EC309

Direct Harvest of Dry Edible Beans

A Nebraska Perspective

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Introduction

Harvest is the culmination of the dry bean crop season and the realization of profitability for the crop. Harvest establishes the return for the crop's yield and seed quality. Harvest is also the most important field operation for dry edible beans in terms of risk and cost. Since about 2010, some growers in western Nebraska and adjoining areas of Colorado and Wyoming have begun to direct harvest pinto and great northern beans. By the year 2014, an estimated 20 percent of the Nebraska dry bean crop was direct harvested. Direct harvest is the process by which beans are harvested by a single pass through the field with a combine, in contrast with the conventional undercutting and windrowing process followed by combining after the beans have dried in the windrow.

Direct harvest is not a new practice for dry edible beans. Some growers in Michigan and North Dakota have used direct harvest for navy beans for over 30 years, and more recently for pinto beans. For example, direct harvest of pinto beans in North Dakota in 2012 was estimated to be at least 70 percent.

This publication will examine why some Nebraska dry bean growers are now starting to use direct harvest and why other growers are not, along with a detailed discussion of individual cropping practices that will lead to a successful direct harvest outcome. Direct harvest must be considered as a total cropping system, not just a change in combine header. The difference between a successful direct harvest crop and disappointment is almost always attention to, and proper execution of, details of the entire cropping system.

Is Direct Harvest Right for You?

Direct harvest is not the best system for all producers, at least at this point in time. Improvements in bean plant architecture, herbicide systems, and combine headers will continue to make direct harvest more practical for growers. In the meantime, growers must carefully consider advantages and disadvantages of direct harvest, compared with conventional harvest production systems. Growers must also consider other aspects of their entire operation to determine whether direct harvest is right for them, including other uses for a direct harvest header and narrow row planter or drill; the need to upgrade equipment for other reasons; size of operation; and labor availability. *Table 1* contains some of the advantages and disadvantages of direct harvest, compared

The biggest concern of direct harvest systems—and the primary reason more producers do not use direct harvest—is high harvest loss. How high? Before that question can be answered, we need to define harvest loss for conventional harvest systems as a reference. A University of Nebraska—Lincoln study that examined harvest loss of each harvest operation in one field for each of 23 Nebraska bean growers during a two-year period found that total field harvest loss for conventional harvest averaged 1 ½ bu/ac. Harvest loss for these 23 growers ranged from a low of ½ bu/ac to a high of almost 5 bu/ac for one field. Most growers, in the absence of bad weather conditions, maintained a total field harvest loss in the 1–2 bu/ac range, thus we consider 1 ½ bu/ac a typical total field harvest loss for conventional harvest.

Total harvest loss from direct harvest systems currently will be higher than 1 ½ bu/ac. Based on actual measurements in fields of producers using direct harvest within the last several years, a current realistic, and achievable, target for total field harvest loss for direct harvest of pinto beans is about 3 bu/ac, and 3 ½ bu/ac for great northern beans. Total field harvest loss as high as 10 bu/ac has been measured in one grower's field, while some growers have had total field loss as low as 2 bu/ac or less. These grower field measurements will be discussed later in this publication, but the important fact

Table 1. Advantages and disadvantages of direct harvest systems, compared with conventional harvest systems.

Advantages	*Disadvantages/Concerns*
Reduced weather risk from rain and wind after plants are undercut in the conventional harvest system.	Harvest loss can be high, even very high, if field is not level, plant structure does not accommodate direct harvest, or the correct combine header is not used.
One field operation for harvest for minimal equipment and labor inputs.	Time of combining operation will be later than with conventional harvest.
Minimizes soil taken into combine to reduce combine wear and hauling cost.	Harvest aid must be used if green weeds or green bean plants are present at time of combining.
Stubble remains after harvest for some wind erosion protection.	Weeds must be controlled in the growing crop with herbicides, not cultivation.
Cultivation is not used or needed for controlling weeds in the growing crop.	Direct harvest may not be applicable to light red kidney beans.
Growers don't have to cut and windrow in the dark when dew is present.	

is that some growers have consistently maintained direct harvest field loss as low as 2 and 3 bu/ac. However, if not careful with the details, growers have also had field losses as high as 10 bu/ac.

Two primary factors contributing to excessively high harvest loss in growers' fields were low hanging pods at the time of harvest (less than 2 inches from the soil surface) and high operating height of the sickle of the combine header. Pod height is greatly affected by variety selection, crop production practices, and environmental factors throughout the season leading up to harvest. The operating height of the header is a function of field levelness, the model of header, and the skill of the operator.

The importance of keeping pods high off the soil surface and keeping the sickle of the combine header as low as possible is illustrated by two general, but applicable, "rules." Both rules are based on actual research with direct harvest, and by calculation of bean plant physical dimensions and attributes.

Direct harvest rule No. 1:	For each inch you hold the cutterbar off the soil surface, you will lose about 3 bu/ac.
Direct harvest rule No. 2:	If you lose one pod from each plant, your field loss will be about 3 bu/ac.

The clear implications of these rules are:

- You must do everything you can to make the soil surface as level as possible at harvest time so the combine header will operate as low as possible. A soil ridge 1 inch tall will add about 3 bu/ac to harvest loss.
- You must select a variety and grow the plant so as many of the pods as possible are as high as possible off the soil surface at harvest time. The total of one pod per plant cut by the combine header will add about 3 bu/ac to harvest loss.

Measurement of harvest loss as the harvest operation progresses is another necessary key of management of direct harvest and will be discussed in detail in another section of this publication. You cannot correct harvest loss problems unless you know your actual loss.

As with any other cropping system, success or disappointment of a direct harvest system will be found in the mastery of the details of the particular system you choose. These key details will be discussed in following sections.

Crop Insurance

The USDA risk Management Agency may have different rules for insurability of direct harvest systems than conventional harvest systems. These guidelines are not specifically about direct harvest but rather with row spacing and the ability to cultivate between rows of bean plants.

Prior to 2014, dry edible beans planted in narrow rows represented a "non-typical" production practice for crop insurance and required a special written agreement with the insurance company. In some instances, growers couldn't collect insurance because their beans were planted in narrow rows without a written agreement. As of the 2014 crop year and following years, regular coverage has been extended to beans in narrow rows in some, but not all, Nebraska counties. This new coverage was extended to the entire Panhandle and to some of the southwest counties. Keith, Perkins, Chase, Dundy, and Lincoln counties were listed in this new policy, but not Hayes, Hitchcock, and Arthur counties. Growers in counties not listed will need a special written agreement with the insurance company to grow beans in narrow rows as they did before.

The language covering these policies from the United States Department of Agriculture Risk Management Agency is written as Special Provisions of Insurance for certain crops (rma.usda.gov). These provisions for dry edible beans include some new definitions. For 2014 and succeeding crop years, IBR stands for intertilling between rows. This means the crop is planted in rows wide enough to intertill between rows with a row cultivator. NIBR stands for non-intertilling between rows. This means the crop is planted in rows too narrow to intertill between rows with a row cultivator. Many bean fields planted for direct harvest are planted or drilled in rows too narrow to cultivate, putting them in the NIBR classification.

Additionally, only dry bean varieties that exhibit 1A, 2B, or 3A growth habit are eligible for insurance when planted in narrow rows. These are the varieties that have more upright plant architecture. Consult your seed supplier about the growth habit of your chosen bean varieties before planting in narrow rows for direct harvest. Even though the USDA Risk Management Agency includes the 3A growth habit as acceptable for direct harvest, the authors of this publication do not recommend the 3A prostrate growth habit for direct harvest due to unacceptable harvest loss from low hanging pods.

If you are drilling or planting NIBR beans (narrow row), check with your insurance agent each year prior to the insurance sign-up deadline to determine coverage in your county. Bean yield history from regularly planted rows applies when being insured for narrow row coverage. Also, NIBR (narrow row) bean insurance may carry a 10–17 percent surcharge, compared with a standard dry bean policy. Growers planning to plant beans in narrow rows and direct harvest in states other than Nebraska should check with their crop insurance agent to determine the particular rules that apply in their state and county.

Tillage

A number of tillage systems and tillage implements are applicable to direct harvest, but they must provide a very level soil surface for the planting operation with no ridges or depressions (See Rule No.1 on page 4). Vertical tillage implements are typically used with soil leveling and soil firming accessories at the rear of the implement to leave the soil surface level and firm. Since the bean crop often follows corn, flat coulters or regular disk blades included in the implement are useful for cutting the corn stalks into short lengths. Corn root balls can hold the combine header off the soil surface so they must be broken down, buried, or pushed into the soil. Tandem disk implements can be used but should have trailing accessories to level and firm the soil surface.

Another important tillage issue is soil compaction from the previous crop. Before tillage begins, and when the soil profile has good soil water content, probe the soil to at least 1 foot in depth in a number of areas of the field, including field ends, to check for soil compaction. If compaction is present, an implement with shanks that penetrate the soil deeper than the depth of the compaction must be used. To be effective, this operation to alleviate soil compaction must be done when the soil profile is dry to facilitate soil "shattering." Avoid tillage when the soil is too wet and avoid soil compaction and deep tracks by the tractor tires.

Field Surface Residue

Because the field should be very level before and after planting, the soil can be highly vulnerable to wind erosion until the bean plants become established. Where possible, retain enough surface residue after tillage and planting to suppress wind erosion. This is easily done if the previous crop was wheat or corn harvested for grain. The residue from either crop does not interfere with the harvest operation unless the soil surface is very wet at harvest time, which could cause cutterbar plugging. University of Nebraska researchers have suggested that excessive surface residue from the previous crop might contribute to foliar diseases in the bean crop, including white mold.

Row Spacing

Almost any row spacing can be used for direct harvest, but typically growers use relatively narrow row spacing such as 22, 20, 15, 10, or 7 ½ inches. Early and mid-season weed control is noticeably better with the narrower row spacing. Research at the University of Nebraska—Lincoln that compared 30, 15, and 7 ½ inch row spacing (70,000 plants/ac, 105,000 plants/ac, and 115,000 plants/ac, respectively) with pinto and great northern

Figure 1. A comparison of 7½ inch drilled rows on the left with 30 inch planted rows on the right.

market classes has shown that 7 ½ inch rows typically increased seed yield by 2–4 bu/ac, compared with 30 inch rows, but that 30 inch rows had about 1 bu/ac less direct harvest field loss than 7 ½ inch rows (*Figure 1*).

When selecting row spacing, plant population and variety must be considered. Expect more foliar plant disease pressure with narrower row spacing. Most direct harvest growers are using 7 ½ inch or 15 inch row spacing. Row spacing of 15 inches and greater allows the divider at the ends of the combine header to run between rows to minimize field loss at the header divider. Availability of an appropriate narrow row drill or planter is another consideration. Thus, there are disadvantages and advantages for both narrow rows and wide rows for direct harvest production systems. Each producer must select a row spacing that best fits all factors within his or her operation.

Plant Population

Plant population is generally increased for direct harvest, especially with narrow rows. A typical recommendation is 75,000 seeds/ac for 30 inch rows, 100,000 seeds/ac for 15 inch rows, and 120,000 seeds/ac for 7 ½ inch rows. Higher seeding cost with narrow rows must be considered. These recommendations need to be adjusted for particular varieties, market classes, expected percent emergence, and field soil productivity. The complete canopy cover of a narrow planted crop provides a very favorable microclimate for flower and pod development, and protects the crop from wind damage, which can open the plant to bacterial diseases.

Early indications are that beans planted in narrow rows

mature three to five days later than beans planted in 22 or 30 inch rows. The delay may even be greater if beans are harvested into October. Narrow rows with a higher plant population will be more vulnerable to plant diseases, so attention must be given to variety selection and prudent irrigation scheduling. Mold is a major concern with the closed canopy, and growers must be aggressive in managing this. Careful scouting after canopy closure and timely fungicide applications will be critical in controlling mold.

Variety Selection

Variety selection is more important with direct harvest than with conventional harvest. Not only are yield and seed quality important, but the plant architecture must accommodate direct harvest. Always plant several varieties so you can compare, and in following years, refer to information from your production system about yield, harvest loss, disease, etc. Select the varieties that have long branches with a tall upright architecture at harvest time, with the majority of pods positioned high in the plant. Long branching also allows the flowers to fall to the ground, keeping white mold from starting in the plant structure. Do not select a prostrate-type plant, a short bush, or a short plant with pods positioned very close to the main plant stem.

The reel of the combine header is very important for low harvest loss. If the reel tines cannot engage and lift the plant to raise the pods above the cutterbar sickle and sweep the cut plants quickly off the cutterbar, the harvest loss will be high. The reel tines must be able to lift and move the plant. If the plant is short, the branches are short, or the pods are attached to the plant very close to the soil surface, the reel cannot fulfill its intended purpose, and harvest loss will be high. That said, at the end of the day, the best variety must put the most yield of high quality seed into the truck! So, don't forget the yield potential and seed quality of the variety.

Currently, compared with great northern varieties, pintos have a greater selection of varieties with strong, upright plant architecture suitable for direct harvest. Sinaloa and La Paz are pinto varieties that have been used successfully in the direct harvest system. Aries and Draco are great northern varieties that have proven suitable for direct harvest, but in any case consult with your bean dealer about choosing a strong, upright variety of bean with good yield and quality before planting for direct harvest. Additionally, visit the UNL CropWatch Web page at http://cropwatch.unl.edu/varietytest/othercrops to determine bean varieties with the 2B upright growth habit. Upright varieties can also perform poorly when growing conditions limit good upright plant architecture or cause low yields.

Plant breeders are striving to incorporate upright and branching architecture into more lines in their breeding programs as more growers begin to use direct harvest systems. New varieties need to be suitable for narrow rows, high plant populations, and direct harvest combines. In addition to plant architecture and yield, varieties with good disease resistance are important, particularly when beans are planted in narrow rows at higher populations.

Drill vs. Row Crop Planter

A row crop planter generally will provide improved seed depth control, improved emergence, and better plant spacing within the row, compared with most drills. Drilling tends toward poor plant spacing, and large gaps in the early canopy can occur unless seeding populations are significantly increased. However, a drill is required for row spacing narrower than 15 inches.

If using a drill, select a model with an opener type that leaves the soil surface very smooth, without ridging. Also, select a model that is very gentle to the seed within the seed distribution system. Bean seed is very dry at planting time and the seed coat is easily damaged. Bean seeds with damaged seed coats often will not emerge, or the seedlings will have "bald" heads and will not develop into productive plants. Do not use a drill with hoe or shoe-type openers because it will create ridges, and the plant will emerge in a furrow, causing the lowest pods on the plant to be too close to the soil surface.

Land Roller

Land rollers are very effective for pushing surface rocks into the soil to prevent the rocks from entering the combine during harvest. One large, or even medium-size rock, can do significant damage to the threshing and separating sections of a combine and cause long downtimes. Many dry bean, and even soybean, producers in North Dakota use land rollers for rock protection (*Figure 2*).

Land rollers can be effective to break up or punch corn root balls into the soil. Land rollers should not be used for leveling the soil surface because they will create severe soil compaction when soil ridges are compressed. If used, do not make a final clean-up round around the outside of the field because two passes will often create soil compaction, causing short plants and low yield. Rolling will leave the soil surface very smooth and subject to wind erosion so ample surface residue must be present.

Individual sections of a land roller should be short, no wider than 8 feet, to avoid compacting ridges or elevated soil areas of the field. Land rollers are available in widths up to 120 feet and can be operated at high field speeds. Land rollers

Figure 2. Land roller with short individual sections.

require high horsepower to pull, and a heavy tractor to turn and stop. Use tractors with high floatation tires or rubber tracks.

Weed control

Weed control is a key component of direct harvest. Weeds that are present at harvest have competed with the crop all season and have already reduced your seed yield. Why not make the investment in weed control early in the growing season? It will avoid yield loss from weed competition and the additional expense to control weeds at harvest. Weeds can interfere with the actual combining operation by causing abnormal wear to the combine or reducing combine capacity. Green weeds will stain the seed coat of dry beans, reducing the value of the seed.

Avoid excessive damage to bean plants when you apply herbicides. Often, damage to bean plants by tractor or sprayer tires will cause these damaged plants to mature a week or so later than the other plants.

Minimize making tire tracks or worse, small soil ridges beside the tire tracks during herbicide application. These soil ridges will hold the combine cutterbar higher off the soil and increase harvest loss.

Weed control in dry beans that will be direct harvested requires the use of herbicides since inter-row cultivation should not be used. Cultivation could possibly be used in 30 or 22 inch rows, but experience has shown us that even flat running sweeps on narrow shanks will create small ridges that will still be in place at harvest time. These ridges will hold the cutterbar higher on the plant and will increase harvest loss. In most situations herbicides will need to be applied at planting and again post emerge to ensure the crop is weed free.

Nightshade must be controlled with herbicides because there will not be an opportunity to "pick out" the nightshade plants at harvest time. Narrow bean rows, commonly used with direct harvest, can be an advantage for weed management because they will "close the row" much earlier and more completely than wider rows and will be more effective to discourage mid- and late-season weeds. Consult the most recent edition of Nebraska Extension's *Guide for Weed, Disease, and Insect Management in Nebraska*, EC130, for updated information on weed control recommendations.

The herbicide system must be sufficiently aggressive to control weeds throughout the bean crop season because there is no alternative. However, do not use a herbicide system so aggressive that it causes sufficient bean plant injury to cause the crop to mature later in the season. A bean crop that "stands still" for a week in July due to herbicide injury, could delay maturity as much as two weeks in late September when temperatures are cooler and days are shorter.

When direct harvest occurs in late September or in October, other negative issues can often complicate the harvest process, such as late season foliar diseases, wetter and cooler weather, and even snow. Target a good herbicide system that will control weeds but not delay crop maturity. Use the right application techniques (applying herbicides at specific times of day, use appropriate adjuvants, etc.) to minimize bean plant injury, which will, in turn, minimize harvest delay.

Irrigation

The following recommendations are for irrigation using center pivot sprinkler systems. It is less common for growers to direct harvest beans grown with furrow irrigation but it can be done successfully. See the section on "Options and Alternatives to Direct Harvest" for guidelines on furrow irrigation when planning to direct harvest. Irrigation for a direct harvest crop is similar to a conventionally harvested crop, except the timing of irrigation can be more critical during specific periods of the growth cycle:

- Irrigate for uniform and rapid emergence. It is important that the crop emerge quickly to avoid delay of harvest. Uniformity of emergence is important so the crop matures at the same time within the field and harvest is not delayed.
- Irrigate to keep the crop progressing to avoid a late harvest and to develop a plant with good height and good branching. Short, stunted plants will cause high harvest loss, in addition to reduced yield potential.

- Do not over irrigate. Irrigate only *when* needed and in the *amount* needed. Over irrigation will often initiate or exacerbate foliar diseases, particularly white mold. This is especially true with narrow rows and high plant populations often used with direct harvest systems. Be very careful with irrigation timing and rates during the period from plant flowering until harvest. We have observed severe white mold in narrow row direct harvest fields of growers who had little problem with the disease in 30-inch rows for conventional harvest.

Minimize tire tracks by the pivot tires. If there are tire ruts, there are accompanying soil ridges beside the ruts. These ridges will become a major harvest issue. How do you direct harvest with these soil ridges?

- You can harvest through them but you may introduce excessive amounts of soil into the combine tank.
- You could run a narrow pivot track-filling implement over the pivot tracks, but there will be a very high yield loss from that implement and the associated tractor tire tracks.
- You can lift the header at the pivot tracks but that will miss an unacceptably high number of pods, cause high harvest loss, and also create an unattractive appearance.
- You also can harvest around the pivot, but there will still be a harvest loss at the cutterbar divider that adjoins the pivot track.

It is best to greatly reduce pivot tracks in the first place. Visit with your pivot dealer and neighbors for ideas of how to avoid pivot tracks. Here are some suggestions:

- Arrange individual sprinkler heads at the pivot towers so water is not applied on the tire track area.
- Reduce the rate of irrigation so water does not puddle in the tire tracks and tracks are not formed.
- Consider pivot tire size, tire or track types, and number of tires per tower.
- Use tire track fillers mounted on the pivot tower. However, be aware that these can create other issues such as plugging the fillers or dragging debris.

Plant Disease

Direct harvest systems typically include narrower rows and a higher population of bean plants, compared with conventional harvest systems. As a result, more foliar disease pressure should be expected. Select varieties with the best disease tolerance in addition to other direct harvest traits. Be particularly careful with irrigation scheduling and rates from the time of flowering until the last irrigation.

If foliar disease persists, particularly white mold, consider 22 or 30 inch row spacing, or varieties with a better upright architecture that will allow better air movement between plants. After canopy closure, scout fields regularly for disease. If disease such as white mold is present, apply fungicide early and reduce irrigation to minimize yield loss.

Keep the Crop Progressing

Use good crop production techniques to develop a relatively tall plant with long branches, which will mean more pods higher off the soil surface. Plant in the early to the middle part of the normal planting season, rather than late, to accommodate relatively early dry down and plant harvest. Apply adequate fertilizer and, where possible, use early irrigation to develop a tall, healthy, and early plant. Do not over fertilize or use excessive irrigation—you want to produce pods, not just large plants. Excessive plant development can also contribute to foliar diseases.

Develop a crop production system that causes all sections of the field to emerge, grow, mature, and dry down evenly. If, for example, the outer rim of a pivot irrigated field does not receive adequate irrigation water, it is likely that these plants will mature later than the rest of the field. This presents a dilemma at harvest time: desiccate the late plants too early, combine the late plants too early, or allow the rest of the field to wait too long to harvest. Field uniformity is very important.

Desiccant/Harvest Aid

A desiccant is any substance or mixture of substances used to accelerate the drying of plant tissue. A harvest aid is an herbicide used prior to harvest to desiccate or dry down green stems and leaf tissue. Sodium chlorate can be used as a desiccant but seldom is because it is not as effective as herbicides labeled as harvest aids. At the time this publication was written, four herbicides were labeled in Nebraska as harvest aids for dry beans: Gramoxone® SL, Roundup Power MAX®, Sharpen® and Valor®. The use of any of these herbicides can be restricted by seed processors, depending on whether the seed will be shipped domestically or sold to foreign markets.

Check with your processor before you use any of these materials as harvest aids. Roundup Power MAX is not labeled specifically as a desiccant but is labeled preharvest for late season weed control. It should only be used if bean moisture is less than 30 percent throughout the field. Applying Roundup Power MAX earlier than this could leave a chemical resi-

due in the bean. End users are residue testing for glyphosate and growers who use it have a higher liability.

Consider how to apply the harvest aid. Ground rigs can cause significant bean seed loss. Use narrow tires, wide booms, and apply when the pods do not shatter. Does the entire field require a harvest aid? Consider applying only to sections of the field that actually need a harvest aid. Certain desiccants are often not allowed if the crop is used for seed. Always check with your processor or seed buyer before using a desiccant and follow label directions.

Some fields in some years will not require a harvest aid. One of the goals of the direct harvest system should be focusing on avoiding the need for harvest aids, not just to avoid use of the chemical but to attain the advantages of a uniformly maturing, weed-free crop. Some cropping practices that will help avoid the need for a harvest aid include:

- Uniform emergence
- Uniform, unhindered plant growth throughout the season
- Uniform, timely irrigation
- Good weed control
- Uniform irrigation across the length of a pivot, especially outside the last pivot tower. Often plants at the perimeter of a pivot receive less irrigation water with resulting delayed maturity. The entire field then must wait for the relatively small area outside the pivot.
- If you use more than one planting date or bean variety within a field, arrange the beans so they can be harvested at different times if necessary.

The herbicide/harvest aid should not be applied until at least 80 percent of the pods are yellowing and no more than 30 percent of the leaves are still green. Applying the harvest aid too early will result in yield loss due to undeveloped seed. Environmental conditions following herbicide application will influence how rapidly plant material dries down. If it is cool and wet, the drying process slows down, while if it is hot and dry, desiccation will be much faster. In most situations it will take a minimum of seven days following herbicide application before dry beans are ready to harvest. Pay attention to the preharvest interval on the herbicide label.

A question often asked is whether a harvest aid can be utilized to desiccate nightshade plants so their berries will fall to the soil surface before harvest. The results from several experiments have shown that harvest aids are not effective in solving this problem. Growers should consult the latest edition of Nebraska Extension's *Guide for Weed, Disease, and Insect Management in Nebraska,* EC130, for updated information on harvest aid recommendations.

If the bean pods and seeds are dry enough to harvest, but some bean plants or weed plant leaves are still green, these green leaves will stain the bean seeds within the combine. These stained seeds will likely be found in the tare sample, causing increased tare or causing the entire load to be rejected by the processor. Observe the dry down of the field carefully, and use an appropriate harvest aid if necessary. Sometimes the harvest aid will cause the plant (and weed) leaves, pods, and seeds to dry but the plant stems will remain green and ropey. These green stems can create severe wrapping and plugging within the combine.

When to Harvest

The field should be harvested when the aggregate bean seed reaches a moisture content low enough to be accepted by your processor. If you wait longer, the bean plants will continue to shrink down and allow more pods to be positioned closer to the soil surface. A second reason not to delay harvest is that plants and pods become drier, which contributes to an increased loss of pods and bean seeds from pod shattering. It is estimated that in good drying weather, waiting one week beyond when the field could have been first harvested with acceptable seed moisture content will typically cause an additional 1–2 bu/ac field loss.

Developing a production system that produces a relatively early and uniformly maturing crop will contribute to overall lower harvest loss. This includes the selection and timing of a desiccant.

Header Selection

Five general types of combine headers have been recently used to direct harvest dry edible beans, particularly pinto and great northern market classes. Although all five header types have been used, and could be used, in reality only two—flex-auger and flex-draper—are currently used by Nebraska growers.

Stripper Header

In about 2010, at least six Nebraska dry bean growers began to direct harvest and used the Shelbourne Reynolds® stripper header. These growers used no-till practices for their other crops and already owned a stripper header to harvest their grain crops. There are unique advantages for using this type of header for edible beans, primarily high field speed of the combine; retention of most of the bean plant attached to the soil surface for wind erosion protection; and minimal plant material passing through the combine to improve combine capacity.

However, most growers encountered two problems that

caused them to switch to other header types. The header must be operated very close to the soil surface to pick up bean pods attached very low on the plant, and in the process, the header takes too much soil into the combine. A very good header height sensor and control system helped deal with this problem, but did not completely solve it.

A second problem was high mechanical seed damage. The primary source of this damage was within the stripper header itself because of the high rotational speed necessary to carry the bean seed around the top of the header rotor. Attempts were made to reduce the rotational speed but a minimal speed was required for the header to operate properly and that speed was still too high.

Another possible source of seed damage with this header is that minimal plant material is taken into the combine with the bean seed, and it is thought that plant material "cushions" the bean seed from metal surfaces within the combine. Harvesting when the bean seed moisture content was higher than 15 percent reduced this seed damage, but maintaining that level of moisture often was not practical.

Deere Row Crop Header

The Deere row crop header, designed by Deere and Co.® to harvest soybeans but no longer available from Deere, has been used for dry edible beans. This model was available in a 30 inch row width minimum (could be modified for narrower row spacing) and in header widths up to 12 rows. This header incorporates a pair of rubber belts that "grab" the lower part of the bean plant, and a rotary cutter cuts the plant very close to the soil surface. The belts hold and carry the plants to the header cross auger, which moves the plants into the feederhouse. Other than not accommodating narrow rows, the primary problem with this header in edible beans is that the header gathering points are the same as was used on the Deere corn headers and do not get under and lift the edible bean plant, resulting in high field loss.

With more upright bean plants, this header could otherwise be a possibility. Replacement of the sheet metal gathering points with a low silhouette shape (to get under the bean plants) and an open, skeleton design (to allow any pushed soil to move sideways out through the gathering point and not into the combine) has resulted in very low header loss in dry edible beans.

Rigid Grain Head

The rigid grain head would be a good choice for edible beans if the field is very flat, but in reality few fields are. A rigid head is usually only applicable if in addition to a level field, the head is 25 feet or less wide. Even then, the head must "float" (tilt) side to side to allow for tilting of the combine relative to the field.

However, a rigid head has two important features not found on a typical flex head. First, the reel tines can be positioned very close to the sickle because the cutterbar does not flex up into the reel tines. The tines must be close to the sickle, preferably nearly touching, so the tines can move material off the sickle quickly and effectively.

Second, since the cutterbar does not flex up and down, the approach area between the sickle and the auger can be horizontal or nearly horizontal to allow loose pods and loose bean seed (and rocks!) to be swept by the reel tines into the auger or draper. This approach area with a flex head is almost always at an upward angle, sometimes steep, making it difficult to move the loose pods and seeds uphill to the auger or draper. In current combines, a header width of 35 feet and wider is necessary to utilize the combine capacity, and some flex or hinge arrangement of the cutterbar is necessary to constantly keep the sickle close to the soil surface.

Auger-Type Flex Head

With the exception of the MacDon® FlexDraper® header series, auger-type flex heads were the most popular combine headers for direct harvest of dry edible beans until about 2012 when most other header manufacturers introduced flex-draper headers. Compared with rigid auger headers, auger-type flex headers accommodate flexing of the cutterbar to follow gently undulating surface contours of the field.

This cutterbar flexing action becomes more important as the header width exceeds 25 feet. Although the cutterbar flex is important, this feature generally gives up two important attributes, compared with a rigid head as discussed in the section about rigid headers. Except for the MacDon FlexDraper, a typical flex header in flex mode will not allow the reel tines to operate closely (within 1 inch) to the sickle, resulting in an upward ramp approach to the auger. Both of these issues can contribute to substantially higher field loss.

Flex-Draper Headers

Flex-draper headers are similar in features and performance to flex-auger headers with one significant difference—the draper conveys material away from the sickle or approach from the sickle faster and more uniformly than an auger. The faster the pods and bean seeds get away from the sickle, the less chance of seed damage. Additionally, augers tend to bunch material into the combine feederhouse, compared with drapers, which feed much more uniformly. Increased seed quality and increased combine capacity results from uniform feeding into the feederhouse.

Growers should look for these header features:

- Cutterbar that will allow the sickle to operate very close to the soil surface, preferably less than 1 inch.

- Reel tines that can be positioned as close as possible, preferably within 1 inch of the sickle, to move cut bean plants and pods off the cutterbar as soon as they are cut.
- Reel action to move cut plants, loose pods, and even individual bean seeds off the cutterbar onto the draper or into the auger as quickly as possible to avoid being recut by the sickle or dropped off the front of the cutterbar.
- Cutterbar system (linear speed of sickle, sickle stroke, sickle section cutting edge, and guard shape) that cuts the stems fast without shaking or dragging the plants.
- The reel must lift the plants and pods before the sickle engages the plant. The reel tines need to drop gently straight down into the crop, gently tilt and lift the plant, quickly move the cut plant across the cutterbar, and release the plant to the draper or auger. The reel tines should not drag in the crop.
- There should be a small rock dam that will repel rocks yet allow pods and loose bean seeds to move into the header, a difficult combination.
- The header must tilt side to side independent of the combine to allow the wider headers to make contact with the soil on both sides of the header—especially important with wide headers.
- The header must tilt forward and rearward manually from the combine cab to fine-tune a close cut, yet control the entrance angle into the header to prevent bean seeds from rolling out of the head.
- In addition to tilting side to side, the cutterbar should flex or bend to allow the sickle to follow the contour of the soil surface, especially important with the wider headers.
- Crop dividers at the ends of the header should lift and separate the bean plants and not push them down or cause seed shatter. A narrow, lifting divider design will usually be better for dry beans than a wide, blunt design.
- Bean seed tends to roll more than other grains so there should not be gaps, such as where draper sections overlap, to allow loose bean seeds to dribble out of the header.
- The header should accommodate an even flow into the feederhouse to avoid bunch feeding and attendant combine threshing and separation problems.
- Guard options to prevent cutterbar plugging and allow cutting very close to the soil surface without disturbing the soil. An example is stub guards.
- The reel should be adjustable forward and rearward and up and down from the cab to obtain best reel performance for specific harvesting conditions within a field.
- The reel tine path, or cam action, should be adjustable for more or less "aggressiveness" of the tines to lift and move the bean plants. This tine path may need to be adjusted between fields but will generally not need to be changed within a field.
- A nine bat reel will have more ability to lift the plants and move the cut plants across the cutterbar than a five or six bat reel. At least one manufacturer offers a nine bat reel.

Header Accessories

Several designs of lifter guards have been developed to help lift and hold the bean plants and pods above the cutterbar. In certain conditions these lifter guards can reduce harvest loss, but more often standard cutterbar guards perform as well or better. When plants are standing upright, the lifter guards can provide more "metal" to contact the plants and pods and cause more pods to drop or more pods to shatter.

Many growers add a wind system to their combine reel, which moves a high volume of air up and across the cutterbar. This helps the tine reel to lift the plants and pods above the cutterbar, and helps move the plants and pods—especially loose bean seed—across the cutterbar and into the auger or draper. If header loss is very low, these air systems provide little help. If header loss is high, especially from loose pods or loose bean seeds falling from the front of the cutterbar, these air systems can significantly reduce harvest loss. In one study at the University of Nebraska—Lincoln, header loss from a flex-auger header was about 5 bu/ac, but a wind system reduced the loss to about 3 ½ bu/ac. One complaint of the wind system in dry, sandy soils is that the dust caused by the moving air can create a serious vision problem, especially looking into the sun in late afternoon.

Header Operation

The combine operator must focus on the primary objective of keeping the header cutterbar as close to the soil surface as possible without taking soil into the combine. Avoid bringing soil into the header because this can quickly increase tare and add useless weight for transporting the crop. In addition, it will increase wear to the sickle components and to the entire combine. Have a spare sickle with the header and consider it normal to need to replace sickle sections as often as every 300 acres. Soil type and skill in adjusting the header will determine how often to replace the sickle.

It is useful to frequently move the reel forward or rearward, to tilt the header forward or rearward, and to change the reel speed to determine if these adjustments help reduce header loss. Most headers and combines have a proportional reel speed option to maintain the correct reel speed when the combine field speed changes. This is an important option to prevent tine drag or pushing in the plants when you need to change field speed.

If plant conditions change, consider adjusting the reel cam action to make the action more or less aggressive for lifting plants and keeping the cutterbar clean. Always keep an eye on the soil surface behind the header to visually monitor seed loss as you make any header or combine changes. Select a header width that allows you to keep combine field speed as low as possible, preferably below 3 mph, while utilizing combine capacity.

Combine Operation

Stone traps and grain loss monitors are two important combine features that the direct harvest combine operator must use to the fullest. Stone traps should be inspected to make sure they are in good operating condition at the beginning of the season. Stone traps tend to fill with soil clods and small rocks, and become packed with loose soil. Review your operator manual for stone trap operation and maintenance. Clean the stone trap at the beginning of each day and at least once during the day. One large rock intercepted by the stone trap can save thousands of dollars of repairs and several days of downtime.

Try driving parallel to the direction of the rows and at an angle to the rows to determine which direction provides the least harvest loss. Observe seed shatter at the header dividers. Determine if driving with the rows causes less shatter at the dividers than at a slight angle to the rows. Generally, driving the combine perpendicular to the direction of the bean rows causes excessive wear on the cutterbar drive mechanism and is not encouraged.

Since plant and bean seed condition might vary more during direct harvest than conventional harvest, keep an eye on the combine seed loss monitor. Make adjustments in field speed, threshing, and cleaning as appropriate to keep combine threshing and separating losses at a minimum. For the same reason, check on bean seed damage in the combine grain tank.

On a very hot, dry day, header losses can become excessive in late afternoon, with few options to correct the problem. Consider stopping the combine operation for a few hours until evening when header losses will be less. Remember, we have always shut down the bean undercutting operation in conventional harvest systems when plants become too dry, so it follows that we may need to shut down the direct harvest combine operation for a short time when bean plants become too dry.

Monitor Seed Quality

Our first goal in harvesting dry edible beans is to produce a quality bean. Mechanical seed damage should be monitored as changes are made in combine settings, as field conditions change, and as the harvest day progresses. If you can spot broken seeds in the combine tank, or if you see mechanically damaged seed in a handful from the tank, it is time to check closer. Remember, if you can see broken seeds, there will be at least twice as many seeds with checked seed coats found in a water soak test by the processor. Seed damage can be measured by visual inspection of the seed and by an evaluation of water-soaked seed. The following are descriptions of two suggested tests that can be done quickly and easily on the combine and will provide rough estimates of mechanical seed damage. Take seed samples to your processor for more accurate assessment of seed quality.

Visual seed damage estimate: Take a ¼ cup measuring cup from your kitchen. Swipe it through a representative area of the beans in your combine tank and scrape the beans off level. You will have approximately 100 seeds if your beans are typical pinto or great northern beans. Count the number of broken seeds plus the number of seed parts. This total number will be an approximate percentage of mechanically damaged seeds found by the naked eye.

Seed damage estimate using a water soak test: Take a ¼ cup measuring cup, a drinking cup, a bottle of water, and a roll of paper towels with you in the cab of the combine. Swipe the ¼ cup measuring cup through a representative area of the beans in your combine tank. Scrape the cup off level. You should have approximately 100 bean seeds with typical pinto or great northern beans. Fill the drinking cup about half full with water and pour the bean seeds from the measuring cup into the water. Let the beans soak in the water for about five minutes. Dump the water out of the drinking cup and put the bean seeds on a paper towel. Pick out and count any bean seeds that are mechanically damaged by the combine or that have swollen seed coats. The number counted will be the approximate percentage of mechanically damaged bean seeds. (*Figure 3*).

If the percentage of mechanically damaged bean seeds seems too high, have a sample checked by your bean processor. Make adjustments to your combine, if necessary, before

Figure 3. Water soak test. Beans on the right demonstrate wrinkling and damage.

continuing to combine. Bean processors can remove the broken beans and splits by air, screening, gravity tables, and electric eyes, but this will be a loss to the grower. However, a nondestructive method to separate and remove beans with checked seed coats is not available. Checked seed coats are a major problem for the canning industry as evidenced by the unsightly appearance of the damaged seeds found in a soak test (*Figure 3*).

Refer to your combine operator manual for suggested settings for dry edible beans to reduce seed damage. Two University of Nebraska—Lincoln publications might also provide suggestions for reducing seed damage: ECO5–773, *Recommendations for Harvesting Dry Edible Beans with the John Deere STS Series Combines* and EC05–774, *Recommendations for Harvesting Dry Edible Beans with the John Deere Walker Series Combines* (find at http://digitalcommons.unl.edu/).

Monitor Harvest Loss

Header loss is the No. 1 concern with direct harvest. Unless you know with a reasonable level of accuracy your header loss as you combine, you cannot make a good decision to make an adjustment in your combining operation, or to make adjustments to next year's production practices. Several times during the day, stop the combine so you or an associate can make a harvest loss measurement to know your current header loss.

Measure the harvest loss more often if field conditions change. Without extensive experience, it is difficult to eyeball the difference between 3 bu/ac and 5 bu/ac field loss without measuring. A 2 bu/ac harvest loss can make a substantial difference in profitability in a day's harvesting. Unless you measure harvest loss, it is very difficult to know if header or combine operation adjustments could easily make a difference in harvest loss.

How to Measure Field Harvest Loss

Measuring field loss during harvest is very important, especially with direct harvest. A quick, easy, and reasonably accurate method to measure harvest loss for pinto and great northern classes of edible beans is below. No weighing, measuring, or calculators are necessary. Each sample should take less than three minutes. It will provide sufficient accuracy for you to make good decisions. If you need a more precise measurement, or want to separate header loss from combine loss, continue reading the following sections.

This dedicated method uses a measuring frame of specific dimensions made ahead of time in any farm shop. The inside dimensions of the frame must be 12 inches long by 66 inches wide. Suggested construction is to use a ⅜ inch diameter rod. Apply heat to make square corners and weld mating ends to make a rectangle. Weld in one cross member, also made with ⅜ inch diameter rod, near the center of the 66-inch dimension to make the frame more rigid (*Figure 4*). You can carry this measuring frame in your pickup, or even your combine cab.

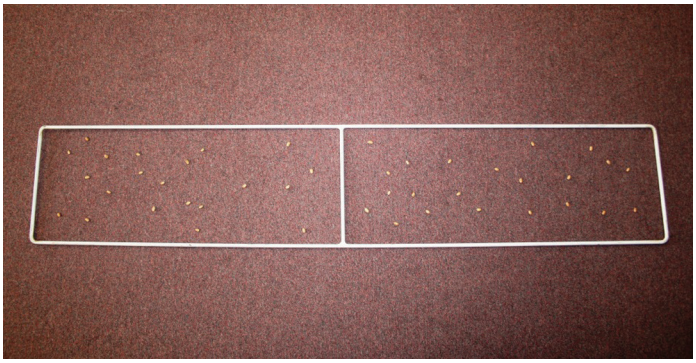

Figure 4. Harvest loss frame with 43 beans in it.

Here are the five simple, quick measurement steps:

1. *Randomly locate a measuring spot behind the header*. After the combine and header have established a stable operating condition in the field, randomly choose a sampling point at least 200 feet into the field. This can be done by tossing an object so your sample isn't biased. At this locality, use the frame to take three counts: one behind the left side of the header, one behind the combine, and one behind the right side of the header.

2. *Position the measuring frame*. Place the short dimension of the frame in the direction of combine travel. Do not make counts at the very ends of the header but rather a short distance from the end.

3. *Count the bean seeds*. Count all loose bean seeds and seeds still in pods within the frame area. Count each broken seed as one seed.

4. *Divide by 10*. Divide the total number of bean seeds found within the measuring frame by 10. The result is the header loss in bu/ac.

5. *Average the three counts for total harvest loss*. This will measure total loss, including threshing or separating losses. Determining threshing and separating losses complicates the measurement and are generally relatively low.

If the bu/ac loss directly behind the combine is two or more times the bu/ac behind the header only, especially if using a chopper or spreader, then the combine loss must be explored further. For example, suppose you find a total of 43 bean seeds inside the frame at the first sampling location in the field. Dividing 43 seeds by 10 results in a measured field loss of 4.3 bu/ac at this first site (*Figure 4*).

There are several limitations or "compromises" with this system. The inside dimensions of the frame must measure 12 inches by 66 inches (or 5.5 square feet). This frame size was designed to work only with typical great northern and pinto sized bean seed. It will not work with smaller or larger seed such as navies or light red kidneys. Because this system is based on one seed size (an average of locally grown great northern and pinto beans), there will be a relatively small, but usually unimportant, error if the particular pinto or great northern seed is very small or very large.

Always make measurements in at least two or three spots in the field, preferably including both sides of the header, and average the results. Field losses are variable so expect some difference among measurements, which is the reason for making several measurements before making important decisions.

Harvesting Other Market Classes of Beans

If the beans you are harvesting are larger or smaller than the typical great northern or pinto bean seed, or you are harvesting a different market class, the measuring frame method described above will not be accurate unless you change the size of the frame. For example, if you are harvesting light red kidney beans with a typical seed size of 900 seeds per pound, a good measuring frame size would be 24 inches long by 48 inches wide. If you are harvesting navy beans with a typical size of about 2,400 seeds per pound, the measuring frame size would be 12 inches long by 36 inches wide. Other than that, the method described previously will work—count the seeds inside the correct measuring frame, divide by 10, and the result will be harvest loss in bu/ac.

Another option for estimating field harvest loss is to count the number of seeds, including seeds in any pods (count broken seeds as whole seeds), in a square foot area and convert to bu/ac or lb/ac based on the seed size listed in *Table 2.* For example, if you are harvesting seeds that are about 1,800 seeds/lb, and you count five seeds within a frame that is 1 foot on each side, *Table 2* indicates the harvest loss is 121 lb/ac or about 2 bu/ac based on 60 lb/bu. To use this method, you should make a measuring frame that has inside dimensions of 1 foot per side; make at least three to five measurements; and average the results. As with the method described previously, locate random measuring sites behind the left and right wings of the header pass and behind the combine itself to estimate total harvest loss.

Frequently Observe Soil Surface Behind the Header

The combine operator should continually watch the soil surface behind the header through both sides of the combine cab to monitor header loss. Remember that approximately two pinto or great northern bean seeds per square foot represent roughly 1 bu/ac field loss. Thus, if a square foot of the area contains seven bean seeds, the approximate field loss is 3 ½ bu/ac for typical size pinto or great northern beans. If there is a question about field loss, use the more accurate measuring frame method described previously. Continually monitor header loss and measure frequently.

Determine Combine Threshing and Separating Losses

A reliable measurement of combine threshing and separating losses is complicated and beyond the scope of this publication. Keep in mind that if the combine has a chopper or spreader to distribute straw and/or fine material, it will be difficult to determine how far that material is spread or concentrated. If there is no chopper or spreader, the combine loss will be concentrated directly behind the combine separating section. Any sample measured there will include header loss plus a concentration of threshing and separating loss. To determine actual threshing and separating loss, the header loss must first be subtracted, and the remaining loss must be divided by a factor, which is the ratio of the width of the header divided by the width of the combine separating section.

Observe Combine Grain Loss Monitor

Your combine grain loss monitor will provide a good indication of any large changes in threshing and separating losses. Refer to your combine operator manual for specific instructions on calibrating your loss monitor. Although these monitors may not give you the exact grain loss through the combine, they will provide a good indication that the loss is

Table 2. Relationship of field loss, average number of seeds lost per square foot of soil surface area, and seed size of the variety harvested.

Seed Size (seeds/lb)	*Average number of seeds lost per square foot*														
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0	9.0	10.0
800	27	54	82	109	136	163	191	218	245	272	327	381	436	490	545
1000	22	44	65	87	109	131	152	174	196	218	261	305	348	392	436
1200	18	36	54	73	91	109	127	145	163	182	218	254	290	327	363
1400	16	31	47	62	78	93	109	124	140	156	187	218	249	280	311
1600	14	27	41	54	68	82	95	109	123	136	163	191	218	245	272
1800	12	24	36	48	61	73	85	97	109	121	145	169	194	218	242
2000	11	22	33	44	54	65	76	87	98	109	131	152	174	196	218
2200	10	20	30	40	50	59	69	79	89	99	119	139	158	178	198
2400	9	18	27	36	45	54	64	73	82	91	109	127	145	163	182
2600	8	17	25	34	42	50	59	67	75	84	101	117	134	151	168
2800	8	16	23	31	39	47	54	62	70	78	93	109	124	140	156

Values in table are field loss in pounds/acre

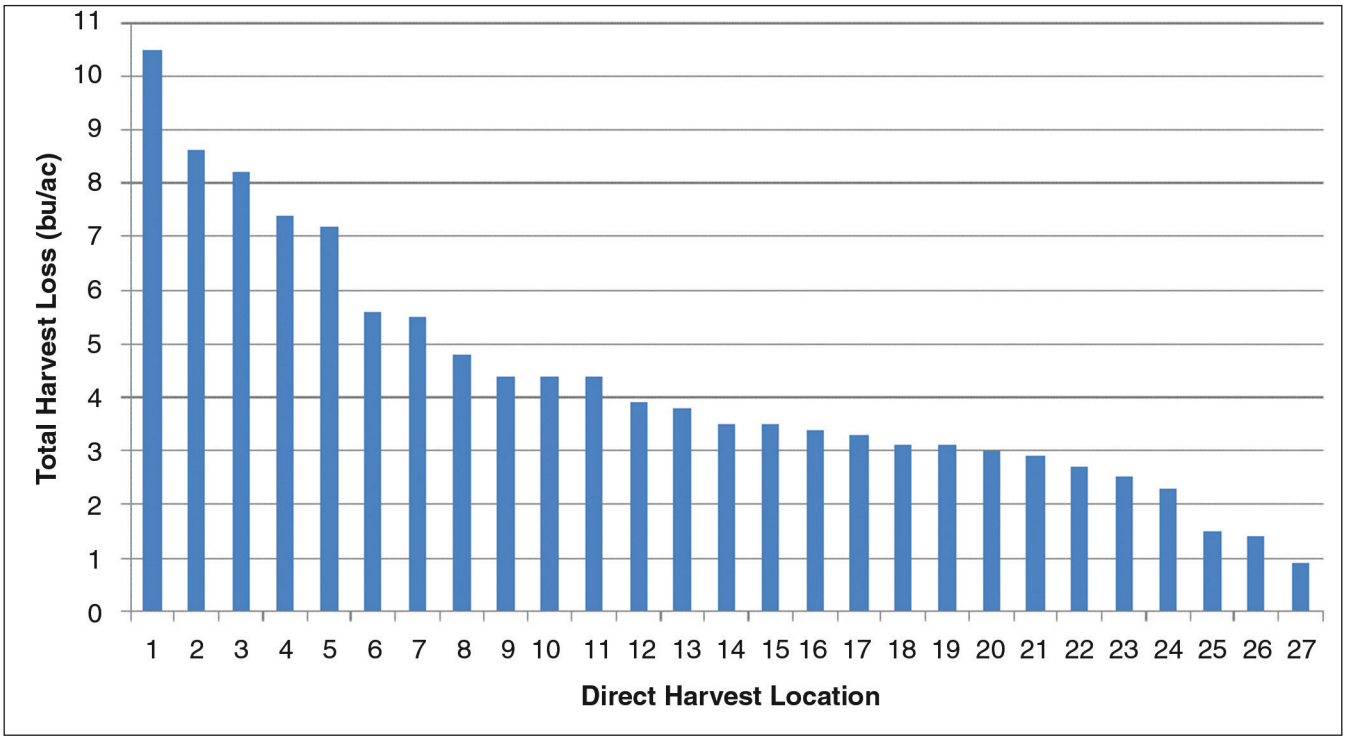

Figure 5. Field loss measurements from 27 growers' fields (2014). Sites were labeled 1–27, based on the level of harvest loss.

changing. If the monitor indicates loss is increasing, believe it, stop, and investigate the problem. Harvest loss is a loss of yield and crop income. Find a harvest loss measuring system that works for you and use it frequently.

Field Loss Measurements from Growers' Fields

Twenty-seven harvest locations in the Nebraska Panhandle (actual growers' fields) were sampled in 2014 to determine the total direct harvest loss (*Figure 5*) and the average pod height at harvest time. Losses ranged from 0.9 bu/ac to 10.5 bu/ac. This wide range in harvest loss varied from very small to unacceptably large. Losses above 4 bu/ac are unacceptable, and growers need to determine what went wrong. Many growers who have less than a 4 bu/ac loss are very pleased with direct harvest and don't intend to use conventional systems again.

Pod height at harvest is the primary factor in harvest loss that we have been able to measure and relate to harvest loss on a field- to-field basis. Pods less than 2 inches above the soil surface are very likely to be shattered during harvest

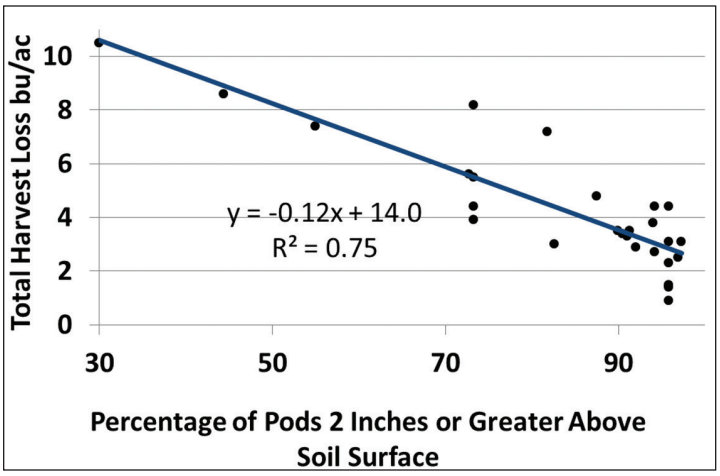

Figure 6. Relationship of pod height vs. total harvest loss from the 27 harvest locations in 2014.

by the cutterbar. In each of the 2014 harvest locations, pod height was measured at harvest time. Most of the fields with a harvest loss less than 5 bu/ac had more than 90 percent of the pods 2 inches or more above the soil surface. A regression analysis of pod height with harvest loss indicated an R^2 value of 0.75, suggesting a high correlation between pod height and yield loss (*Figure 6*). Dry bean varieties with a strong upright structure holding pods higher than 2 inches above the ground must be chosen when producers are planning to direct harvest.

Other factors increasing harvest loss were an uneven soil surface that raised the header higher above the soil surface; less suitable headers such as older auger flex feed heads; operators not making timely adjustment in header angle and height;

Figure 7. Furrow irrigated beans in firm, flat- topped beds.

harvesting at too high a field speed; and harvesting during the hottest part of the day, which increases pod shattering.

Harvest loss data was collected in 2012 and 2013 also. The 2014 data is very representative of the full three years of data. These data give producers an understanding of how bad harvest loss can be and the realization that harvest loss can be minimized.

Options and Alternatives to Direct Harvest

Furrow vs. Pivot Irrigation

We generally assume that direct harvest will only work under pivot irrigation, but furrow irrigation also can work. Furrow irrigation imposes several limitations on direct harvest and makes crop management more critical, but has been successful for several growers.

Row spacing is limited to some arrangement of furrow spacing. Generally, furrow spacing is limited to 22 inches or greater. One bean row could be planted between 22 inch furrows, or furrows could be spaced wider and more than one of the closely spaced bean rows could be positioned on "beds" between the furrows. Beds with distinct furrows and flat, firm tops should be made before planting. After planting, the furrows should be reformed in a way that the ridge tops remain flat, smooth, and a consistent height from bed top to bed top. These flat, level bed tops form the surface for the combine header just as a flat surface under a pivot. Varieties must be used that do not fall or tip into the furrow because the combine header may not be able to pull the plants out of the furrow. Weed control should be limited to herbicides because cultivation will likely create soil ridges on the tops of the beds.

One furrow irrigation system that has been used successfully begins with creation of firm, flat- topped beds with deep, defined furrows (*Figure 7*). This can be done with an implement that has wide shovels with trailing heavy press wheels/rollers to form the furrow and flatten the top surface.

Herbicides can be applied and incorporated with an implement having nozzles centered over the beds, followed by several rolling incorporating devices to incorporate the herbicide, and to firm and level the tops of the beds. The planting tractor will need to have very narrow tires to maintain the furrow shape. The tractor and planter combination must avoid pushing up ridges beside the bean rows and maintain a flat bed surface consistent from bed to bed.

The variety used had an erect main stem that did not tip and fall into the furrows. The irrigation furrows were reformed after planting. Large, independently weighted V-shaped wheels made a smooth, firm furrow without pushing up any new soil on the tops of the beds. The crop was harvested with a standard flex head with very low total harvest loss. One unexpected advantage of this bed, furrow-irrigated system is that bean yields were several bu/ac higher than a sprinkler flat surface system, compared with a replicated research study. A possible reason for the yield difference is that the beds created an ideal environment for the bean plant roots with no soil compaction and good water drainage.

Figure 8. At right, beans planted into fall-planted wheat cover crop.

Figure 9. Plants shown on the left demonstrate long-stemmed bean architecture when planted into a very tall cover crop.

Planting into Tall Cover Crops

Planting dry beans for direct harvest into tall, dense, evenly growing cereal cover crops can help reduce harvest loss. Research at the University of Nebraska—Lincoln found

that planting dry beans into a winter-planted cereal crop caused the bean pods to develop higher in the bean plant structure, which reduced harvest loss. However, the cover crop had to be tall and dense at the time the bean plants were emerging (*Figure 8*). This necessitated a fall-planted cereal crop, not spring-planted, to develop enough dry matter in the cereal plant to maintain enough height and density to cause the bean pod to develop higher (*Figure 9*).

The cover crop was sprayed immediately before planting to maintain enough cereal plant for this height and density. Bean row spacing was 22 inches in this particular study. Two other advantages of this winter cover crop were increased bean seed yield (2–4 bu/ac), and excellent weed control from the time of fall planting of the cover crop until bean harvest.

One disadvantage of the cover crop was increased water use during the cover crop growth period. Planting into the cover crop was not an issue with the standard double disk planter furrow openers if preceded by a single disk coulter to cut residue. Row cleaners should not be used because they remove too much of the cover crop needed to cause elongation of the emerging bean plants. The residue from the cover crop that remained at harvest did not cause a problem with the combine header.

Swathing vs. Direct Harvest vs. Undercutting

The swathing harvest system is in many ways an "in-between" system, compared with the direct harvest and conventional harvest systems. Growers who have light red kidney beans often prefer the swathing system over direct harvest because they can better control seed moisture content and seed color.

If the grower already has a swather for other crops, new equipment or headers aren't needed. Swathing, if done when there is dew on the plants, has very low field loss, compared with direct harvest. Swathing has very little soil in the windrow, and thus in the combine, compared with conventional harvest. But swathing exposes the cut plants in the windrow to risks from wind and rain, similar to conventional harvest.

From the perspective of field operations and crop production, the swathing system is the same as direct harvest until swathing. After swathing has placed the bean plants in a windrow, the swathing system is very similar to the conventional harvest system. Refer to the direct harvest system explained previously for details of the production system up to the swathing operation. Crop production details of the swathing system that are different from either the direct harvest system or the conventional harvest system include:

Crop insurance. The same rules apply to swathing as to direct harvest if the crop is planted in narrow rows. If you plant rows narrower than 22 inches, discuss narrow rows with your crop insurance agent prior to the sign-up date to make sure you have the coverage you are counting on.

When to swath. Swathing is typically done at the same time as undercutting would typically be done. Some growers prefer to swath when about 70–80 percent of the pods have begun to change color. Light red kidney growers will often swath at this time to manage seed color and seed moisture content. At the other extreme, some growers, especially those growing pinto beans, will wait until the plants and seeds are sufficiently dry so the plants can be swathed in the morning and the windrows combined in the afternoon. This practice minimizes the risk from wind and rain on the windrows. Desiccants or harvest aids are seldom used or needed in swathing systems.

As with conventional undercutting, the swathing operation must be done when dew is on the plants, generally early in the morning. When the plants become dry, the swather will create excessive pod damage, resulting in high harvest loss. Keep an eye on the soil surface behind the swather header for loose bean seed or loose pods. When done correctly, field loss from the swathing operation should be less than 1 bu/ac, or even less than ½ bu/ac.

Swather Selection and Operation

Producers who swath edible beans usually select a swather that has been designed for edible beans. The MacDon swather series has been very popular for swathing edible beans, but models from other manufacturers can also be used. The model must be a cereal swather design, not a hay or forage design. The swather must have draper belts to move the cut plants, not an auger or conditioner rolls. The swather should have options to drop the windrow in the center of the machine, at the end of the machine, and near the end of the machine. Header width can be 30 feet or more. If the windrower drops the windrow near the end of the header and places two windrows side by side, the volume of material taken into the combine can keep the combine near full capacity without excessive field speed.

Desired features of the windrower head are very similar to the combine header for direct harvest. The sickle must operate very close to the soil surface, actually just "tickling" it. The header must float, and if wide enough, must flex or

bend to follow the contour of the soil surface. The header must tilt forward and rearward to position the sickle as close as possible to the soil surface without actually operating in the soil. Plan for high wear to the sickle sections and guards, and replace when necessary.

The swather reel is critical for lifting the plants and for moving cut plants uniformly and quickly onto the draper belt. Keep the tines as close to the sickle as possible. Adjust the forward and rearward position of the reel, reel speed, and reel tine cam action to determine the best combination for each field.

Experiment with the best direction for swathing relative to the direction of the plant rows. Often, driving a slight angle to the direction of rows will improve cutting and lifting of the plants. Also consider which direction might provide the least risk from prevailing winds that could move or roll the windrow.

Can Direct Harvest Be Successful in Nebraska?

Based on the growing number of Nebraska dry bean growers who are switching to direct harvest, the answer is a definite "yes." But the practice does not fit every operation at this time. Each producer must carefully examine his or her own operation and weigh the advantages and disadvantages. Observe neighbors' operations and talk with other producers or extension educators. If you decide direct harvest might fit your operation develop a plan to move carefully into the new production system.

Perhaps have a neighbor do narrow row planting; custom combine for the first year on part of your bean acreage; or lease key equipment for the first year to gain experience. But do not compromise on quality management of any of the system's critical steps. Remember: keep the soil surface level all season long; grow several varieties; grow a tall plant; and measure field loss as you harvest.

University of Nebraska Lincoln

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