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Economic Potential of Compost Amendment as an Alternative to Irrigation in Maine Potato Production Systems*

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ABSTRACT

Potato productivity in the northeastern US has been relatively constant for over 50 years, raising questions about what factors are limiting productivity. Research was initiated in 2004 to identify key constraints to potato productivity by evaluating Status Quo (SQ), Soil Conserving (SC), and Soil Improving (SI) cropping systems under both rainfed and irrigated management, and it was found that addition of compost or irrigation substantially increased yield. In this study, we employed partial budgeting to determine cost differences and their impact on net revenue for these cropping systems. Differences in systems were primarily associated with rotation length, tillage operations, compost and application expenses, and water management practices. When compost (as composted dairy manure) was annually applied at 19 $Mg \cdot ha^{-1}$ and evaluated over the entire 3-year crop rotation cycle, the compost-amended rainfed SI system was more expensive to maintain than the irrigated SC system if compost cost exceeded \$3.63 Mg^{-1}. Average marketable yields were used to calculate gross and net revenue for each system. Because average potato yield for the irrigated SQ system (28.4 $Mg \cdot ha^{-1}$) equaled that in the rainfed SI system (28.3 $Mg \cdot ha^{-1}$), we were able to compare cost of irrigation versus compost for achieving comparable yield. The compost-amended SI system under rainfed management generated more net revenue from the potato crop than the irrigated SQ system when compost costs were less than \$7.42 Mg^{-1}. When compared to the commonly used rainfed SQ system, rainfed SI achieved higher net revenue as long as compost cost was less than \$22.95 Mg^{-1}. The rainfed SI system achieved higher net revenue than the irrigated SC system when compost cost was \$9.43 Mg^{-1} or less, but generated greater net revenue than the rainfed SC system regardless of compost costs, due to substantially higher yields associated with compost amendment. This investigation demonstrates that compost is a potentially viable substitute to irrigation for potato in the northeastern US; however, such potential is highly dependent on suitable compost sources and application costs.

Keywords: Compost; Cropping Systems; Economic Potential; Irrigation; Partial Budgeting; Potato Production; Water Stress; Yield

1. Introduction

The Maine potato industry is a major contributor to the State's economy, annually generating \$540 million in direct, indirect and induced impacts, and supporting employment for more than 6000 people [1]. However, the industry has contracted to about one-third of the land base used in the 1950s; during the late1940s Maine was the largest producer of potatoes in the country [2]. Much of the reduction can be attributed to increased irrigated production promoting substantially elevated yields in other regions of the United States such as the Pacific Northwest.

Other factors have also contributed to the drop in Maine's competitive position. As shown in **Figure 1** [2], potato productivity in Maine has remained relatively constant over the past five decades, while productivity in other Fall potato producing states has increased. This raises the question, "what factors are limiting productivity in Maine potato systems?"

One possible limitation may be related to the soil itself. The potential benefits of incorporating biological amendments (manure, compost, green manures, etc.) to soil are well recognized. In potato systems, these amendments increase soil carbon and nitrogen, improve soil structural

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characteristics, improve moisture-holding capacity, and may confer disease-suppressive advantages [3-9]. These attributes may be especially appealing to producers with limited water and/or degraded soil resources. Successfully implemented, soil amendments can have a positive impact on profitability and risk.

Farmers look not only at the biological potential of a crop, but also the variability in yields from season to season [10]. Yield fluctuations are caused by variable weather conditions, pest pressures, nutrient levels and other factors [11]. Due to its shallow root system, Potato (*Solanum tubersum* L.) is very sensitive to weather-related variations [12,13]. Wide fluctuations in seasonal yield that may be compounded by constraints in the plant-available water supply from degraded potato production soils make management more difficult, and also increase the level of economic risk.

The standard industry practice in Maine potato cropping systems that has prevailed for the past several decades has been a 2-year rotation with barley (or another small grain). During the potato phase of the rotation the soil is intensively tilled and undergoes other mechanical operations (hilling, spraying, fertilization, vine-kill, and harvesting). This intensity can lead to reductions in soil organic carbon concentration and structural stability and adversely affect yield potential [14-16].

Porter *et al.* [3] conducted long-term evaluations of soil management practices and supplemental irrigation and their impacts on soil properties, tuber yield, and quality in Maine. They hypothesized that water stress can reduce potato yield and quality. Treatments consisted of soil management (a green manure at the start of the rotation, and annual applications of manure, and compost) under both rainfed and irrigated conditions. After the first growing season, amended plots showed improved soil properties (e.g. increased soil organic matter, increased cation exchange capacity). After two years of amendment contributions, bulk density decreased. Amendment and irrigation both resulted in significant yield increases. Opena and Porter [13] evaluated the use of soil amendments rich in organic carbon in combination with supplemental irrigation to promote potato root growth. The amended systems had increased root length density, which was correlated with tuber yield. Supplemental irrigation showed positive impacts in one out of two growing seasons.

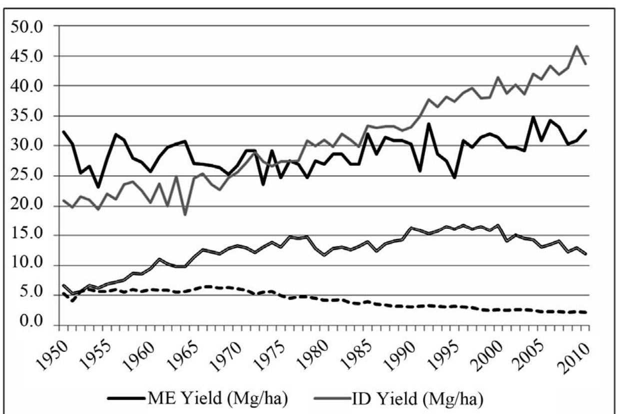

Figure 1. Historical fall potato yields and total harvested areas for Maine and Idaho from 1950 to 2010.

Under intensively tilled short rotations, managing soil carbon and nitrogen can be difficult. Griffin and Porter [16] examined the results of a long-term trial to assess the effect of cover crops, green manure, and amendment application frequency on soil carbon and nitrogen pools. They concluded cover crop and green manure had little impact on total carbon and nitrogen content. However, a single application of paper mill sludge, animal manure and/or compost increased carbon and nitrogen by 25% - 53%. It was found that these latter management practices led to large increases in total particulate organic matter and microbial biomass carbon and nitrogen.

As previously mentioned, one criterion producers evaluate for crop selection is stability in yields. Mallory and Porter [17] reported on potato yield variability from a long-term (13 years) potato cropping systems study conducted under contrasting soil management strategies. Of particular interest were yield differences between amended and non-amended potato systems. They found the amended systems increased total yield by up to 54% with US no. 1 yield gains up to 36%. In addition, the amended soil management system promoted greater yield stability, particularly in seasons with low rainfall.

A recurring theme of these studies is that increasing soil organic matter can decrease yield risk. Porter *et al.* [3] suggested that incorporating biological amendments may be an alternative to supplemental irrigation. Although adequate precipitation is generally received in Maine, the timing of that rainfall often does not occur at critical stages of crop growth. Benoit and Grant [18] computed a plant water deficit index and compared this to the actual evapotranspiration over the growing season. Based on 30 years of weather data, they found that even in the wettest years, potato still faced periods of five days or more with insufficient water. In subsequent research, Benoit and Grant [19] found that potato yields were also adversely affected by too much water and recommended the adoption of both supplemental irrigation and improved drainage. The Maine Irrigation Guide [20] projected that in 9 out of 10 years potatoes will benefit from supplemental irrigation. Authors of the guide also reported that irrigation will increase yield of US no.1 tubers by an estimated 38%.

Given the interest in both supplemental irrigation and organic amendments in Maine, it is surprising that little

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research has been conducted on the economics of these cultural practices. An exception is the research conducted by Dalton *et al.* [21] they compared the risk management benefits of supplemental irrigation versus federal crop insurance programs and uninsured rainfed crop production. An expected utility framework was used to differentiate the programs. They found for large-scale contiguous field operations (>81 ha), there are risk management benefits for water development. The impact on smaller operations with respect to managing risk was less certain. Dalton *et al.* [21] concluded that supplemental irrigation is preferred by the risk-averse producer over buying crop insurance. They also found that the risk management benefits are technology dependent. Thus, while supplemental irrigation can reduce production risk, the ability of producers to deploy this practice is dependent on scale factors (small vs. large) and technology (fixed vs. portable system).

The analysis by Dalton *et al.* [21] demonstrates the complexity of the irrigation decision. Unless conditions are favorable (*i.e.*, appropriate scale and technology), irrigation may not be economically beneficial due to uncertainty regarding weather events, future costs and revenues generated by this practice. The objectives of our investigation were to determine if improving soil properties by adding compost can achieve the same risk reduction benefits and if compost amended potato systems were comparable in cost to supplemental irrigation.

2. Material and Methods

2.1. Field Study

Field experiments were established in 2004 that encompass different categories of cropping systems designed to identify limitations to sustainability. Systems were designed and managed as 1) Status Quo (SQ); 2) Soil Conserving (SC); and 3) Soil Improving (SI) (**Table 1**). The SQ system consisted of a barley-potato 2-year rotation (typical for potato growers). The SC system was a 3-year rotation of no-till barley underseeded with timothy (forage grass) in Year 1, timothy alone in Year 2, and potato followed by straw mulch in Year 3. The SI system built upon the SC system by adding composted dairy manure at a dry weight equivalent of 19 $Mg \cdot ha^{-1}$ in each phase of the rotation. All rotation entry points were grown each year under both irrigated and rainfed management (thus potato crops were harvested each year); 5 replications were arranged in a split-block design, with water management as the main block and cropping system as the sub-plot. Each cropping system by water management sub-plot combination was 4 m wide by 16 m long, with a 16 m buffer between sub-plots to ensure the separation of water management treatments which were applied with a lateral, overhead sprinkler irrigation system. Irrigation water (1.25 cm) was applied to all irrigated treatments, and application was triggered when 25% of the tensiometers placed in irrigated plots registered 0.5 MPa. Insects and weeds were controlled in all plots using commercially available pesticides (and tillage) following University of Maine recommendations**.** Each system was evaluated by our interdisciplinary team for plant growth and productivity, soil chemical-physical-biological properties, tuber diseases, soil-borne diseases, foliar diseases, economics, and their interactions. Additional details of the set-up and methodologies of the field experiment, as well as system effects on soilborne disease and soil microbial communities are available in Larkin *et al.* [7]. Rotations and treatments were maintained each year and data were collected from potato crops for this study from 2004 to 2008.

2.2. Economic Analysis

A partial budgeting approach was employed to determine cost differences and their impact on net revenue [22]. Partial budgeting includes only those costs that vary from one enterprise (system) to another. For example, since all systems received the same fertilization regime these costs are not included. Costs that varied were associated with tillage operations, compost and its application, and water management practices (*i.e.*, rainfed or irrigated).

To evaluate the differences in costs related to potato cropping systems utilizing compost versus irrigated and non-irrigated systems, associated costs were determined on an annual basis as well as for the full 3-year rotation period. Costs for the 3-year rotation includes all costs for each crop in the rotation (costs of seed, planting, tillage, crop maintenance), including crops that derive no revenues (such as timothy forage crop). We evaluated the cropping systems with compost costs ranging from \$0 Mg^{-1} to \$27.21 Mg^{-1}. Irrigation costs were based on values from Dalton *et al.* [21] adjusted by the spring 2008 producer price index for agriculture from the Bureau of Labor Statistics. The cost for spreading compost was based on the average NASS custom rate from Pennsylvania.

Table 1. Characteristics of the cropping systems evaluated in this study comparing a typical 2-year rotation (Status Quo, SQ) with 3-year Soil Conserving (SC) and Soil Improving (SI) alternative systems.

Cropping system	Year one	Year two	Year three
Status Quo (SQ) (2-yr)	Barley/ red clover	Potato	N/A
Soil Conserving (SC)	Barley/timothy	Timothy sod	Potato
Soil Improving (SI)	Barely/timothy + Compost	Timothy + Compost	Potato + Compost

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Additional economic data collected over a 5-year cropping period (2004-2008) included marketable yields and revenue. Marketable yield for potatoes was determined as the weight of all tubers that were 114 g or greater, which corresponds to commercial standards. Revenue was determined from the marketable yield based on average market prices from NASS figures for Maine for each harvest year. Average marketable yields were used to calculate gross and net revenue for each system over the course of the study.

3. Results and Discussion

3.1. Costs and Revenues

Differences in costs related to potato cropping systems utilizing compost versus irrigated and non-irrigated systems were determined on an annual basis as well as for the 3-year rotation period. The relative annual cost of irrigation was estimated at 9.94% of the total potato production costs, whereas costs associated with compost included both the cost of spreading it on the fields (estimated at 2.6% of production costs) and the cost of acquiring the compost (which ranged from 0% to 27.1% of total potato production costs as compost cost increased from 0 to \$27.21 Mg^{-1}). Cost of the rainfed SI cropping system ranged from 90% to 165% of the cost of the irrigated SQ barley-potato cropping system (**Figure 2(a)**). The rainfed SI system became more costly than the irrigated SQ system once compost costs exceeded \$3.63 Mg^{-1}. Cost of the rainfed SI system ranged from 115% to 210% of the cost of rainfed SQ system over a 3-year cropping cycle (**Figure 2(a)**). As shown in **Figure 2(b)**, the SI system was always higher in cost compared to the SC system over the 3-year rotation interval, except when the compost cost dropped below \$1.81 Mg^{-1} and the SC system was irrigated.

Gross and net revenue for each system were calculated from average marketable yields. Interestingly, average potato yield for the irrigated SQ system (28.4 $Mg \cdot ha^{-1}$) equaled that obtained in the rainfed SI system (28.3 $Mg \cdot ha^{-1}$). Consequently, this parity in yield outcomes provided a rather unique opportunity to compare costs of irrigation vs. compost to achieve the same overall yield. In this comparison, the SI system under rainfed management generated more net revenue from the potato crop than the irrigated SQ system if compost costs were under \$7.42 Mg^{-1} (**Table 2**).

The rainfed SI system was also compared to the rainfed SQ system. With compost cost ranging from 0 to \$27.21 Mg^{-1}, net revenue from potato in the SI system ranged from \$391.94 to \$208.06 (**Table 2**). Net revenue from rainfed potato in the SI system exceeded that in the SQ system when compost cost less than \$22.95 Mg^{-1}. Comparing only the potato years, this suggests that growers using the traditional barley-potato rotation under rainfed management could possibly increase their net revenue by applying compost when the cost of this amendment was below \$22.95 Mg^{-1}.

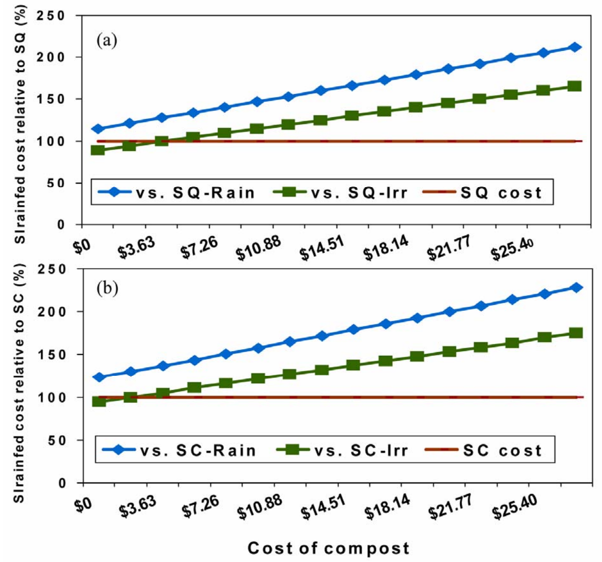

Figure 2. Comparison of production costs for Soil Improving (SI) rainfed cropping system (with compost) in relation to A) Status Quo (SQ) (standard 2-year rotation) and B) Soil Conserving (SC) (3-year system, without compost) cropping systems under both rainfed and irrigated conditions for the entire 3-year cropping cycle, and expressed as a percentage of costs for each system. Horizontal (red) line represents same cost as comparison system (100%).

For making compost versus irrigation comparisons over an entire cropping system, the two most appropriate management strategies to consider were the rainfed SI system and the irrigated SC system. This is because the same 3-year barley-timothy-potato rotation was used in both systems, but compost was added only to the SI system. The SQ system (a 2-year rotation) restricted systems level comparisons with the 3-year rotation systems due to the unequal rotation length and associated cost disparities. When considering just the potato crop alone, the rainfed SI system returned greater net revenue than the irrigated SC system at all compost prices evaluated (**Table 2**). If all three crops (barley-timothy-potato) were included in the analysis, net revenue was less negative in the rainfed SI system compared to the irrigated SC system when compost cost was below \$9.43 Mg^{-1} (**Table 2**). In this case, although production costs were higher for the compost-amended SI system than the SC system even at relatively low compost cost (**Figure 2(b)**), overall revenues were higher for the SI system due to substantially higher yields associated with compost amendment. For example, average marketable potato yield for the rainfed SI system yield was 28.3 $Mg \cdot ha^{-1}$ compared to 21.7 $Mg \cdot ha^{-1}$ in the irrigated SC system, which represents an

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Table 2. Net revenue generated from three cropping systems under irrigated or rainfed conditions in relation to variable costs of compost for a single potato crop and over the entire cropping cycle for each cropping system.

Cropping system[a]	Cost of Compost ($/Mg)	Net Revenue from One Potato Crop ($/ha)	Net Revenue from 3-yr cropping system ($/ha)
SI rainfed	0.00	391.94	89.05
	1.81	351.94	(30.95)
	3.63	311.94	(150.95)
	5.44	271.94	(270.95)
	7.26	231.94	(390.95)
	9.07	191.94	(510.95)
	10.88	151.94	(630.95)
	12.70	111.94	(750.95)
	14.51	71.94	(870.95)
	16.33	31.94	(990.95)
	18.14	(8.06)	(1110.95)
	19.95	(48.06)	(1230.95)
	21.77	(88.06)	(1350.95)
	23.58	(128.06)	(1470.95)
	25.40	(168.06)	(1590.95)
	27.21	(208.06)	(1710.95)
SQ irrigated		228.51	259.86[b]
SQ rainfed		(114.17)	(83.65)[b]
SC irrigated		(237.47)	(534.80)
SC rainfed		(173.87)	(112.67)

[a]Cropping systems: SQ = Status Quo system, 2-year (barley/red clover-potato) standard rotation; SC=Soil Conserving system, 3-year (barley /timothy-timothy-potato), reduced tillage; SI = Soil Improving system, same as SC (3-year, barley/timothy-timothy-potato), but with yearly compost amend- ment (composted dairy manure at 19 Mg·ha^{-1}) added. [b]Since SQ system is a 2-year rather than a 3-year rotation, these values reflect net revenues over the 2-year cropping system instead of 3 years.

average yield increase of 30%. It also should be noted that in these 3-year cropping systems, the middle year of the rotation consisted of timothy, a forage grass crop, which yielded no revenue. Thus the net revenue over the 3-year rotation is substantially lower than for the potato crop year alone due to this lack of revenue for the timothy rotation crop.

3.2. Risk and Stability

In 2004, each entry point of each crop rotation was initiated so that yields were available from five full years of potato crops, although the effect of the full rotation was not observed until the 2006-2008 growing seasons. When the response to compost was evaluated by comparing yield in the rainfed SI system to yield in the irrigated and rainfed SQ systems, in only one year was the response negative when compared to the irrigated SQ system; it was never negative when compared to the rainfed SQ system. Using these same comparisons, the response to compost resulted in at least a 20% yield increase in five out of ten potato crops (both irrigated and non-irrigated), and over 10% increase in yield in eight out of ten potato crops (**Figure 3**). This represents an average yearly yield increase due to compost amendment of 11% and 33% compared to the irrigated and non-irrigated SQ system, respectively, over the full five years of the study. The yield benefit from compost amendment was even greater when compared to the SC system, in which the yield from the composted SI rainfed system was at least 40% greater than that from the SC system in four out of ten potato crops, and at least 15% greater in every potato crop from 2004 to 2008 (**Figure 3**), representing an average yield increase due to compost amendment of 28% and 47% compared to the irrigated and non-irrigated SC system, respectively.

3.3. Additional Considerations

Our economic analysis indicates that the SI cropping system, as presently configured, does not offer the most economically advantageous system in the short-term (less than or equal to 4 years from implementation of amendment additions). There does appear to be a greater likelihood of conferring an advantage for the potato crop when compared to the conventional SQ rotation in rainfed circumstances, and an advantage over the conventional SQ rotation in the irrigated system depending on compost costs. The strength of the compost system comes from utilizing the compost as a moisture regulator in the soil, to buffer the crops through high moisture levels and conserve moisture in the soil through moisture

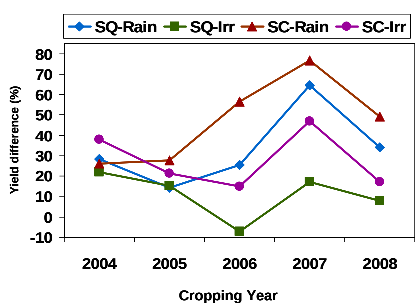

Figure 3. Relative change in marketable yield (%) compareing tuber production from SI rainfed cropping system to other cropping systems (SQ and SC, rainfed and irrigated) in potato crops from 2004 to 2008. SQ = Status Quo system, 2-year (barley/red clover-potato) standard rotation; SC = Soil Conserving system, 3-year (barley/timothy-timothy-potato), reduced tillage; SI = Soil Improving system, same as SC (3-year, barley/timothy-timothy-potato), but with yearly compost amendment (composted dairy manure at 19 Mg·ha^{-1}) added.

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deficient periods.

Previous researchers have quantified that in three out of every four years, there is at least one 5-day period where moisture levels are lower than optimal for potato production [18]. This indicates that supplemental applications of water may be needed, but generally only over very short periods of time during the growing season. Thus, if compost can improve soil quality so that surplus water drains more effectively [23,24], and plant-available water holding capacity is enhanced [25], then compost amendments may serve as an important alternative to supplemental irrigation for improving yield and reducing risk. And use of compost amendments as an alternative to irrigation does not have the high initial development costs inherent in establishing an irrigation system.

Other studies have indicated that compost-enriched soil can also reduce erosion, alleviate soil compaction, increase soil microbial abundance and diversity as well as help control diseases and pest infestations in plants [7-8,26-30]. Potato is in the top tier of crops with the highest erosion risk [31,32]. Additionally, in some production settings harvest erosion rates may be of the same order of magnitude (approximately 10 $Mg \cdot ha^{-1} \cdot yr^{-1}$) as water and tillage erosion on sloping land. Tiessen *et al.* [33] reported soil losses of 20 - 100 Mg $ha^{-1} \cdot yr^{-1}$ from convex landscape positions in commercial potato production systems of Atlantic Canada; these observations were linked to crop yield reductions of up to 40%. Recent geospatial assessments of agri-environmental indicators (combining farmland and erodibility classifiers) based on a 3-year production footprint showed that close to 85% of Maine potato systems soils were either "potentially highly erodible" or "highly erodible" [34,35]. These soils require the highest standards in soil conservation practices. Investigators in Atlantic Canada found that the use of a bulk yield monitoring device with GPS helped resolve the yield benefits of an alternative residue management strategy compared to the conventionally managed portion of the field [36].

High-resolution investigations that detail crop yield in topographic/hydrodynamic contexts and assess fine-scale soil resource risks (preferably farmscape-assemblage to watershed- or subregional-level) for key "food security" cropping systems such as potato using geographic information systems (GIS) based approaches are needed [37]. Geospatial frameworks help resolve patterns and trends in production environments (at multiple scales). Implementation of these technologies will help farmers build detailed archives on site-specific production constraints that may enable improvements in adaptive management strategies which enhance yield and increase whole-farm profitability. Longer-term beneficial outcomes from compost use tailored to potato systems have the potential to improve soil quality and health and increase plant productivity while possibly reducing alternative management costs such as deep tillage to alleviate compaction and pest/pathogen applications.

Another value that can be attributed to compost is its plant nutrition content. This could significantly lower fertilization costs. The value of the P and K fertilizer used for these cropping trials varied from year to year due to market conditions. For example, application of 2.5 cm of mature compost containing 1% P_2O_5 will add 840 kg of this nutrient per hectare [38]. In addition, since K is not incorporated into soil organic matter, K furnished by finished compost is much more available for plant uptake compared to N and P [38]. The potential offset of costs by using compost to meet P and K crop requirements ranged from approximately \$185 ha^{-1} to over \$370 ha^{-1}. Considering this fertilizer cost offset makes the rainfed SI system more profitable than the irrigated SC system at any compost cost when evaluated for a single potato crop (**Table 3**), and at compost costs less than approximately \$15 Mg^{-1} for the entire three-year rotation system (**Table 3**).

Table 3. Net revenue generated by the Soil Improving (SI) cropping system under rainfed conditions and with variable compost costs (as updated to reflect lower fertilizer costs) compared with the Soil Conserving (SC) cropping system under both rainfed and irrigated conditions for one potato crop as well as the full 3-year cropping system.

Cropping system	Cost of Compost (\$/Mg)	Net Revenue from One Potato Crop (\$/ha)	Net Revenue from 3-yr cropping system (\$/ha)
SI rainfed[a]	0.00	597.94	463.05
	1.81	557.94	343.05
	3.63	517.94	223.05
	5.44	477.94	103.05
	7.26	437.94	(16.95)
	9.07	397.94	(136.95)
	10.88	357.94	(256.95)
	12.70	317.94	(376.95)
	14.51	277.94	(496.95)
	16.33	237.94	(616.95)
	18.14	197.94	(736.95)
	19.95	157.94	(856.95)
	21.77	117.94	(976.95)
	23.58	77.94	(1096.95)
	25.40	37.94	(1216.95)
	27.21	(2.06)	(1336.95)
SC irrigated		(237.47)	(534.80)
SC rainfed		(173.87)	(112.67)

[a]Cropping systems: SC = Soil Conserving system, 3-year (barley/timothy-timothy-potato), reduced tillage; SI=Soil Improving system, same as SC (3-year, barley/timothy-timothy-potato), but with yearly compost amendment (composted dairy manure at 19 $Mg \cdot ha^{-1}$) added.

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4. Conclusions

Our analyses indicate that compost amendments may be a viable alternative to supplemental irrigation. One major advantage is that it requires no large capital outlay. For example, as Dalton *et al.* [21] found, a field slightly over 80 ha could cost as much as $200,000 when water development costs were included. This represents a large opportunity cost. In addition, the majority of potato production areas in the Northeast U.S. present significant challenges for irrigation (e.g. lack of surface or ground water source, undulating topography, irregularly-shaped fields, and a high number of non-adjacent fields).

Consideration of weather-related impacts and the probability that in three out of every four years, there is at least one 5-day period where moisture levels are lower than optimal for potato production [18], compost amendments may serve as an important alternative to supplemental irrigation for improving yield and reducing risk.. However, a noteworthy constraint to the SI system is the cost of compost and its application in the short-term (≤4 years). Current market rates for purchasing compost in Maine can run as much as $30 to $40 Mg^{-1} (Mark Hutchinson, University of Maine, personal communication), which would make compost application much less economically feasible for potato growers. However, with on-farm composting, local availability, and cooperative associations with livestock farms and compost producers, compost costs may be substantially reduced to more favorable levels, making the use of compost far more attractive. Further research is also needed to determine if the same or similar yield benefits from adding compost can be attained at reduced application rates or application frequencies, perhaps also coupled with the feasibility of site-specific applications. Additional considerations involve customization of the compost mixture for a particular application and soil type based on parameters that include maturity, stability, pH level, density, particle size, moisture, salinity, and organic content. Other system modifications such as inclusion of more marketable rotation crops may also serve to improve overall system profitability.

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