement was undertaken; costs of the soil improvement including, if necessary, transport costs and changes in machinery capital investment; changes (increase or decrease) in variable input usage – fertilizer, herbicides, pesticides, or fungicides; and changes (increase or decrease) in crop yields. The questionnaires were sent approximately two weeks before the in-person focus group meeting with the purpose of having the information readily available for the focus group meeting as well as in hardcopy.

Results and Discussion

The outcomes of the focus group for each soil improvement are summarized separately below and in Figures 2, 3 and 4. The partial budgets, used as basis for the figures, are provided in the Appendix below. Note that the focus of the subsequent discussion is not on actual numbers or one set of specific costs (i.e., how use of a specific type of fertilizer changed); rather this section focuses on the costs in general (i.e., how did fertilizer use vary) and how this relates to the profitability of the decision to adopt a particular practice in the context of other variables and costs.

Bulk Organic Amendments

The focus group for this practice consisted of three producers, plus additional data were provided by two other producers who participated in a focus group for another improvement practice. Two of the producers in this group used aged/composted cattle manure, either feedlot or dairy, and one organic producer used chicken manure compost. As there was only one observation for chicken manure, and this was in an organic system, it was not included in the analysis to avoid over-estimating or biasing costs and or benefits. An example of compost application is pictured in Figure 1.



Figure 1. Compost application in the field.

Additional costs. As shown in Figure 2, the major costs for this practice are the manure/compost (i.e., about 64% of the total additional costs), transport to the farm location, and spreading. A minor cost indicated by one producer was for compost testing to determine nutrient content, particularly phosphorus (P) and potassium (K). All producers assumed that there was little available nitrogen in the product, thus there were no cost savings in terms of nitrogen fertilizer in the year of application. This assumption is consistent with previous research of composted cattle manure (Larney et al. 2006; Castellanos and Pratt 1981; Pratt and Castellanos 1981).

Costs saved. Because producers assume nitrogenous fertilizers were still required, most of the cost savings in the compost system were from reduced P and K; these account for 51% of the total benefits (Figure 3).

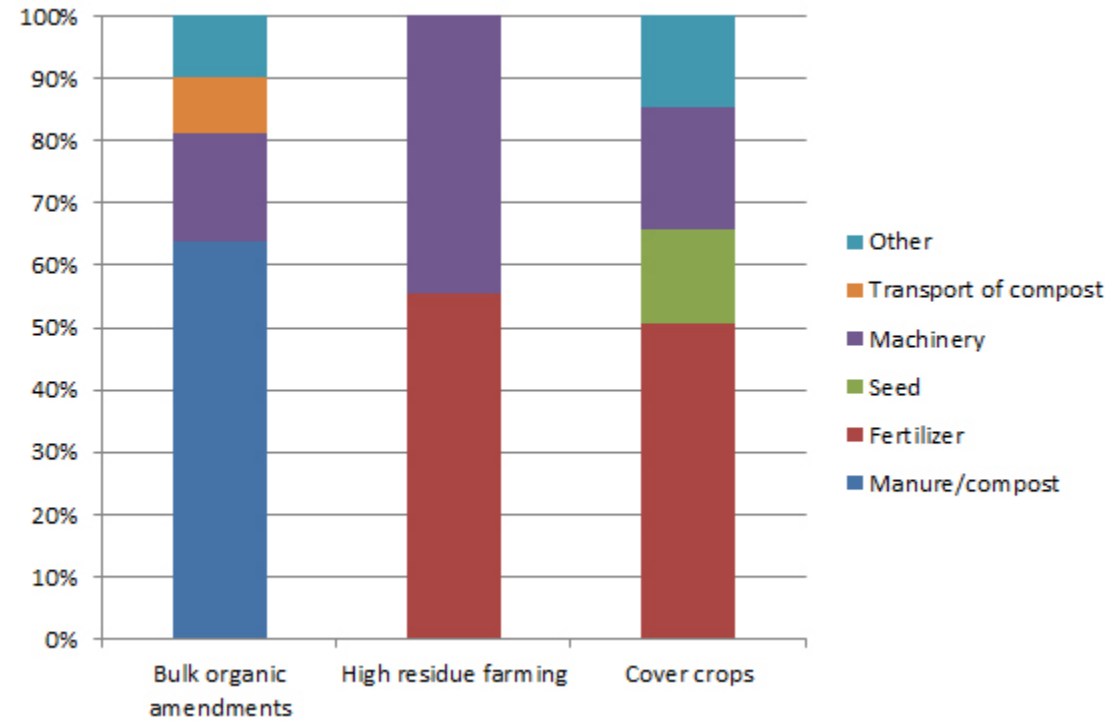


Figure 2. Costs based on grower input during focus group discussions about the different soil improvement practices

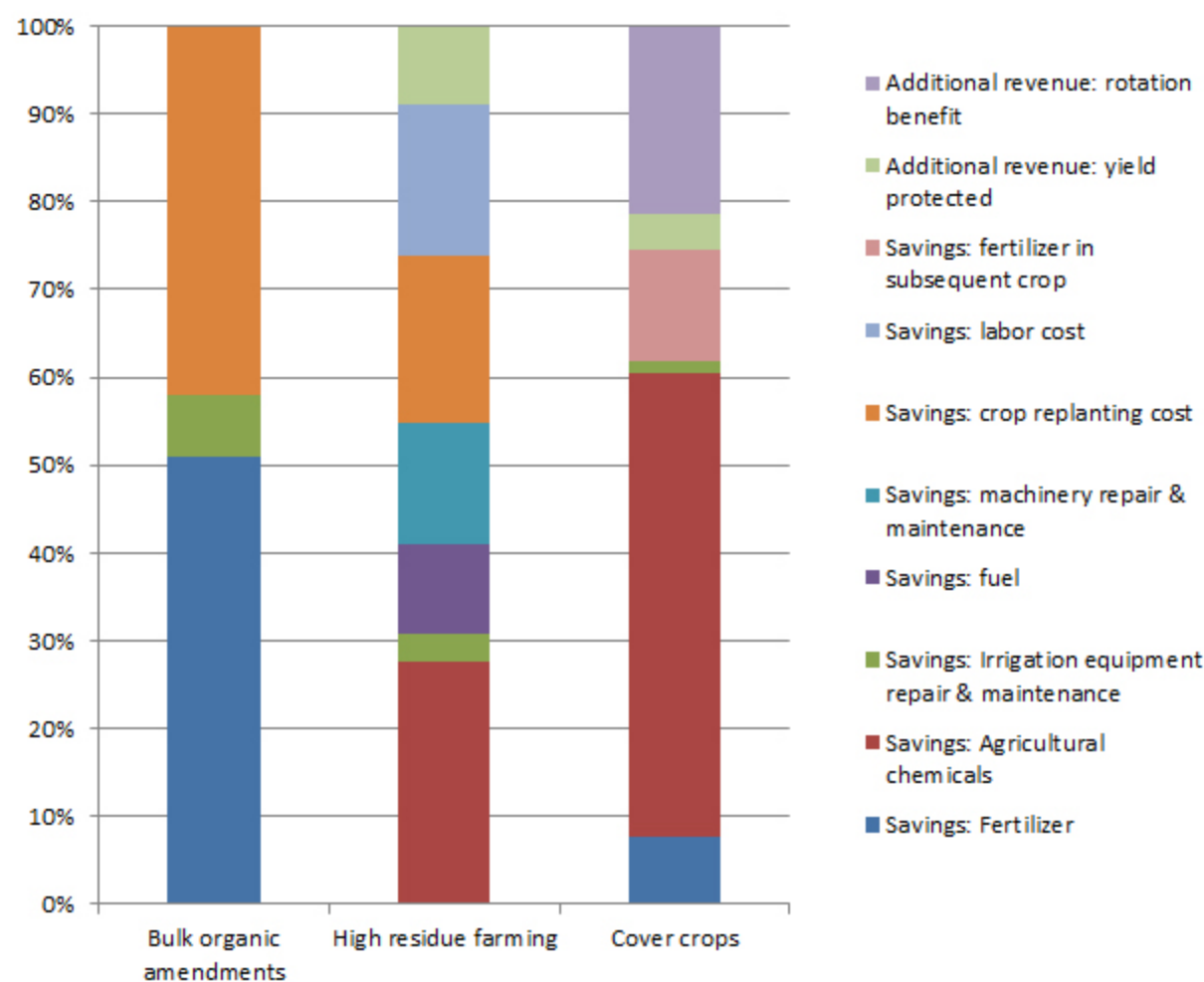


Figure 3. Benefits based on grower input during focus group discussions about the different soil improvement practices.

Wind erosion in early spring is a problem in the Columbia Basin, and with the increase in soil organic matter the soil surface was less susceptible to wind erosion and associated sandblasting of seedlings. Thus, it is reasonable to include soil improvement practices as part of a risk management plan.

Producers indicated that reduction in replant costs (over the crop rotation cycle) or reduction in the risk of needing to replant was partly attributable to the soil amendment. Replant costs depend on the crop and could range between \$100 per acre (e.g., alfalfa) to \$1,000 per acre (e.g., onion) (Hinman and Pelter 2004; Norberg and Neibergs 2014). Note that the replant costs do not account for the potential reduction in yield due to planting at a later date, thereby reducing the growing season.

Also, it was assumed in this study that other factors, (i.e., changes in water management or number of crops in a rotation), also contributed to a reduction in wind erosion costs, thus only a net of 5% was attributed to the compost system (equivalent to \$27.50 per acre using the average replant cost of \$550 per acre).

Net change in profit. The average net change in gross margin for the compost amendment was negative (Figure 4). The additional cost savings incurred for the compost amendment did not quite offset the additional costs incurred. The biggest saving was in terms of replanting cost and the net change in gross margin is partly dependent on the crop being replanted. For this practice to break even, the value of avoided replant costs would need to be just over \$30 per acre (while holding all other costs constant).

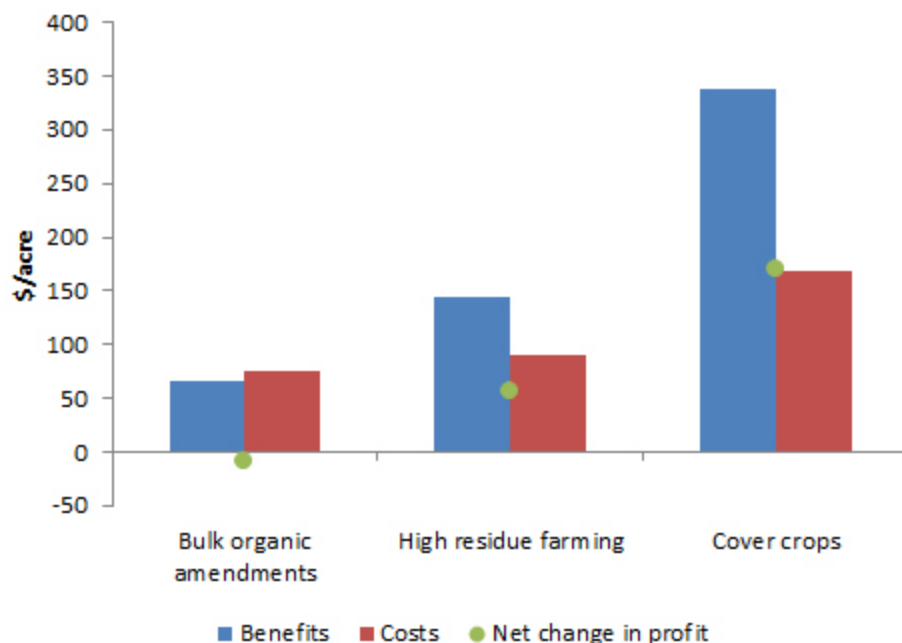


Figure 4. Benefits based on grower input during focus group discussions about the different soil improvement practices.

High Residue Farming Systems

“High Residue Farming” is an umbrella term for cropping systems in which less tillage is used in order to keep crop residue on the surface of a field. It includes both strip-till and no-till or direct-seeding. The focus group for this soil improvement practice consisted of three producers who undertook some form of high residue farming in some of their cropping systems to maintain higher surface crop residues and reduce soil disturbance and machinery trips. Some producers also tried to minimize tillage for crops such as potatoes, but indicated the disturbance from bed forming and harvest precludes a high residue option.

Additional costs. As expected in the case of strip-till or no-till systems, a major cost was the purchase of specialized machinery (i.e., 44% of total costs) with the capacity to operate in heavy crop residues or plant into a firm soil bed (Figure 2). Other than the cost of machinery, producers noted that because of the crop residues and the crop management practices, higher rates of fertilizer (i.e., 56% of total costs), particularly nitrogenous fertilizers were required to offset lower available soil nitrogen.

Costs saved. However, all producers indicated that although the machinery was heavier and costlier, the additional cost of the machinery was reduced somewhat by lower total maintenance costs when compared to tillage machinery needed in conventional cropping systems, and lower labor and fuel costs due to the reduced number of operations required. Dhuyvetter (2010) observed a similar outcome in that capital costs of machinery were higher in no-till systems than conventionally tilled farming systems. Two additional benefits were mentioned by all producers: improved water infiltration, which leads to lower numbers of irrigation applications and reduced crop plant losses due to wind erosion. These benefits are captured in the costs saved for irrigation equipment and crop replant costs (Figure 3).

Also, some of the increased fertilizer costs mentioned above were offset by a reduction in herbicides and fungicides (i.e., 28% of total benefits). The reduction in herbicides was due to a reduction in the use of water as a method of wind erosion control (i.e., using water to keep the soil surface moist and bound to reduce soil loss caused by wind); lower levels of water use reduced early weed seed germination, thus less herbicide in total was used. The residues retained on the soil surface can also reduce weed pressure and evaporation of water.

Additional revenue. An interesting outcome of no-till or strip-till systems reported by producers was in relation to yields of various crops. One producer indicated that crop yields of legumes, such as peas and beans were reduced, while another producer, who grew peas, beans and corn, indicated an increase in yields. The third producer noted that the yields would have been lower without using strip-till or no-till. In Figure 3 we have included a saving to account for what we have titled “yield protected”, which was 9% of the estimated total benefits. Yield protected is designated to account for yield that would otherwise have been lost if the soil improvement practice had not been undertaken. This type of yield protection appears in other research work as a yield increase in the minimum or no-till system (see for example Dhuyvetter, 2010).

Net change in profit. The estimated total benefits outweigh the estimated total costs for high residue farming. Hence, the average net change in gross margin for this particular practice was positive.

Other benefits (not included in the partial budget). Another benefit is savings in tillage and planting cost. The custom farm rate for a full tillage approach is about \$125 per acre compared to a minimum till approach of about \$55 per acre thus resulting in a saving of \$70 per acre. This cost was not included in the economic analysis because not all producers use custom operators. However, this value is mentioned here to show a further reduction in costs for those who do use custom operators for their tillage operations.

A specific benefit of strip-tillage (a form of reduced tillage) that was also described but not included in the analysis shown is double cropping. Growers in the area often grow green peas or sweet corn for processing. These are not full season crops, and returns per hectare are often minimal. With standard tillage, double cropping is not possible within the region’s growing season because the time required preparing a field after harvest of green peas and planting it to sweet corn extends the production period beyond the optimal growing season. By using strip-till as a one-pass planting operation, the time between crops is greatly reduced, allowing growers to successfully double-crop green peas and sweet corn, thus increasing total revenue per hectare per year and improving the profitability of these crops.

Cover Crops

The focus group for the cover crop soil improvement practice consisted of four growers. One of the growers undertook all three soil improvements studied in this research but participated only in the cover crop group.

All producers grew a mustard cover crop, planted in late summer and incorporated in late fall as a green manure, prior to a potato crop in the next crop year (Figure 5).



Figure 5. Mustard green manure crops are routinely chopped before disking into the soil.

Additional cost. The major component of the cover cropping improvement was the cost associated with sowing and termination of the cover crop, such as seed and fertilizer (i.e., 66% of the total costs, combined), and mowing and immediately incorporating the cover crop (i.e., 13% of the total costs) (see Figure 2). This is supported by Ransom et al. (2014) who showed that the cost of the cover crop seed plus sowing and termination accounted for the majority of total costs associated with the soil improvement practice. Because of the use of machinery for sowing and termination, machinery repairs and maintenance costs were higher when compared to systems that used herbicides (see for example Mitchell et al. 2012). Other minor costs associated with cover cropping included additional water to germinate and produce the crop, soil testing, and transport and management costs (i.e., 15% of the total costs, combined).

Costs saved. All producers preferred to mow or flail-chop the cover crop in order to induce the “biofumigant” effect (McGuire 2012) rather than use herbicide to kill the crop, thus saving on herbicide costs for volunteer wheat that would have been needed. Most producers also reported significant savings in inputs due to the cover cropping system, particularly for a subsequent potato crop. Most notable in these savings is the reduction in soil fumigants to control nematodes and soil-borne disease. One producer reported that in the potato crop following the mustard crop they did not use any soil fumigants. Total savings on fungicides, fumigants, and herbicides accounted for 51% of the estimated total benefits in cover cropping (see Figure 3).

Producers also reported that much of the nitrogen applied to the cover crop became available for the potato crop (about 50% N carried over the following year) as the cover crop decomposes.

This reduces input costs in potatoes (offset by the cost in the cover crop). The increased plant available nitrogen is consistent with findings of Sullivan and Andrews (2012). There were also savings from reduced P and K nutrients (i.e., 7% of total benefits), as well as reduced application of center-pivot irrigation due to improved water infiltration and water holding capacity. The latter led to a reduction in the cost of irrigation equipment repair and maintenance and cost of water penetrants.

Additional revenue. A major source of additional revenue in the cover cropping system is the ability to grow potatoes every other year, made possible with the use of mustard cover crops. Without cover crops, a potato crop is normally grown one in every three to four years due mainly to buildup of soil-borne disease. A typical three-year rotation would be potatoes–corn–wheat (Sustainable Agriculture Research and Education 2007). After the adoption of cover cropping, which increases the speed of the rotation (“rotation benefit”, Karlen et al. 1994), potatoes could be successfully produced every other year (wheat plus mustard cover crop, then potatoes) due to the reduction in nematode populations and disease pressure. As potatoes are a major profit driver in the overall farming system, this is a significant economic benefit. The rotation benefit is estimated to account for 21% of the total benefits for a cover cropping system.

Net change in profit. As can be seen in Figure 4, cover crops generated the highest return among the three soil improvement practices compared, most of which was from a reduction in fumigant costs, and the rotation benefit. Because of these benefits, the use of this type of cover cropping has increased to over 30,000 acres annually in the Columbia Basin of Washington State (McGuire 2012). Note that the increased frequency of potatoes in the rotation may lead to problems in the future with soil borne pathogens or pest infestations, which needs to be considered in the overall decision-making process.

Additional Data

In addition to the data supplied by producers in the questionnaires and focus groups, other information may be required to fully estimate the impact of a soil improvement practice. One type of additional information required, as noted above, is the cost of acquiring knowledge concerning the practice, such as travelling to workshops, conferences, talking to other producers who have tried the practice, and the time spent gathering information from electronic sources.

In the current study we did not have any data on learning or knowledge costs; hence, they are not included in the budgets. In a North Carolina cover crop program, one producer recorded and tabulated all costs involved in learning about cover crops and estimated the cost to be approximately \$67 per acre (Ransom et al. 2015). However, this cost must be treated with some caution as the total value was \$2,420, and the authors allocated this cost to all cover crop area in one year, rather than amortized over several years. There are two potential methods to capture these costs in a partial budget; one is to treat these costs as a type of fixed costs and amortize over the life of the improvement or a pre-specified period, that is, two, three or five years; and the other is to simply calculate a total cost and provide a note on the budget to that effect.

Another potential benefit of the soil improvement is the maintenance of, or perhaps increase in, land value due to the increase in productivity of the soil because of improved soil health (Lazarovits et al. 2001). The challenge with this benefit is the level of attribution that can be assigned to the practice and how, and to whom, the benefit is assessed, particularly if the land is rented. In some cases, due to difficulty in assessing or attributing the benefits, it may be that the benefit is acknowledged but not assigned. For example, land rental fees in the state of Iowa are rated based on a corn suitability rating (CSR) that takes into account soil and land characteristics, for example, slope, inherent soil properties, and erosion resistance (Iowa State University 2013). Thus, the value of any practice that improves soil productivity is captured in the CSR, and therefore, the rental value of the land. However, the value accrues to the landlord and not the tenant, even though the tenant may have incurred all the costs associated with soil improvement. A similar problem arises in determining the value of a soil improvement practice that reduces soil loss, given that soil loss and the loss of productivity can occur over a period of many years (Tanaka and Aase 1989), thus a value of saved soil or reduced soil loss is difficult to incorporate in the context of the proposed tool. However, there are several methods to estimate the value of lost soil. The first is to estimate the replacement value of lost soil nutrients, for example, fertilizer and soil carbon or organic matter (Tozer and Leys 2013). The second method is to estimate the loss in crop yield and assign a value to that loss based on crop prices (Williams and Tanaka 1996).

Other Factors to Consider – Unpriced Benefits

As noted above, most producers in all three focus groups reported, based on their observations, that the soil improvement practice they undertook increased the water holding capacity of their soil in some way or improved the tilth of their soils (e.g., soil structure or aggregation). Most producers attributed this to higher soil organic matter or soil carbon. A study of soils from most of the focus group participant's farms (McGuire et al. 2017) confirmed the observed improvements in the soil. In a parallel study of paired adjacent fields in the Columbia Basin (with and without soil improvement practices; McGuire, 2009) farmed by one of the focus group participants, fields where soil improvement practices (cover cropping) were implemented had significantly higher soil organic matter levels (0-15 cm depth) than untreated fields.

Although increase in water holding capacity or soil tilth is captured somewhat in the reduction in irrigation costs or reduced fuel costs, the value of the increased soil carbon is not captured in the simple model used. Mitchell et al. (2012) reported that in a 10-year trial, soil organic matter under a continuous no-till/minimum tillage system with or without cover crop system in California increased by 0.6 – 1.5 t/acre, soil tilth increased (with reduced compaction), and tractor trips lessened thus saving fuel costs by over 60% relative to standard tillage with or without cover crop.

Conclusion

The objectives in this research were to develop and validate a simple tool to use in measuring the costs and benefits of soil improvement practices with a particular application to the Columbia Basin of Washington State. The results show that two of the three soil improvement practices enhance the profitability of cropping enterprises in the region. Most of the increase in profit is generated by cost savings due to a lower probability of replanting crops caused by sandblasting, or by reduced soil fumigation. Demonstrating that soil improvement practices can “pay their way” in the near term is important for inducing grower interest and adoption. However, it must also be remembered that any one of the three practices is a component in a larger system, the farm production system, and as noted above some producers use more than one practice in their own system when suited to the individual crop or soil type of interest at that time in the production plan.

Numbers provided in this study are estimates based on the input of growers who participated in the focus groups. Benefits and costs for individual growers may differ, thus the results cannot be generalized to represent the population of farmers. An interactive Excel Workbook, described below, is provided to enable individual growers to estimate their returns based on their soil improvement practice.

Furthermore, we identified a set of costs and benefits that could not be incorporated into the budgets, but which could have significant long-term economic consequences, such as carbon sequestration or the increase in land value due to higher productivity. These costs are dynamic and inter-temporal in nature, and therefore are difficult to incorporate into a static economic framework. However, it is imperative in the economic analysis of any soil improvement practice to at least acknowledge these factors, and where possible assign a value that can be noted in the economic analysis of the practice to ensure producers and producer advisers are aware that not all costs and benefits are included in the budget, and that these audiences are aware that there are further added costs or benefits due to the chosen practice.

Excel Workbook

An Excel spreadsheet version of the partial budgeting tool is available at the [WSU School of Economic Sciences Extension](#) webpage for specialty crops. Growers can modify the values in the spreadsheet provided to evaluate their own soil improvement practices and any associated changes in production costs and returns.

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Cover Image:

Direct-seeded dry beans (Photo taken by Andrew McGuire).

Appendix: Partial Budget Analysis

Appendix Table 1. Partial Budget of Compost Application (\$/acre).

Costs Saved (A)	\$65.33	Additional Costs (C)	\$67.98
<u>Inputs</u>		<u>Inputs</u>	
Fertilizer savings		Manure/compost	\$47.58
- P	\$16.67		
- K	\$16.67		
<u>Machinery and Infrastructure</u>		<u>Machinery and Infrastructure</u>	
Irrigation equipment repairs and maintenance	\$4.50	Spreading	\$13.08
<u>Other Costs Saved</u>		<u>Other Additional Costs Incurred</u>	
Crop replanting costs*	\$27.50	Compost testing	\$0.65
		Transport	\$6.67
Additional Revenue (B)	\$0.00	Foregone Revenue (D)	\$0.00
Total Benefits (A+B)	\$65.33	Total Costs (C+D)	\$67.98
Net Change in Profit (Total Benefits - Total Costs) = -\$2.65/acre			

Note: * This study assumed that other factors, i.e., changes in water management or number of crops in a rotation, also contributed to a reduction in wind erosion costs, thus only a net of 5% was attributed to the compost system (equivalent to \$27.50 per acre using the average replant cost of \$550 per acre).

Appendix Table 2. Partial Budget of High Residue Farming Systems (\$/acre).

Costs Saved (A)		Additional Costs (C)	\$90.00
<u>Inputs</u>	\$132.00	<u>Inputs</u>	
Herbicides	\$20.00	Fertilizer	
Fungicides	\$20.00	- N	\$50.00
<u>Machinery and Infrastructure</u>		<u>Machinery and Infrastructure</u>	
Irrigation equipment repairs and maintenance	\$4.50	Machinery/equipment purchase	\$40.00
Fuel	\$15.00		
Machinery repair and maintenance	\$20.00		
<u>Other Costs Saved</u>			
Crop replanting costs	\$27.50		
Labor	\$25.00		
Additional Revenue (B)	\$13.00	Foregone Revenue (D)	\$0.00
Yield protected (yield x price)	\$13.00		
Total Benefits (A+B)	\$145.00	Total Costs (C+D)	\$90.00
Net Change in Profit (Total Benefits - Total Costs) = \$55.00/acre			

Appendix Table 3. Partial Budget of Cover Crop (\$/acre).

Costs Saved (A)	\$254.00	Additional Costs (C)	\$168.28
<u>Inputs</u>		<u>Inputs</u>	
Fertilizer savings		Fertilizer	
- P	\$12.50	- N	\$85.00
- K	\$12.50	Seed	\$25.91
Fungicides	\$20.00		
Fumigants	\$132.50		
Herbicides	\$20.00		
Water penetrants	\$10.00		
<u>Machinery and Infrastructure</u>		<u>Machinery and Infrastructure</u>	
Irrigation equipment repairs and maintenance	\$4.50	Seed broadcasting	\$8.50
		Mowing/chopping	\$14.00
		Machinery repairs and maintenance	\$10.00
<u>Other Costs Saved</u>		<u>Other Additional Costs Incurred</u>	
Fertilizer in subsequent crop	\$42.00	Soil testing	\$0.37
		Management	\$5.00
		Transport	\$2.00
		Water	\$17.50
Additional Revenue (B)	\$82.99	Foregone Revenue (D)	
Yield protected (yield x price)	\$12.99		
Rotation benefit*	\$70.00		
Total Additional Benefits (B)	\$82.99	Total Revenue Foregone (D)	\$0.00
Total Benefits (A+B)	\$336.99	Total Costs (C+D)	\$168.28
Net Change in Profit (Total Benefits - Total Costs) = \$168.71			

Note: *The rotation benefit is estimated at \$70 per acre from discussions with producers and based on changing from a 3-year alfalfa crop (A) and one year of potatoes (P) to a 1-year wheat plus mustard (W/M) cover crop then potatoes times two (i.e., AAAP to W/MP*2) to account for change in rotation length.



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