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Fieldwork Days and Machinery Capacity

Department of Agricultural Economics

One of the more difficult decisions for farm managers is determining the appropriate machinery performance level to match the workload. The vagaries of weather, the narrow window of time to complete critical fieldwork, and the relatively high capital cost of equipment add complexity to an important decision.

Uncertainty in the number of days available to conduct timely fieldwork creates risk with economic consequences. If equipment is sized to complete field activities in virtually every year, machinery costs will be relatively high and there will be excess capacity in some years. But with less machinery capacity, a farmer can expect to encounter delays in at least some years that may have high costs in terms of quantity and quality of harvest.

In this guide, the probability of not completing fieldwork in a timely fashion is used as a way to quantify the risk of incurring excess costs due to weather uncertainty. Without climatic data it is difficult to estimate the extent of risk exposure or to judge whether a farm is over or under capacity.

This guide presents information in support of a spreadsheet tool called Probable Fieldwork Days Model (PFDM). PFDM was developed by the University of Missouri Food and Agricultural Policy Research Institute (FAPRI) to help farm managers quantify the probability of completing, or not completing, fieldwork with specific machinery capacities.

Risky decisions

PFDM is a tool for evaluating the selection of a single piece of equipment for a particular field activity in a specific window of time. The tool relies on survey data of days suitable for fieldwork over the last 30 years as compiled by the USDA National Agricultural Statistics Service. A companion MU publication, G362, *Days Suitable for Fieldwork in Missouri*, summarizes the data set. The model includes only Missouri data.

PFDM provides insight into the following kinds of questions faced by farmers:

- Given my current crop acreage and equipment size, what percentage of the time can I expect to get a job completed on time?
- If I increase equipment size, how much does it increase the odds that I finish on time?
- How will shifting acres in my crop mix change the percentage of time I can complete fieldwork?
- Which change has the biggest effect in reducing my risk during planting season: going from a 12-row to a 16-row planter, or installing equipment that lets me plant 12 rows 0.5 mile an hour faster?
- If I am able to complete disking in two weeks in only eight out of 10 years, how many acres are likely to be left undone in the other years?

PFDM is a powerful tool to aid in making decisions, but it does have limitations due to the underlying data. Users are cautioned not to rely too heavily on information at the ends of the data range, say beyond the 90 percent level, which is based on less than three occurrences in 30 years. It is important to understand that although historical data establish an expectation about future days suitable for fieldwork, there is no guarantee that history will predict the future. There could be a number of reasons for a deviation from history, including a change in weather patterns.

User's guide

The PFDM tool has two main user sections: the *Scenario* section where users enter information they wish to evaluate, and the *Results* section that presents information in graph and table form.

To illustrate the use of PFDM for machinery management, we model a northwest Missouri farmer who desires to plant 750 acres of corn during a four-week period from April 8 to May 5. The farmer has an eight-row (20 foot) crop planter that travels at 5.5 miles

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per hour through the field. The farmer estimates that he can perform fieldwork 12 hours per day and has a six-day workweek.

Scenario section

The *Scenaro* section of the PFDM spreadsheet (Figure 1) allows users to enter information to be used in calculations. Users enter their information in seven yellow cells (shown in gray in Figure 1). Intermediate calculations associated with the input are shown to help evaluate the accuracy of entries.

Users begin by specifying which region of the state they farm. Northwest is shown in the illustration in Figure 1. Press the *Select Region* button to use a clickable map of the nine USDA regions.

The user then specifies the implement to be used, along with various descriptors that affect how many acres can be covered in a single hour. The *Help Me Decide* button presents a list of common field equipment and will automatically enter default implement speed and field efficiency. In the example shown in Figure 1, PFDM calculates machinery capacity to be 8.7 acres per hour. The user can change the implement width, field speed, or field efficiency to cause the calculated performance to match actual or targeted performance.

Implement performance and the number of acres to be worked affect the desired implement size. The more acres worked, the larger the implement needed. The example in Figure 1 assumes 750 acres. PFDM calculates that 86.5 hours of suitable field conditions will be needed to plant 750 acres given the 8.7 acres per hour already estimated.

Labor availability also affects the amount of work that can be accomplished within a certain time period. The tool provides a guideline for the number of hours to be worked in a day by calculating the hours between sunrise and sunset for a particular region and time period. Users may select A*ll daylight hours in period* or select *My hours* and enter the number of hours they are able to work in a single day on the task being evaluated. *My hours* might be shorter than the daylight hours because of other responsibilities such as livestock feeding; or longer, if equipment is able to assist with fieldwork in the dark. *Days worked in 7* allows users to specify that they are not available to work every day of the week. The hours worked refers to time spent in the field. It does not include time spent doing activities such as travel between fields or major implement preparation.

Most fieldwork must be performed during critical periods. Ideal start and end dates are chosen based on crop growth and expectations of climate and soil conditions. Users specify when they would like to start and end the particular field activity. PFDM reports the average number of days and hours available between the start and end dates.

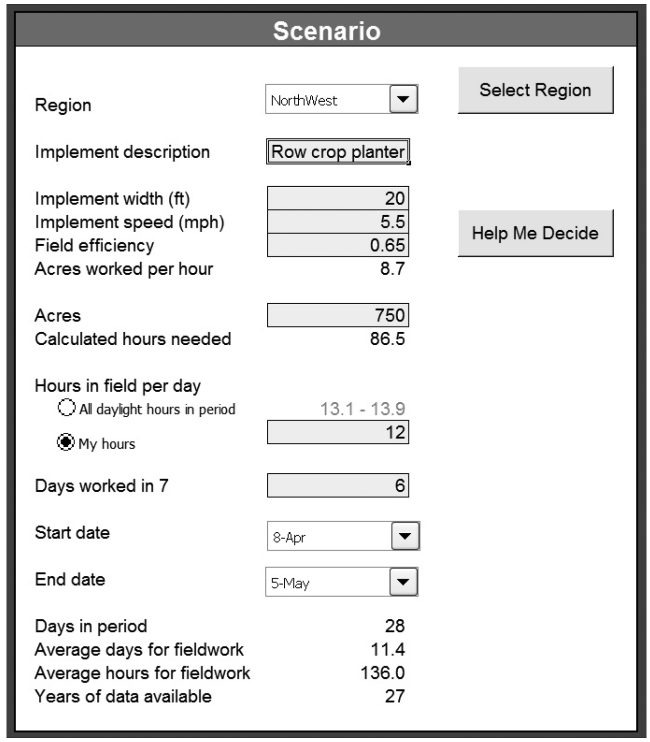


Figure 1. Users enter information about their equipment and operations in the Scenario input screen.

Results section

The *Results* section presents information in both a chart and a table in ways that facilitate decisions involving uncertainty. All examples in the *Results* section reflect the illustration used in the *Scenario* section.

The chart provides a quick picture of the

Field efficiency

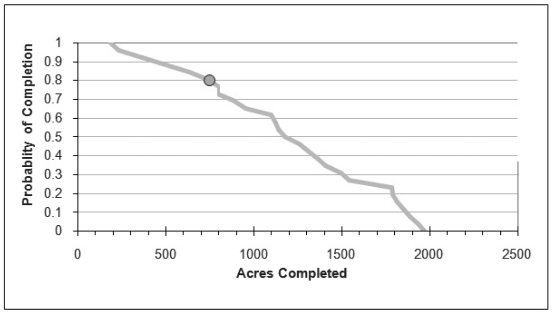
Determining the area that can be covered for a given field operation such as planting is a simple calculation based on speed traveled and the width covered. Many factors decrease the actual fieldwork that can be accomplished. The simplest example of a factor that can decrease field efficiency is the short time it takes to turn at the end of the field. Other factors specific to the type of field operation include downtime from handling materials such as filling a planter, fertilizer buggy or sprayer. The time required for refueling, lubricating, making adjustments or repairs and unclogging equipment also affects the actual work that can be accomplished, as do operator habits or capability. One final set of factors that affect field efficiency are field shape, field size and other field conditions.

Empirical data have been used to estimate field efficiency for most field operations. The numbers may sometimes seem low; for example, a field efficiency of 0.65 (65%) is not uncommon for operations such as planting. Unless you have a specific reason to adjust field efficiency based on personal experience, use the default value that is automatically entered for the field operation you select from the menu.

— Bill Casady, MU Extension Agricultural Engineer

Results

Probability of completing acres (Apr 8 to May 5)



Cumulative acres completed starting Apr 8

	Date ending			
Percentile	Apr 28	May 5	May 12	May 19
50	829	1,177	1,480	1,819
60	743	1,108	1,360	1,569
70	645	865	1,171	1,462
80	544	751	849	1,198
80	543	750	846	1,196
85	496	606	777	956
90	205	365	554	811
95	147	272	362	487

Figure 2. The Results screen of PFDM returns information in both graphical and tabular form.

probability of working various numbers of acres given the time frame specified in the *Scenario* section. The horizontal axis shows the number of acres that could be covered with the implement, and the vertical axis indicates the probability of having weather conditions that allow completing the fieldwork. Using Figure 2 (graph in top half), a farmer wishing to complete 1,000 acres of fieldwork would draw a straight line up from 1,000 on the horizontal axis labeled "Acres Completed." From the point where that line intersects the plot on the chart, a straight line is drawn left to the vertical axis labeled "Probability of Completion." The result indicates that about 65 percent of the time (or 6.5 of 10 years) one could expect to have the desired number of days available to do fieldwork. The dot in the graph marks the probability of completion for the number of acres specified in the *Scenario* section. In the example, 750 acres could be completed about 80 percent of the time.

The table in *Results* (see Figure 2, bottom half) provides customized information for scenarios with different ending dates. The start date selected in the *Scenario* section is the earliest date planned to begin the activity, but the ending date is flexible, permitting the user to view how many acres could be completed at weekly intervals from the beginning of fieldwork.

The numbers in the body of the table are acres completed with the implement specified. Columns represent the weeks ending on a specified date and rows indicate the probability of completion in percentiles. The highlighted column (May 5 in this example) identifies the end date chosen in the *Scenario* section. The highlighted row reports the probability of completion associated with the specified number of acres. Find the number of acres in the scenario at the intersection of the highlighted row and column.

Percentile

A percentile is a value below which a specified percentage of the observations fall. For example, the 70th percentile is the value below which 70 percent of the observations are found. In Figure 2, 70 percent of the time, 645 acres can be worked by April 28; 50 percent of the time 829 acres can be worked.

To continue the example, the table shows that 750 acres can be planted in four weeks, 80 percent of the time. At the same probability level, 543 acres can be planted by April 28, three weeks into the season, or 846 acres by May 12, five weeks after starting.

It is imperative to understand that the percentile is the probability of completing the work. An important number that can be calculated from this is the percentage of time that the fieldwork will not be completed. This is critical information because it is the cost of not completing the work in a timely manner that is compared with the cost of additional labor and machinery capacity to allow completion of work within a specified time frame. In our example, 750 acres can be planted in eight years out of 10 within the four-week period from April 8 to May 5. This means, 20 percent of the time (two years out of 10), fewer than 750 acres can be planted within the same four-week period.

What about when it is not possible to complete the work in the four weeks? Can the farmer plan to compensate for poor weather by lengthening the time window in those years? The table provides some helpful information.

By extending planting into the fifth week (see the May 12 column) there is about an 85 percent chance that all of the 750 acres (777 acres in the table) can be planted. In other words, 5 percent of the time, (85 minus 80) we expect that stretching the planting season one week will get all the planned acres planted. To get the exact percentage, change the end date in the *Scenario* section to include the next week and it shows that 750 acres could be expected to be done 86 percent of the time.

Continuing to move the end date shows how long the planting season must be to offset the chance of poor weather conditions. To have 99 percent certainty of getting 750 acres planted one would need to plan for an eight-week planting season that ends June 2. This is clearly not a practical option. In other words, given the current implement and management assumptions, the farmer runs the risk that there will be some years that corn planting will not be completed.

A more useful way to consider what occurs when planting cannot be completed in the four weeks is to estimate how many acres are likely to be left undone in those years. Compare the acres completed by May 5 at the 80th and 90th percentiles. Estimate acres left unplanted by subtracting the number of acres completed in the 90th percentile (365 in our example) from the number of acres completed in the 80th percentile (750 in our example). The result is 385 acres. This indicates that one year out of 10, the farmer can expect over half of the planned corn crop not to be planted by May 5.

This leaves another 10 percent of the years still unexplained. For this, we have to be satisfied with only a partial answer because of data limitations. We can confidently say that something more than 385 acres will be left unplanted.

(Note: It is not appropriate to estimate the number of acres completed in a single week by calculating differences in the columns. Instead, change the start and ending dates in the scenario section to generate a new table for the specific week in question.)

Improving performance

Many management decisions can result in better equipment performance that can increase the probability of completing fieldwork in a timely manner. Changing equipment width, field speed, or field efficiency will affect performance. Acquiring control of larger equipment will increase the number of acres per hour. New seed loading technologies, use of a grain cart during harvest, and hiring more employees can increase field efficiency. Another option is to increase the number of hours worked per day when fieldwork can be performed. This may take the form of hiring additional employees to keep the equipment running more hours of the day or acquiring precision agriculture technologies that permit operation during the night.

Each of the above performance-enhancing options can be tested with the PFDM to estimate how much the probability of completion is altered. The magnitude of the impact may be surprising. One more scenario from our example: doubling the size of the planter from 8-rows to 16-rows reduces the probability of failure to plant all of the acres from 20 percent to 12 percent. That's an improvement of almost one year in 10.

Overview

Having sufficient equipment for every year is usually deemed too expensive and results in excess capacity in most years. Having insufficient equipment for every year can result in costs such as reduced yields or poor quality. While the Probable Fieldwork Days Model (PFDM) tool does not estimate the cost of owning too much equipment or the cost associated with untimely fieldwork, it does help estimate how many years fieldwork may not be completed in a timely fashion.

The PFDM tool can be beneficial to producers who are interested in assessing their current equipment management or who are considering purchasing new equipment or possibly farming more land. Understanding the risk associated with uncertain weather events on machinery management can assist farmers in planning for those risks.

Access

The Probable Fieldwork Days Model spreadsheet can be downloaded from the Food and Agricultural Policy Research Institute Web site at ***fapri.missouri.edu***.

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