Harvesting Michigan Navy Beans
Michigan State University Extension Service
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Issued June 1992
8 pages

Cooperative Extension Service ● Michigan State University ● Extension Bulletin E-2408 June 1992

AG FACTS

Harvesting Michigan Navy Beans

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Michigan has long been one of the leading producers of dry edible beans in the United States. Although dry beans are commonly grown in 40 of Michigan's 82 counties, nearly 75% of the crop is produced in 6 counties in the east central region that includes the Saginaw Valley and the Thumb area. Navy beans account for about 80% of the dry bean crop and Michigan Navy beans make up more than 50% of U.S. production.

The most common Navy bean harvest method has not changed greatly in several years. The plants are cut with a knife or blade puller/cutter when 90% of the pods have matured and turned buckskin brown. The cutting operation begins before dawn when the pods are damp and tough from the morning dew. The plants are windrowed with a pickup and draper belt windrower during the cutting operation, or in a separate operation within a few hours of cutting. The crop is harvested later the same day with an edible bean or conventional combine equipped with a windrow pickup attachment. During the 1980s, 95% of the dry beans in Michigan were harvested at a moisture content of 16.5 to 19%.

One of the greatest challenges that Michigan Navy bean growers face is to get their crop harvested and out of the field without rain damage. In the Saginaw Valley the normal rainfall for September is 3.0 inches; for October, 2.7 inches (Michigan Department of Agriculture Climatology Program, 1989). On average, there will be more than six days in September and six days in October with at least 0.1 inches of rain. The threat of rain damage has a strong influence on the harvest strategies chosen by Michigan bean growers.

Navy bean field harvest loss was measured on several farms in the Saginaw Valley and the Thumb area in 1990 and 1991. Four harvest methods were compared while harvesting the upright variety May-flower:

1. Direct harvest with a floating flex-head and a finger/air reel.
2. Direct harvest with a floating flex-head and a standard pickup reel.
3. Pull and windrow using a knife cutter.
4. Pull and windrow using a rod cutter/windrower.

Precleaning loss for the pull and windrow trials includes loss at the rod or knife, windrowing loss and loss at the combine pickup. Precleaning loss

Cutting Michigan Navy beans with a knife cutter

Table 1. Average Navy bean harvest loss in 1990 and 1991

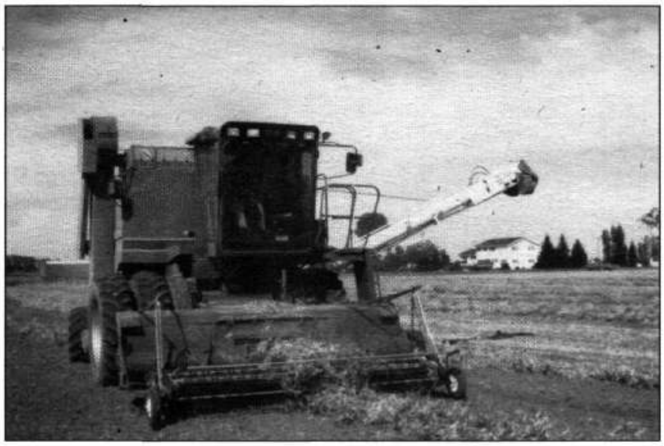
Harvest Method	Average Precleaning Loss, % [Range]	Average Cleaning Loss, % [Range]	Average Total Loss, % [Range]
Pull & Windrow Rod Cutter	1.6 [1.1-5.0]	2.1 [0.8-3.6]	3.7 [2.9-5.3]
Pull & Windrow Knife Cutter	2.3* [1.1-10.9]	2.4 [1.4-5.7]	4.7* [2.6-12.3]
Direct Harvest Finger/Air Reel	6.9 [2.9-10.4]	1.2 [0.6-1.9]	8.1 [3.5-11.4]
Direct Harvest Finger Reel	11.7% [3.3-20.0]	2.0 [1.9-2.0]	13.7 [5.4-21.9]

*Includes only those trials where equipment was operating as intended.

the direct harvest trials includes loss that occurs at the combine header. Cleaning loss includes beans that passed through the combine during cleaning and threshing. Split or shriveled beans were not included.

Pull and Windrow Harvest

Pulling and windrowing causes lower harvest loss than direct harvest. However, the risk of rain damage is high when the plants are lying on the ground in a windrow. Plan harvest operations so that the beans pulled and windrowed in the morning can be gathered and threshed in the afternoon.



Harvesting with a rotary combine with a windrow pickup attachment

Pull and Windrow—Knife Cutter

Pulling and windrowing should begin early in the morning when the plants are damp and tough from the morning dew. The knives or blades should be set to cut the plants one or two inches below the soil surface. As the knives cut and lift the plants, windrowing rods move the plants from two rows into a single windrow. A pickup and draper belt windrower then combines the plants from four, six or eight rows into a single, larger windrow either during the cutting operation or in a separate operation within a few hours of cutting. Side discharge windrowers can place two windrows side-by-side to be picked up with a single pass of the combine and increase combine efficiency. Knife pullers work better in 28- or 30-inch rows than in narrower row spacings.

If harvest conditions are good, a skilled operator will be able to keep pulling and windrowing losses below one percent of crop yield. Loss at the combine pickup will be about one percent. Cleaning and threshing loss will usually be between one and two percent. Total harvest loss of about three percent is acceptable. However, higher losses can occur because management practices, operator skill, equipment adjustment and field conditions all affect harvest loss.

Pulling and Windrowing

Pulling and windrowing leads to lower harvest loss than direct harvest.

- Pull and windrow early in the morning when the plants are damp and tough from the morning dew.
- Loss increases at the knife if depth control is a problem, at the windrower or combine pickup if pickup speed does not match ground speed, and during cleaning and threshing if the combine is overloaded or not properly adjusted.
- Row cultivation usually facilitates ease of cutter operation.

The most common source of harvest loss when pulling and windrowing is poor performance of the cutter knives. Cutting loss can be kept below one percent when the knives are working well, but losses as high as ten percent of crop yield can occur in fields where depth gauging problems or dull knives cause the knives to intermittently ride out of the ground. They may bury or knock the plants over rather than cut and lift the plants from the soil.

The second most common source of harvest loss is the cleaning and threshing operation. Cleaning losses of three to six percent can occur if the combine is overloaded. The plant material going through the combine is usually very dry so it is possible to run too much material through and increase harvest loss without plugging the combine.

Another source of harvest loss when pulling and windrowing is at the windrower or combine pickup. Pickup loss is greatly influenced by pod moisture and pickup adjustment. Adjust the pickup speed for an even, smooth flow of material. Loss will increase if the speed of the windrower or combine pickup does not match ground speed and the windrow bunches up or tears apart. Pickup speed poorly matched to travel speed will increase loss in all conditions. If the pods are dry and brittle, the pickup fingers will break open some pods even when pickup speed is well matched to ground speed. Since the bean pods are driest when entering the combine, high pickup losses are more likely to occur at the combine pickup than at the windrower pickup.

Pull and Windrow—Rod Cutter

The rod cutter used for bean harvest is very similar to the rod weeder used in the Western and Plains states for weed control. Rather than using a blade or knife to cut and lift the plants from the soil, the rod cutter uses a rotating rod that runs below the soil surface to cut the plant stem. A second, larger rotating rod runs at the soil surface to lift the plant from the soil and deliver the plant directly to the pickup head and cross conveyor. Pulling and windrowing is a one-pass operation.

Rod Cutter

May have an advantage:

- In hard soils.
- With varieties that pull hard with a knife cutter.
- In narrow rows.

In good harvest conditions, harvest loss with the rod cutter will be about the same as with the knife cutter. But it may be easier to avoid high losses under difficult harvest conditions with a rod cutter than with a knife cutter. Once the rod cutter is adjusted for field conditions, it is less sensitive to minor changes in ground contour or plant maturity than the knife cutter. The rod cutter will also have an advantage when pulling varieties with well developed root systems that are difficult to pull with a knife cutter. Rod cutters are better suited to narrow rows than the knife cutter.

Direct Harvest

Direct harvest of dry beans is being adopted on many farms. Direct harvested dry beans are cut and gathered in one operation with a bean header on the combine. There are several potential advantages with direct harvest:

1. Reduced machinery investment.

2. Elimination of the cutting and windrowing operation.

3. Reduced risk of rain damage to the cut and windrowed crop; the beans will either have been harvested or will remain standing.

4. Reduced difficulty of planning harvest operations. Harvest can begin as soon as the crop is dry enough and continue as long as weather conditions allow.

5. Suitable for narrow rows.

Historically, the biggest objection to direct harvest of Navy beans has been excessive harvest loss, as high as 20 to 50% in some cases. But equipment improvements such as the floating flex-head with a narrow pitch (quikcut) cutterbar, vine lifters, and air injected in front of the cutterbar—together with upright varieties such as the Navy bean Mayflower—have encouraged Michigan growers to reconsider direct harvest.

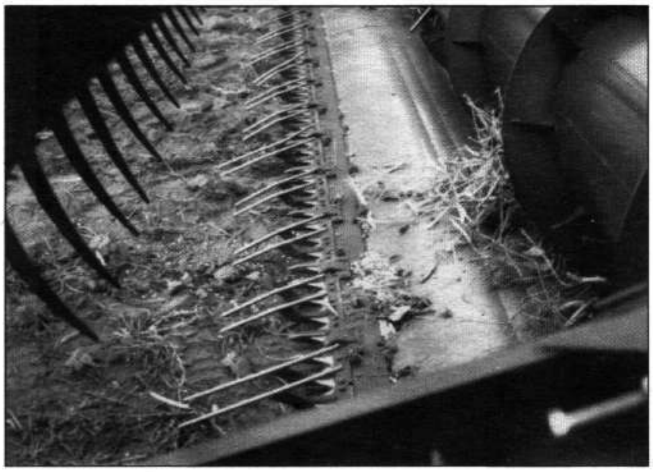
Most of the loss that occurs during direct harvest is shatter loss, shelled beans that are cut but not delivered to the combine. Stubble loss (beans in pods attached to the stubble left by the combine header) can be significant if the plants are cut too high. Varieties with improved lodging resistance such as Mayflower, a Type II indeterminate with short vine development and upright, erect growth habit, make it possible to reduce stubble and shatter loss compared to determinate plant types.

When direct harvesting, it is important to cut the plant as close to the ground as possible. Equipment improvements which reduce soybean harvest loss will also reduce Navy bean loss. Research in Illinois during the 1970s showed that the floating header reduced soybean losses by about 25% compared to a standard header. In separate studies, a floating flex-head reduced losses by about 25% compared to a conventional floating header. The quikcut sicklebar reduced loss by as much as 40% compared to a standard sicklebar.

Research in Michigan indicates that Navy bean harvest loss is reduced by 40 to 50% when air is injected in front of the cutterbar. The air helps move the plant material and loose beans off the cutterbar and into the combine before they have a chance to accumulate and spill out onto the ground. Navy bean harvest loss averaged 8.1% when direct harvesting with a finger/air reel, 13.7% when using a standard pickup reel.

Air is most beneficial under the most difficult harvest conditions when the bean pods are dry and brittle and easily shattered. Early in the day the plants reach a moisture content suitable for threshing, yet the pods are not brittle. Then, direct harvest header losses may be as low as 3% whether or not air is used. But as the pods dry

Direct harvesting with air injected in front of the cutterbar



Vine lifters lift leaning plants and low-hanging pods above the sicklebar

throughout the day, header losses may reach 10% or more when air is used and may exceed 20% with a standard pickup reel.

Direct Harvest

Reduce harvest loss with:

- Upright varieties.
- Floating, flex-head cutterbar.
- Air injected in front of the cutterbar.
- Vine lifters.
- Narrow pitch (quikcut) sicklebar.

Vine lifters on the cutterbar lift leaning plants and low hanging pods above the sicklebar before the plant is cut. Field conditions will determine the advantage gained from vine lifters. They will be most beneficial when direct harvesting viny, prostrate plants and varieties that lack upright growth habit. When direct harvesting viny Great Northern beans in Nebraska, vine lifters reduced total harvest loss by about 40%.

No matter what type of sicklebar is used, it must be sharp. Shatter loss can be reduced with a narrow pitch sicklebar which causes less lateral movement of the plant before it is cut than a standard sicklebar. The air jets of the air/reel recover many of the beans that might normally be lost with a standard pickup reel. A narrow pitch sicklebar is most beneficial when it is used with a standard pickup reel.

Cultivation can facilitate harvest in both pull and windrow and direct harvest systems. The shallow furrow created by the cultivator allows the knife cutter to cut the plant stem below the row, yet run near the surface between the rows. Consistent depth gauging is improved and power requirements are decreased. When direct harvesting, clipping at the top of the ridge reduces the number of stones contacting the cutterbar. No increase in harvest loss was noticed for cultivated versus noncultivated fields for either harvest method.

Machinery Economics

Equipment improvements such as the floating flex-head with a narrow pitch cutterbar, vine lifters and air injected in front of the cutterbar, (together with upright varieties such as the Navy bean Mayflower) have encouraged Michigan growers to consider direct harvest of Navy beans. Many growers are also replacing knife or blade cutters with rod cutters for pull and windrow harvest.

The ownership and operating costs for Navy bean harvest equipment are summarized in Table 2. Annual costs are presented on a cash flow, pretax basis. Each machine is purchased, financed and replaced over ten years. Machinery ownership costs are allocated on an hourly basis. Ownership, repair and maintenance costs are based on 500 hours' use per year for the tractor, 200 hours per year for the combine. Operating costs include fuel and lubrication, labor, repairs and maintenance.

Guidelines for Combine Settings

The cleaning and threshing characteristics of the Navy bean crop will change throughout the day as the moisture content changes. Poor combine adjustment can lead to higher than necessary harvest loss as well as cracked and split beans. Refer to the combine owner's manual for specific adjustments. Learn how to make harvest loss estimates and check combine performance frequently throughout the day. Some general rules of thumb that apply for Navy beans:

1. Cylinder speed, 200 to 600 rpm. The cylinder speed should be set no higher than necessary to thresh efficiently. Generally, the drier the crop, the slower the cylinder speed.

2. Fan speed, medium to high.

3. Concave clearance, 5/16" to 7/8".

4. Chaffer, 5/8" to 3/4".

Table 2. Costs of owning and operating Navy bean harvest equipment*

PULLING AND WINDROWING**

	Width	Acre Yr	Tractor HP	Acres Per Hr	Price, $ Tract.	Price, $ Imp.	Ownership, $/Yr Tract.	Ownership, $/Yr Imp.	Operating $/Acre	Total $/Acre
Knife Cutter & Windrower	10 ft.	200	60	5.1	24,000	8,000	236	984	2.19	8.30
	15 ft.	300	75	7.7	30,000	10,000	296	1230	1.56	6.65
	20 ft.	400	90	10.3	36,000	12,000	355	1476	1.24	5.80
Rod Cutter/ Windrower	10 ft.	200	80	5.1	32,000	16,500	315	2028	2.39	14.10
	15 ft.	300	100	7.7	40,000	18,900	394	2322	1.72	10.75
	20 ft.	400	150	10.3	60,000	22,000	591	2704	1.54	9.80

COMBINING***

	Width	Acre Yr.	Combine Capacity	Acres Per Hr.	Price,$	Ownership $/Yr.	Operating $/Acre	Total $/Acre
Direct Harvest (Std. Pickup)	15 ft.	200	4-row	3.4	98,900	3543	5.26	23.00
	20 ft.	300	6-row	4.5	112,400	4372	4.49	19.05
	20 ft.[1]	400	8-row	4.5	125,900	5918	5.28	20.10
Direct Harvest (Air Reel)	15 ft.	200	4-row	3.4	104,700	4255	5.52	26.80
	20 ft.	300	6-row	4.5	118,600	5134	4.69	21.80
	20 ft.[1]	400	8-row	4.5	132,100	6680	5.47	22.15
Windrow Pickup	10 ft.	200	4-row	4.1	101,900	3468	4.21	21.55
	15 ft.	300	6-row	6.1	115,400	3891	3.14	16.10
	20 ft.	400	8-row	8.2	128,900	4314	2.38	13.15

*Real interest rate @ 6%, insurance and shelter @ 1% of purchase price, labor @ $7.50/hr, diesel fuel @ $1/gal plus 15% for lubrication and filters.

**Cutter and windrower speed @ 5 mph, beans pulled and windrowed in one pass.

***Direct harvest @ 2.5 mph, windrow pickup @ 4.5 mph.

[1]Many Michigan growers consider header widths near 20 ft to be optimal. Wider header widths increase the difficulty of following ground contour and cutting the plants close to the ground.

5. Cleaning sieve, 3/8" to 1/2".

6. Combine pickup speed should match combine ground speed to avoid bunching or pulling apart the windrow. When direct harvesting, initially set the reel index (ratio of peripheral speed to ground speed) at 1.2 to 1.3 and adjust accordingly.

7. When harvesting large seeded beans such as kidneys with a conventional combine, split beans and checked seed coats may be excessive. Bean quality will usually improve with an edible bean combine.

Important Management Considerations

In addition to the equipment used and its adjustment, specific management practices affect the quality and quantity of beans harvested. Some of the most important are:

1. Harvest near 18% moisture. Checks, cracks and splits increase as bean moisture content decreases.

2. Choose upright varieties for direct harvest.

3. Good weed control is important. Bean staining is common when harvesting weedy fields.

4. Time field operations to minimize loss. Pull and windrow when bean pods are moist and tough from the morning dew. Direct harvest loss may double, triple or more from morning to afternoon as pod moisture decreases.

5. Monitor harvest loss periodically each day. Using a one square foot frame, count the number of beans on the ground. Beans will not be evenly distributed across the width of the combine, so take five or six measurements and average the results. Precleaning loss can be estimated by stopping the combine, lifting the header or pickup, backing up the combine and counting beans on the ground in the area beneath the combine when it ceased forward motion. Total loss can be measured behind the advancing combine. Cleaning loss will be total loss minus precleaning loss. If harvest problems arise, make the necessary adjustments.

For a more detailed discussion of measuring harvest loss, refer to Neb-Guide 684-725, **Measuring Harvest Loss of Dry Edible Beans** by J.A. Smith, Univ. of Nebraska-Lincoln.

Table 3. Number of beans per square foot equivalent to one hundredweight per acre

SEED SIZE	CLASS	BEANS/SQ. FT.
Small	Navy bean	5.2
	Small White	6.9
	Black Turtle	6.9
Medium	Pinto	2.8
	Great Northern	3.0
	Pink	3.2
	Red Mexicans	3.2
Large	Kidney (light red, dark red and white)	2.0
	Cranberry	2.3

Source: J.D. Kelly, MSU Crop and Soil Sciences, 1992

The authors would like to acknowledge and express their appreciation to the bean growers who participated in the Navy bean harvest loss study: Dick Gremel, Maynard and Dean Haubenstricker, Reif Farms, John Schluckbier, Vern Stephens and the Bad Axe FFA.

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