Grain Harvesting and Handling (GH2) System Sizing Tool

Ag Decision Maker
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File A3-42

Grain yields in Iowa have been increasing for the past several decades. As these yields increase, producers are faced with questions about how to correctly size various grain handling equipment, especially when they buy new or replace existing equipment, and how to match these with available farm help for smooth harvesting, drying, and storage operations. Secondly, as farms acquire more acres into their operations, the proper sizing of equipment to perform the key functions in this system becomes critical. The changes in grain handling systems that a producer may be faced with, due to increases in the number of acres to harvest are magnified by changes brought upon by annual yield increases.

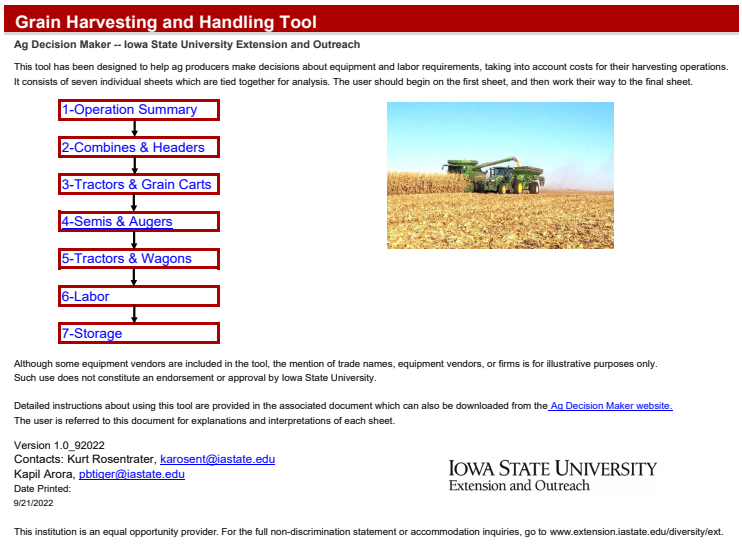
In either case, changes made to grain handling systems in terms of their size and capacity can impact farm profitability for several years into the future. When deciding what changes to make, producers are typically faced with several "what if" types of questions specific to the size and capacity of the components of their grain harvesting and handling (GH2) system. For example, if farm yields have increased by over 20 bushels per acre over the last ten years, and then the farm has inherited 200 more acres this year: what size combine will be needed to meet the increased harvest needs; how does this impact grain transportation from individual fields to the central grain handling and storage facilities; are the grain handling and storage facilities appropriate to keep the farm help fully employed during harvest; how many additional acres could be rented with current equipment; and other similar questions.

In answering these "what if" type questions, producers and planners of GH2 systems may be faced with resizing and purchasing various components. So a simplified tool has been developed using Microsoft Excel to aid in answering such sizing questions. The purpose of developing this tool is to help producers and planners to spend more time on sizing and organizing the components so that their GH2 systems can meet current needs, and can easily accommodate future expansions.

This publication has been written to help the User of the GH2 System Sizing Tool, www.extension.iastate.edu/agdm/crops/xls/a3-42g2hsystemsizing.xlsx, understand what different variables have been used in sizing various components, what the relationships amongst its components are, and how the tool can be used to answer different questions. This publication utilizes information published in MWPS-13 (2017), Paulsen and Odekirk (2000), and McEvoy and Crouch (2015). It also utilizes information published on different farming operations available through the Iowa State University Ag Decision Maker website.

The GH2 System Sizing Tool, www.extension.iastate.edu/agdm/crops/xls/a3-42g2hsystemsizing.xlsx, is comprised of one Microsoft Excel spreadsheet that has seven interconnected worksheets. These sheets include:

1) Operations Summary,
2) Combines and Headers,
3) Tractors and Grain Carts,
4) Semi-Trailers and Bin Augers,
5) Tractors and Wagons,
6) Labor, and
7) Drying and Storage.



Grain Harvesting and Handling Tool

Ag Decision Maker -- Iowa State University Extension and Outreach

This tool has been designed to help ag producers make decisions about equipment and labor requirements, taking into account costs for their harvesting operations. It consists of seven individual sheets which are tied together for analysis. The user should begin on the first sheet, and then work their way to the final sheet.

1-Operation Summary
2-Combines & Headers
3-Tractors & Grain Carts
4-Semis & Augers
5-Tractors & Wagons
6-Labor
7-Storage

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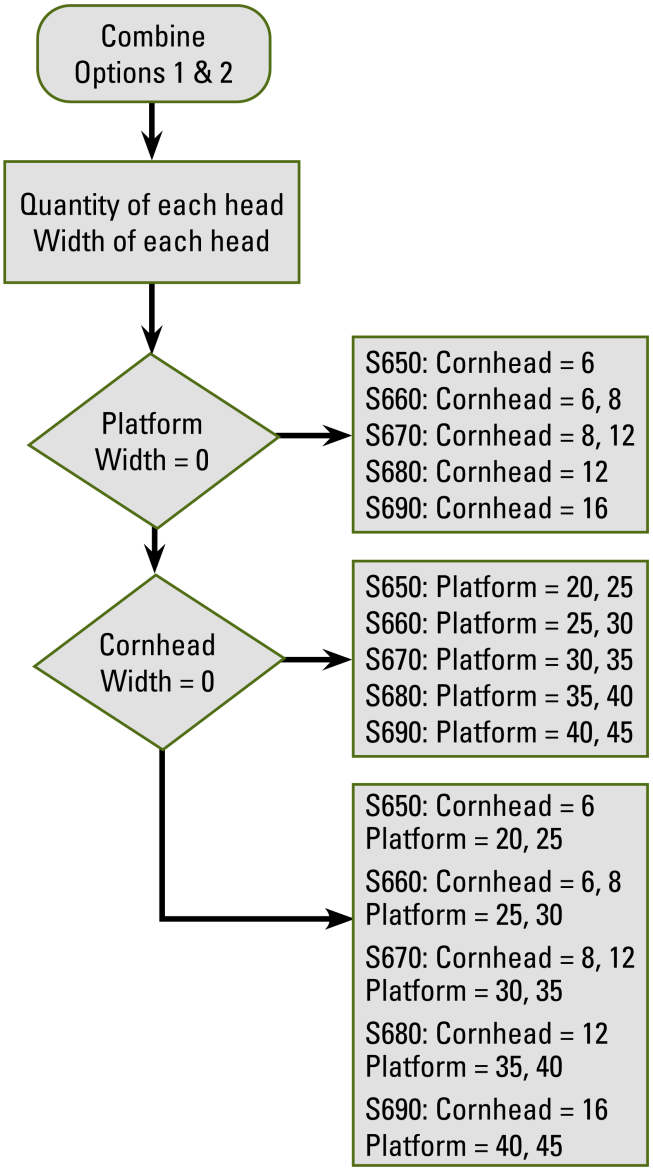
The tool has been programmed using Microsoft Excel and continues to be improved upon to streamline and optimize the sizing steps. The next version(s) of this tool will be released with an update of this publication to explain subsequent improvements made. Each of the worksheets in the Decision tool will be discussed below.

1) Operations Summary

The User will enter values in yellow cells only. The number of acres to harvest for corn, soybeans, or small grains must be entered into this worksheet, along with the expected yields for these crops. When using a number for the expected yield for any one of these three crops, the User has the choice to input average yield, the highest yield in last five years, or any yield number that they expect. The User then also decides as to how many days per week and number of hours per day the equipment will be operational during harvest. The number of days available to complete grain harvest (i.e. harvest window), can be obtained from Ag Decision Maker File A3-25, Fieldwork Days in Iowa, www.extension.iastate.edu/agdm/crops/pdf/a3-25.pdf, or from Table 1 in Paulsen & Odekirk (2000), or any other source that the User deems fit to use. The User enters the aforementioned independent variables into the bright yellow cells in the worksheet, and then the tool produces a summary table by calculating the following dependent variables: total available working hours, total work weeks, total acres to harvest (overall, daily, and per hour) and a summary of required capacities (acres per day and acres per hour) that must be harvested. The calculations from the summary table are then carried over and used in subsequent worksheets.

2) Combines and Headers

In this worksheet, the User decides which header to use by selecting a header model such that the quantity of headers and combines needed for harvesting the respective crop is minimized. To make your selection, choose from options in the drop-down menus in the yellow cells in Table 1. Within this worksheet, the field capacity (acres per hour) of the selected header for the specific



crop will exceed the field capacity calculated in the Operations Summary Worksheet, and so must then calculate the smallest number of headers needed to balance the operation. The field capacity of the selected headers is calculated by using typical combine operating speeds and efficiencies for the three crops, respectively (see Table 4). The headers currently available for selection are the John Deere Corn Head, Draper Head, Bean Head, and Flex Draper Head (see Table 3). The User has the choice of either Option 1 or Option 2 for header selection (both of which minimize the number of headers

and combines needed). This is done in order to give the User choices. In Option 1, the User has the choice to select a corn, soybean, or draper head for each of the three crops, whereas in Option 2, the User can only select a flex draper head - which can be used for both soybeans and small grains. After a certain threshold number of acres of small grains or soybeans, however, it becomes obvious that Option 2 must be selected to reduce the overall number of headers needed. The prices in Table 2 will be color coded for ease of comparison.

The combines are then automatically selected (see Table 2) once the selection of the headers has been completed in this worksheet. The number of combines needed is calculated based on the quantity of headers calculated when selecting the headers for the different crops. The worksheet also calculates the total equipment cost for the harvesting operation, which includes the cost for the headers and combines. It also calculates a first year dollar per bushel cost based on the number of bushels harvested by the specific header and combine.

3) Tractors and Grain Carts

This worksheet has been developed with the understanding that the grain producer, when harvesting, will use tractors and grain carts to move the grain from the combine to semi-trailers, which will then transport the grain from the individual fields to the storage facility. As such, the only input needed in this worksheet is the grain cart travel time between the combine and the semi-trailer (yellow cell). In order to eliminate any waiting time due to a full grain tank on the combine, the number of grain carts are calculated by simultaneously optimizing the number of combines, harvest rate, grain tank fill time, number of offloads needed per hour, offload interval, grain cart travel time to the semi-trailer, offload speed of the grain cart, and the capacity of the grain cart. The number of grain carts needed is always a whole number designed to meet the highest harvest rate (in bushels per hour for the three crops listed in the Operations Summary worksheet). In case the combine grain tank fill time is lower than the grain cart trip time to travel to the semi-trailer and offload, the number of grain carts needed in the harvesting operation is increased to eliminate any combine wait time.

Currently in this worksheet, there are two different cart sizes displayed. Option 1 is sized such that one full cart load equals one full standard semi-trailer load. Option 2 is sized such that one full cart load equals one full triple-axle semi and trailer load. The tractor specifications and prices are from John Deere's website. The specifications and prices for the Brent Grain Carts are from Unverferth's website. The tractors used for the grain carts meet the minimum horsepower requirements by Brent. The total cost is the base price of the tractor added to the base price of the grain cart multiplied by the quantity required. Again, these brands are listed for illustration only.

4) Semi-Trailers and Bin Augers

Grain harvest rate calculated earlier is used to determine the number of semi-trailers needed, taking into consideration the trailer capacity, standard grain test weight, semi-trailer trip time to travel to the offload site, and offload time at the grain storage facility. The grain off-site transportation rate is thus optimized against the combine harvest rate to calculate the number of semi-trailers required. Standard test weights of 56 pounds per bushel for corn and 60 pounds per bushel for soybeans and small grains are used to maintain compliance with legal load limits on Iowa roadways. The User has the option to vary the standard test weights if so desired. And the User can input the travel time to the offload site (in minutes) in the worksheet. The User also determines the time needed to dump the semi-trailer full of grain. A minimum of two minutes is set to offload an entire semi-trailer, unless a pit-elevator is available to offload an entire semi-trailer in less than two minutes.

Two options for selecting semi-trailers are available to the User in this worksheet. Standard semi-trailer is setup as Option 1, which has a haul capacity of 938 bushels of corn year-around on all Iowa roads and 1,080 bushels of corn during the fall harvest season on non-interstate Iowa roads. A triple axle

semi-trailer is set as Option 2, which has higher capacities - 1,060 bushels of corn on non-interstate Iowa roads year-around, and 1,441 bushels of corn during the fall harvest season on non-interstate Iowa roads. The worksheet is setup such that there is a minimum of one semi-trailer per option for each combine in the operation, as determined earlier. In addition, the worksheet automatically increases the number of semi-trailers if the total trip time is greater than the time it takes to fill one semi-trailer by grain cart.

The number of augers that can be used in the operation is currently optimized to one under the assumption that there is only one dump site available for the semi-trailer. The number of augers needed is calculated by taking into account the auger capacity and semi-trailer offload rate. In case the calculation is two or higher, the cell color changes to red indicating the need to resize the augers. The augers currently available in the worksheet are three Westfield models, although the User can input the capacity of any auger make and model already existing in the operation or intended to be purchased. A tractor to operate the auger is currently not considered as a need in this worksheet and is thus assumed to be already available as a spare farm tractor.

5) Tractors and Wagons

Many existing farm operations in Iowa and the upper Midwest have traditional tractors and wagons to transport harvested grain from the field. The User, therefore, has the option to size wagons and the tractors needed to transport the grain. The Decision Tool decides the number of wagons needed in the operation by taking into consideration the grain harvest rate, user-defined wagon round-trip travel time to offload the grain, user-defined offload time at destination, and the pre-defined wagon capacity. The worksheet is setup to calculate the number of wagons needed in the operation for three different capacities, and also if the wagons are towed in single, double, or triples. These options allow the User to select which option best fits with the operation. A minimum of 150 hp per wagon is recommended for use with the grain carts by Brent. The number of tractors needed can be decided by the User based on the calculated number of wagons needed, and the decision to transport grain in double or triple wagon arrangements. The number of augers needed at the destination to offload grain is calculated by the worksheet, taking into account the grain dumping rate from the wagons and the capacity of the augers to handle the grain.

6) Labor

On the Labor tab, the Decision Tool compiles the number of people needed to operate each combine, grain cart, semi-trailer, and wagon options, based upon calculations from the other worksheets, and then determines estimated labor costs for the harvest season. The total number of hours per operation is calculated taking into consideration the previously calculated capacities per hour and the total bushels to handle from the Operations Summary. No labor cost for maintenance or repairs is included in this worksheet. The User must enter the wage rate (yellow cells). Thus this worksheet allows the producer to compare labor costs for the different options selected.

7) Drying and Storage

The main focus in this worksheet is to calculate the number of storage bins needed, taking into consideration the individual crop yields and total acres from the Operations Summary worksheet. Any shrinkage due to drying is currently not considered and it is assumed that the harvested grain does not need any further drying (drying will be added later). The worksheet calculates the number of bins needed for storage of the harvested grain based on grain bin sizes ranging from 25,000 to 500,000 bushels for each crop. Cells are shaded out in the table where the total bushels for the crop are less than 50% capacity of the bin – in these cases, unless a bin is already available in the operation, it is recommended not to construct one. An alternative to such situations is to transport the grain to the nearest grain elevator or processing plant. The cells

appear green when the number of bins calculated for the respective capacity are less than or equal to five. This is the recommended number of bins for the operation. When the number of bins needed exceeds five for any given grain bin capacity, the cells appear red, as this size is not recommended as they are too small for the operation. The bin sizes automatically adjust with User changes to the Operation Summary worksheet page and there is no User input required on this worksheet.

Conclusions

The GH2 System Sizing Tool, www.extension.iastate.edu/agdm/crops/xls/a3-42g2hsystemsizing.xlsx, simultaneously optimizes the harvesting rate with transportation rate, and sizes combines, grain carts, semi-trailers, wagons, and grain bins. It is designed to answer several questions in the grain harvesting and handling supply chain for grain producers, and is quite user friendly. Eventually, this tool will be further developed to include more options for headers, combines, grain carts, wagons, augers, etc. The tool could also be expanded to include a grain drying component. Any further improvements made to the model or this instruction sheet will be released in subsequent versions.

Although some equipment vendors are included in the tool, the mention of trade names, equipment vendors, or firms is for illustrative purposes only. Such use does not constitute an endorsement or approval by Iowa State University or the authors.

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