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Evaluating Self-Propelled Sprayer Ownership with the OwnSprayer Spreadsheet

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Terry Kastens, K-State Ag. Economics (785-626-9000; tkastens@ksu.edu)
Kevin Dhuyvetter, K-State Ag. Economics (785-532-3527; kcd@ksu.edu)

Background

The recent trend towards less tillage brought about by advances in farm chemicals, especially herbicides, has sharply increased the availability and interest in self-propelled crop sprayers that can be used for both pre- and post-plant treatments. This paper accompanies the OwnSprayer computer spreadsheet, which was developed as a "quick and dirty" aid to help individuals think through the self-propelled sprayer ownership decision. Thus, most of the underlying assumptions and formulas are simply asserted rather than developed here. For a more comprehensive treatment of machinery costs, and for development of the mathematical formulas underlying OwnTractor, the reader is directed to Farm Machinery Operation Cost Calculations, MF-2244 (referred to here as MF2244) and Lease, Custom Hire, Rent or Purchase Farm Machinery: Evaluating the Options. Supporting research references are contained therein. Both publications can be found at the website www.agmanager.info. The reader is pointed also to the OwnTractor, OwnBaler, and OwnCombine spreadsheets available at the same website.

Machinery investment decisions are inherently complex because they involve time, and a dollar today is worth more than a dollar tomorrow – because it can earn interest. A few examples of time issues regarding machinery are a) machinery depreciates over time; b) tax depreciation and market depreciation typically occur at different rates; c) repairs tend to increase as a machine ages; and d) as machines age they become less dependable (more prone to breakdowns), leading to owner concerns about timeliness. Although OwnSprayer accommodates most relevant time-dimensioned issues related to sprayer ownership, it does not explicitly deal with timeliness issues. That is, quantifying loss of business for custom applicators or reduced crop yields for farm operators due to excessive breakdowns is not handled by OwnSprayer. Such potentially important considerations are left to the user to assess. Further, although OwnSprayer does consider tendering (i.e., keeping the sprayer supplied with water and chemicals) costs, that part of the spreadsheet is not fully developed.

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In an economic analysis, machinery ownership and operating costs often are classified into the following categories: 1) interest; 2) depreciation; 3) repair and maintenance; 4) labor; 5) fuel and lubrication; and 6) property taxes, insurance, and shelter (TIS). Although the timing of tax depreciation does impact overall costs and profitability, the depreciation ultimately of interest here is market depreciation. Market depreciation is the change in machine market value over time, which represents a real loss in asset value. Although based on prevailing lender interest rates, the interest cost considered most important here is opportunity interest, rather than the interest associated with an actual loan arising from an owner's financing decision. That is, because equity could be invested elsewhere, it is considered to bear interest just as does debt (and at the same rate – see MF2244). Because a machine could have been sold at the end of last year, with the proceeds invested elsewhere, this year's opportunity interest cost is calculated by multiplying last year's machine market value by the prevailing lender interest rate. In its sprayer analysis, OwnSprayer follows the same machinery ownership and operating cost categories as described above.

The goal of machinery investors is assumed to be maximizing after-tax (i.e., income tax) profits. Thus, wherever necessary, OwnSprayer computes after-tax values. However, because decision makers are used to comparing observed costs, which are intrinsically pre-tax (e.g., the price of fuel or reported custom rates), OwnSprayer converts after- to pre-tax values in the final analysis.

Following a discussion around sprayer valuation, this paper proceeds directly into a description of using the OwnSprayer spreadsheet. A brief discussion of underlying concepts and assumptions, on an issue-by-issue basis, is provided in that section.

Market Valuation (Depreciation)

A key requirement of the sprayer investment decision is a reasonable expectation of market valuation (depreciation) over time. That is, how much will a new or used sprayer purchased for X dollars today be worth Y years from now, after being used for Z hours each year? To be most reliable, machinery market valuation formulas should be based on many years of observed market data. Consequently, the market valuation formulas in OwnSprayer were developed using information extracted from Iron Solutions, The Official Guide of the Equipment Industry (the Guide). The Guide is essentially the “Blue Book” of the North American Equipment Dealers Association (NAEDA). It shows expected market values for several brands of sprayers, from new to 10+ years old. It shows the typical hours expected on a sprayer and has formulas for adjusting market value if the hours are different from expected. Additionally, it shows how to value various sprayer options, for example foam markers, specialized guidance packages, stainless steel tanks, and larger boom sizes. The Guide is designed so that a machinery dealer can look up the value for a particular used sprayer today. Since sprayers depreciate over time, it is important for the dealer to have access to the most recent information, and consequently, the Guide is published quarterly.

Although it would be conceptually possible to construct a large computer lookup program based on information from the Guide, that would be most cumbersome and would require constant updating with each new issue. To overcome such problems, OwnSprayer does two things. First, it uses only rate of depreciation information extracted from the Guide, and does not depend on using the Guide’s actual value predictions. Second, OwnSprayer depends on an expected sprayer purchase price that is provided by the user. In addition to always being current, that expected purchase price embodies a great deal of other information. For example, a sprayer with GPS-based automatic steering will have a higher purchase price than one without that feature. Thus, it is left up to the user to be sure “apples” are not being compared with “oranges.” In the example, sprayers with and without GPS steering should not be directly compared unless the user is willing to make an expected price adjustment to the purchase price. All in all, relying on the Guide for only depreciation rate information, and relying on the user for a reliable purchase price, means OwnSprayer should be reasonably reliable for several years to come.

It should be noted that the sprayer market price series from the Guide used in OwnSprayer is the series referred to as the Resale Cash Value. As defined in the Guide, it “is a reference point for what the unit will be worth on the lot, after reconditioning, on a cash basis. It does not take into account the added dealer costs of offering interest-free financing, extended warranty, etc.” Essentially, this price series embodies all repair and rebuilding costs to ensure the sprayer is in top running condition given its age and hours. We considered using an alternative price series, referred to as the Trade Value Premium series, which is typically about 88% of the Resale Cash Value. However, the engineering type formulas we use for repair calculations (described later) assume sprayers are kept in top condition with all of the necessary repair and rebuilding costs. Thus, if a user is accustomed to thinking of used sprayer value being that which he can obtain from a dealer given the dealer will do some reconditioning when he gets the sprayer in, then OwnSprayer might slightly overstate expected future market value for a used sprayer. However, given the engineering-type repair calculations, the spreadsheet will probably slightly overstate repairs for such users. Consequently, on the balance, the two overstatements should offset each other, providing a reasonable measure of total sprayer costs.

In the analysis behind OwnSprayer, we fundamentally considered depreciation as a separate function of age and of hours of use. That is, aging a sprayer without putting hours on it will cause it to depreciate at a certain rate and putting more hours on a sprayer without making it any older will cause it to depreciate at a different rate. We also tested a number of more complex relationships. For example, we examined whether the depreciation due to age might change due to hours and vice versa. We also tested other more complex models of depreciation. Although adding complexity to the depreciation formulas always resulted in predicting market value more accurately for some sprayers, when we tried to generalize the formulas across different sprayers, it would cause other sprayers' market value to be predicted less accurately. Consequently, OwnSprayer uses the more simple depreciation relationship, where age and hours are considered independently.

Considering the tradeoff between predictive accuracy and the generality that fosters usability of OwnSprayer, we settled on five classes of sprayers, with each class having its own age and hours depreciation factors (tank SS denotes stainless steel tank and boom90 indicates 90 foot boom):

Class 1: CaseIH Patriot3185 tankPoly750 boom90
Class 2: CaseIH Patriot4420 tankSS1200 boom90
Class 3: JD4730 tankSS800 boom90
Class 4: SpraCoupe4460 tankPoly400 boom80
Class 5: Willmar8500 tank825SS boom90

Based on the analysis undertaken, we believe that OwnSprayer will be reasonably reliable for a broad class of self-propelled sprayers. We do not consider sprayer options to be particularly problematic for the analysis – though the user is cautioned to compare sprayers with similar options. For sprayer classes not explicitly considered, the user should simply insert the class he believes is most like the sprayer being considered.

Using the OwnSprayer Spreadsheet

The OwnSprayer spreadsheet calculates ownership and operating costs for sprayers using internal calculations based on inputs provided by the user. Blue numbers in the spreadsheet are user inputs and black numbers are calculated from the blue numbers. Simply put, if the user wants a black number to change, he must change a blue number. The spreadsheet accounts for both time-dimensioned variables as well as those that are fixed over time. This section of the paper describes each of the spreadsheet inputs, assumptions, and related calculations. The end result is an annually amortized pre-tax cost per hour that can be compared across alternative sprayer ownership strategies, as well as directly with custom rates.

In OwnSprayer, the time a purchase decision is made is considered year 0. The first year a sprayer is actually used is considered to be year 1, and so on. Although income taxes typically are not paid until early in the year after they are accrued, for simplicity, we assume taxes are paid in the same year as accrued. This should result in little distortion overall, and potentially none for those paying income tax estimates quarterly. Thus, with these assumptions, because the sprayer is considered purchased in year 0, that is also the first year that tax depreciation is taken. Conceptually, for a sprayer that is to be used for 3 years, it is probably best to think of purchasing it on December 31 in year 0, using the sprayer for spraying operations throughout the year-1, year-2, and year-3 seasons, and subsequently selling the machine on December 31 in year 3.

Notice that OwnSprayer assumes the sprayer is explicitly sold following the last year of use rather than traded in. Because trading a machine results in a change in tax basis rather than in depreciation recapture, results would be different than those calculated in the spreadsheet. However, as long as treatment of exiting machines is consistent (as it is here, where exiting machines are always considered sold), then using OwnSprayer to evaluate different sprayers is still appropriate – whether or not a sprayer is in fact sold or traded.

The OwnSprayer spreadsheet has three main sections: 1) user input and related calculations section, 2) time and tax (TT) section, and 3) analysis summary section. User inputs are entered in the user input section. This section also shows related calculations for use elsewhere or otherwise of interest to the user. The time and tax section displays the time-dimensioned variable values over time, ultimately leading to a computation of after-tax net present value of costs. The sprayer analysis summary section condenses the results of the analysis into a breakdown of pre-tax sprayer ownership and operating costs by category, providing costs that can easily be compared across alternative ownership strategies and directly with custom rates.

The OwnSprayer spreadsheet has three main sections: 1) user input and related calculations section, 2) time and tax (TT) section, and 3) analysis summary section.

The following is a step-by-step discussion of the inputs required in the User Input section.

Step 1. Select the sprayer's class, age, and accumulated hours at the time of purchase

Step 2. Select the sprayer's expected purchase price

This is the dollar amount expected to be paid for a sprayer in question (without a trade-in).

Step 3. Select the sprayer's market price

The sprayer's market value determines a number of costs in the spreadsheet. First, it determines a new equivalent price (NEP), which is used to determine accumulated repair costs over time and thus annual repair costs. Additionally, it is used to initialize the market value series that ultimately determines annual market depreciation, opportunity interest costs, and TIS (property taxes, insurance, and shelter) annual costs. Intuitively, these annual costs should not vary based on whether a sprayer buyer happened to get an especially good or especially bad deal on the sprayer purchase. Consequently, the spreadsheet needs to isolate the purchase price from the market price of the sprayer in question.

In practice, the sprayers's purchase price and market price typically should be the same. At least a user should start that way. Then, the user can examine the impact of "talking the dealer down" simply by inserting a lower purchase price in that cell. On the other hand, a buyer might believe that "paying over the market" is appropriate for a sprayer in especially good condition. Inserting a market price that is lower than the purchase price means that the resultant dollars of annual depreciation will be lower than it would have been had it been keyed off of the purchase price (since, given a sprayer usage rate, depreciation is a constant percent of market value) – precisely what is desired for someone purchasing a mint condition sprayer, for example.

Step 4. Select a cash downpayment

As already discussed, there is an opportunity interest cost associated with an investment whether or not money is actually borrowed – because equity funds could just as well be invested elsewhere to earn a return. Thus, for a sprayer investment, the choice of financing does not impact profitability or cost. However, to aid understanding, OwnSprayer allows for a user-selected downpayment. Then, OwnSprayer shows (in the TT section) the cash flows associated with an interest-only loan, followed by a balloon principal payment at the end of the last year of use for the sprayer. Other loan structures, such as an annually amortized loan, are not considered in OwnSprayer. Of course, such alternative structures would not impact profitability or cost. Users might select different downpayment amounts to see that sprayer costs do not change.

Step 5. Select the number of seasons (years) the sprayer will be used before it is sold

Step 6. Select boom width and travel speed
Based on boom width and travel speed, the spreadsheet calculates theoretical acres per hour at 100% efficiency.

Step 7. Select the operating efficiency
Relative to many field operations, and partly due to fast travel speeds, crop sprayers are generally not very efficient. That is, substantial time is spent moving from field to field, slowing down for turnarounds, and tendering the sprayer. MF2244 suggests a field efficiency range of 50% to 80% for pull type sprayers operating at 3 to 7 mph. Likely, self-propelled sprayers are less efficient. Unless the user has better information, we suggest values in the 30% to 50% range. Based on the field efficiency selected, the actual acres covered per hour is calculated.

Step 8. Select the expected number of acres covered annually by the sprayer
Using the user-supplied annual number of acres covered, along with actual acres per hour, the spreadsheet calculates the number of hours expected to be put on the sprayer each year – a key variable for determining repairs, market depreciation, and labor costs. Based on casual evidence from farm and commercial applicators, covering much more than 25,000 acres/year with a single sprayer is often unrealistic. For some farm operators, a practical upper limit may be only 10,000 to 15,000 acres. As a reminder, spraying the same 100 acre field three times counts as 300 acres.

Step 9. Enter the relevant labor information
Due in part to time spent traveling to and from sprayer sites, and to sprayer service time, labor hours used in the spraying operation typically are greater than engine hours tallied on the sprayer. Thus, the spreadsheet asks that you enter an estimate for the labor efficiency associated with the sprayer only (i.e., do not include labor associated with tendering operations). A value of 1.0 would indicate that the only labor associated with the sprayer is when the engine is running. A value of 1.25 would indicate that for every hour the sprayer engine is running, an additional 15 minutes (60 x 0.25) of labor are required. In the absence of better information, a suggested range is 1.1 to 1.5. Also, enter a reasonable hourly wage for sprayer operation. But, be sure that hourly labor charge includes all labor and associated management cost, whether it is hired labor or labor of the operator. Don't forget to include payroll taxes and fringe benefits. If you are an owner operator, this is the wage rate you will be "paid" for your time spent in the spraying operation.

Step 10. Select fuel per hour and price per gallon
Fuel per hour should be the expected gallons per hour consumed by the sprayer. Fuel price is typically the expected price of non-taxable (farm-use) diesel. Besides fuel consumption and price, the user is asked to select the percentage that oil and lubrication cost is of fuel cost. MF2244 suggests this value to be 10%; others suggest values as low as 5%.

Step 11. Select the Repair Adjustment Factor (RAF)
To allow for repairs that increase as sprayers age with use, OwnSprayer calculates repairs following procedures developed by the American Society of Agricultural Engineers. Based on the publication ASAE D497.5 FEB2006 Agricultural Machinery Management Data, obtained from ASAE's website, and which describes the standards as of February 2006, accumulated repairs are described by the formula:

$$\text{accumulated repairs} = NEP*RF1*(\text{accumulated hours}/1000)^{RF2},$$

where NEP is the new equivalent price of the sprayer, and RF1 and RF2 are repair factors. Then, annual repairs is calculated by subtracting last year's accumulated repairs from this year's accumulated repairs. MF2244 provides ASAE-suggested RF1 and RF2 factors for a variety of equipment, but not for self-propelled sprayers. After considering various simulations using OwnSprayer, we believe that MF2244's repair factors for self-propelled windrowers may be reasonable for self-propelled sprayers, namely RF1 = 0.06 and RF2 = 2.0. Based on the user's assessment, repairs could be proportionately adjusted up or down by changing RF1. Thus, setting RF1 = 0.066 would boost all repairs by 10%. Also, if a user believes repairs should grow faster (slower) with increased hours, RF2 would need to be adjusted up (down). However, for simplicity, it is recommended that user adjustments to repairs enter through the RAF factor.

If a user considers the expected future annual repairs calculated by the spreadsheet to be inconsistent with other information he might have, then he can set the RAF factor at some value other than 1.0. The RAF factor does a simple proportionate scaling. That is RAF = 0.90 and RAF = 1.10 imply annual repairs that are 10% lower or 10% higher, respectively, than what would be predicted using the ASAE formula.

Given the related discussion in the Market Valuation section, the user is cautioned against setting the RAF to something below 1.0 merely because he believes the projected repairs are too high. Rather, he should look also at the expected future market value, which might also be too high by his assessment, and thus the two values would more-or-less offset each other. Additionally, it is easy for a farmer who does his own repairs to forget the cost of his labor and the cost of keeping up his shop. It is also easy to forget to prorate large and infrequent overhaul charges across years. In either case, the farmer's intuition about repair costs might be on the low side.

Step 12. Select the property tax, insurance, and shelter (TIS) percentage

The cost associated with property taxes, insurance, and shelter is considered to be a fixed percent of sprayer market value. Assuming no property taxes, MF2244 suggests a value of 1.5%.

Step 13. Select a bank interest rate, income and self-employment tax rates

The selected bank interest rate should be the typical borrowing rate expected from lenders. The combined state and federal income tax rate should be the rate expected on the next taxable dollar earned. Typically, federal income tax rates for sole proprietors are either 15% or 28%, with state rates around 4% to 5%. For many users, a dollar of expense saves both income tax and self-employment tax. Thus, OwnSprayer allows for including self-employment tax (currently 15.3%). Further, because tax depreciation saves income and self-employment tax, yet depreciation recapture when a used sprayer is sold garners only income tax, OwnSprayer distinguishes income tax from self-employment tax rates.

Step 14. Enter tax depreciation information

OwnSprayer allows for the Section 179 expensing deduction for depreciable assets. The Section 179 deduction reduces taxable income by that amount in the year of purchase. This deduction is taken before any IRS formula-based tax depreciation schedule is applied. The maximum allowed is $250,000 in 2008 and $128,000 plus an inflation factor in 2009 (likely, values thereafter will follow prevailing inflation rates. However, the Section 179 deduction diminishes on a dollar-for-dollar basis after eligible annual purchases exceed $800,000 (limits likely will fall again in 2009). For example, a farm with $900,000 purchases in 2008 could not expense more than $150,000 using Section 179; at $1,050,000, the expensing deduction would be $0.

Through the end of 2004, and for assets purchased after May 6, 2003, a bonus first-year depreciation of 50% was allowed on only new machines. OwnSprayer allows a user to consider this tax deduction by inserting a 1 in the appropriate spreadsheet cell. The 50% bonus depreciation is taken after any Section 179 deduction. Like the Section 179 deduction, it reduces taxable income by that amount in the year of purchase. Also like the Section 179 deduction, it directly reduces the dollar amount to which any IRS formula-based tax depreciation schedule is applied. When a 1 is used to signal use of the 50% bonus depreciation, the spreadsheet double checks that the sprayer is actually 0 years old at the time of purchase. Since the bonus depreciation provision ended at the end of 2004, it is no longer relevant. However, we wished to retain this functionality in the spreadsheet in case the provision comes back into tax code at a later date.

After accounting for the Section 179 and 50% bonus depreciation deductions, OwnSprayer uses the MACRS tax depreciation percentages for 7-year property to play out tax depreciation across the years that a sprayer is considered owned. As the spreadsheet is currently structured, faster depreciation (if applicable) can be accommodated by changing the cell values appropriately, with some cells perhaps set to 0. When changing, care should be taken that the values sum to 100%.

Step 15. Tendering costs

Although tendering is an important cost associated with crop spraying, OwnSprayer is not designed to provide and extensive breakdown of such costs. Thus, tendering costs must be entered as a constant cost per acre or a constant cost per hour or both. Based on information from one private source, a tendering cost between $1.25 and $1.75 per acre seems reasonable. However, tendering costs likely will vary considerably for different situations (e.g., due to different application rates or field sizes). Thus, users are encouraged to estimate tendering costs appropriate for their situations.

Cash flows and economic variable calculations over time (understanding the TT section)

The time and tax (TT) section of the OwnSprayer spreadsheet calculates the expected values for those variables that change over time. Some columns are not strictly needed, but are included to aid understanding (e.g., loan interest and loan principal, as discussed in an earlier step, or the annual breakdown of per hour repairs). Most columns are self-explanatory, while others can be understood by examining the formulas they contain. Essentially, this section tracks all cash flows over time, with future cash flows appropriately discounted to year 0 (the present). Tax savings due to business expenses and tax depreciation is considered a cash flow because it would reduce taxes paid.

After discounting for time, all cash flows in this section are summed to provide the after-tax net present value of costs (NPVc). Since the only time-dimensioned variables considered in OwnSprayer are interest, depreciation, repairs, and TIS, the NPVc value must be prorated among these four cost categories. Because opportunity interest and market depreciation are ultimately the relevant interest and depreciation cost categories, prorating NPVc is not immediately straightforward. OwnSprayer handles this as follows. First, though they do not impact cash flows, market depreciation and opportunity interest columns are included in the TT section. Then, the after-tax discounted NPV for each of these two columns, along with that of the repairs and TIS columns, is calculated. Finally, the relative share that each of the four values is of the total of all four, determines the NPVc proration portions.

Sprayer analysis and summary section

First, this section repeats a few of the underlying user inputs and calculated values to facilitate printing a report. Second, based on after-tax amortization of values from the TT section, followed by conversions to pre-tax values, this section reports the ownership and operating costs associated with the sprayer analyzed. To facilitate cost and custom rate comparisons, categorical costs are reported as annual costs, per hour costs, and per acre costs.