Sunflower Plant Drying and Machine Harvest Efficiency—Southern Plains

R. R. Allen, A. F. Wiese, E. B. Hudspeth, Jr.
MEMBER ASAE FELLOW ASAE

ABSTRACT

HARVESTING of irrigated oilseed sunflower was investigated on the Southern Great Plains. Preharvest plant and seed drying patterns with and without a chemical desiccant (paraquat) were evaluated. After plants reached physiological maturity, seed in untreated plants dried to the safe threshing and moisture storage level of 9 to 10 percent in about 10 days although heads and stalks remained relatively green at about 70 percent moisture. The desiccant speeded head and stalk drying by 7 to 10 days but had little effect upon seed drying rate. A shielded-reel heading attachment on the combine-thresher permitted harvesting 5 to 7 days earlier at higher moisture content than with an open-reel machine because less stalk was handled. Using the shielded-reel header also resulted in cleaner seed. The potential advantage of earlier drying using chemical desiccants was offset by the cost of chemical application and the ability of the shielded-reel header to harvest sunflower earlier.

INTRODUCTION

Sunflower (*Helianthus annus* L.) has become the second most important source of vegetable oil in the world. It is surpassed only by soybeans (*Glycine max* (L.) Merr.) (Cobia and Zimmer, 1978). Sunflower is the primary oilseed crop in the Soviet Union, other East European countries, and Argentina, where climate limits soybean production. High-yielding, high-oil varieties developed in the Soviet Union have contributed to wider adaptation and increased production. Sunflower is a major crop in the Red River Valley area of the Dakotas, Minnesota, and adjacent western Canada, northern areas where soybeans are not well adapted. Since 1972, higher sunflower oil prices and the development of hybrids have increased interest and area planted in other regions of the United States, especially in the Southern High Plains, where 75 000 to 125 000 ha/yr were grown from 1975 to 1977.

Most available sunflower harvesting information is based on grower experience. Experience in the northern area has shown that if small grain headers on combine-threshers are modified, they can be used successfully to harvest sunflower. The earlier North American experience came from Canada, where a design and detailed plans were developed for constructing a heading attachment (Putt, 1967). In Tennessee, tests using a sunflower heading attachment manufactured in Minnesota on a combine-thresher showed header losses were about 5 percent as compared to 46 percent without the attachment (Mullins et al., 1972). These attachments operate on a head-stripper principle that includes both seedgathering pans extending ahead of the cutter bar and modified reels.

Chemical desiccants have been used to a limited extent in attempting to speed plant drying and harvesting in order to reduce losses from exposure to birds and weather. Diquat (6, 7-dihydrodipyrido[1,2-a:2′,1′-c] pyrazindeiium ion) was evaluated on open pollinated varieties in Canada, Hungary, and Poland (Sanderson, 1976). Ten days after treatment in Poland, head moisture was reduced to 40 percent and seed moisture was 13 percent as compared with 75 and 17 percent for untreated plants. In the United States, only paraquat (1,1′-dimethyl-4,4′-bipyridinium ion) is approved (1978) as a desiccant for oilseed sunflower. Sodium chlorate is labeled for use in Texas only. In the northern United States, a killing freeze frequently helps to dry plants before harvest. To reduce shatter and bird loss, northern growers may harvest at high seed moisture (15 to 17 percent) and dry with heated air (Cobia and Zimmer, 1978).

We began research in sunflower harvesting at the USDA Southwestern Great Plains Research Center in 1975, the first year that sunflower was extensively grown in the area. Our objectives were to determine: (a) the effect of chemical desiccation on plant drying and (b) the efficiency of a modified small grain combine header for harvesting irrigated sunflower.

PROCEDURE

We conducted a 3-yr harvesting study from 1975 through 1977. Plots were eight 1-m bed-furrows wide by 120 m, each included four subplots for replication. Trifluralin was applied before planting at 0.85 kg/ha for seasonal weed control. Flex-type unit planters were used to plant on the beds that were separated by irrigation water furrows. USDA 'Hybrid 896' was planted on April 16, 17, and 26 during 1975, 1976, and 1977, respectively. Plant population was 40,000/ha during the study. Irrigation water was applied as needed, averaging two to three applications yearly. Sunflower moth (*Homoeosoma electellum*) was controlled during bloom by applying 1 kg/ha methyl parathion using a high clearance sprayer.

After plants had reached physiological maturity (about 30 percent seed moisture), paraquat was applied to desiccated plots at 0.42 kg/ha using a high clearance

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The authors are: R. R. ALLEN, Agricultural Engineer, USDA-SEA-AR; A. F. WIESE, Professor of Weed Science, TAES, USDA Southwestern great Plains Research Center, Bushland, TX; and E. B. HUDSPETH, JR., Research Leader, USDA-SEA-AR, Lubbock, TX.

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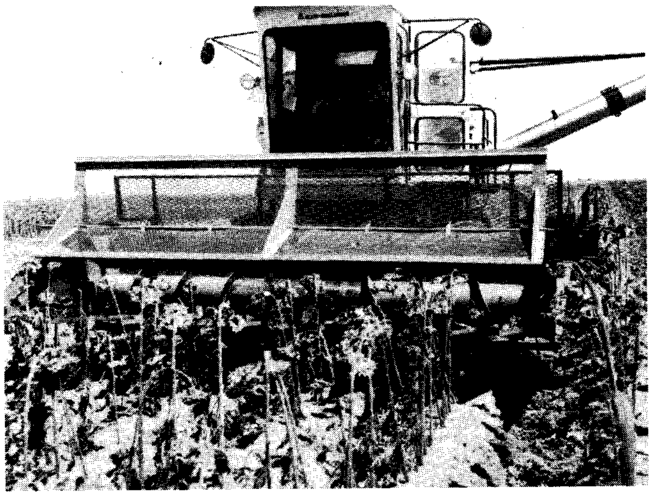
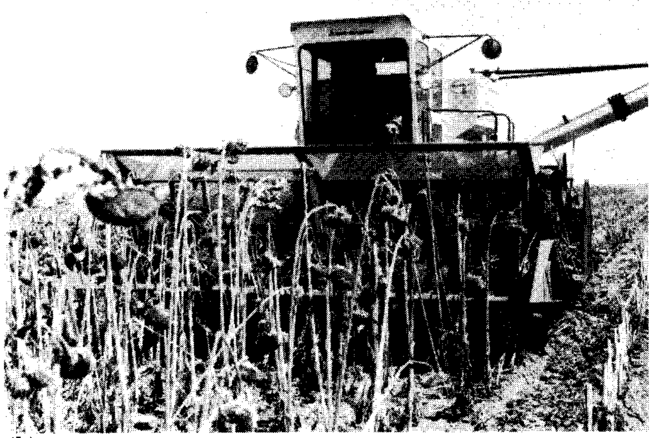


(a)



(b)

FIG. 1 Combine-thresher with large open-reel sunflower heading attachment: (a) Short plants (less than 1.5 m); (b) Tall plants (more than 1.8 m).

sprayer. Physiological maturity was identified as the stage at which the back of the sunflower heads turned lemon-yellow, the outer bracts turned brown, and the seed in the center of the head turned grey-black. Paraquat was applied on August 11, 1975; August 26, 1976; and August 8 and 15, 1977. Beginning about 30 days after bloom, we monitored seed, head, and upper stalk moisture content three times weekly by oven drying samples.

Harvester

We used an Allis Chalmers model "F" combine-thresher* with a 6.6-m small grain header during the study. We installed a locally available, commercial sunflower heading attachment on the combine. The heading attachment was modified the second year using newly available components from a different manufacturer.

In 1975, the heading attachment† consisted of seed gathering pans (22 by 120 cm) extending ahead of the cutter bar and a modified, large, 3-slat 120-cm diameter, open reel similar to Hungarian designs (Fig. 1). The large reel was operated at 20 to 25 rpm (1.2 to 1.4 reel index) with a 4.0-km/h machine travel rate. The reel index is the ratio of the peripheral reel travel rate to the machine travel rate.

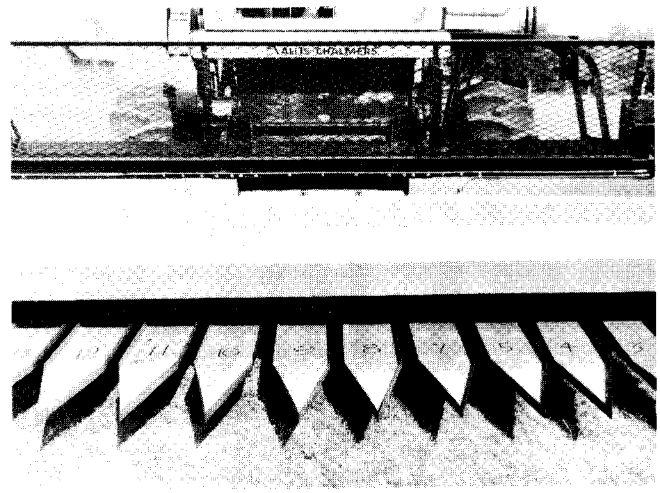
In 1976 and 1977, we substituted a small 40-cm diameter paddle reel‡, partially covered by a shield in

*Use of a proprietary brand name is for information only and does not imply preferential treatment or endorsement.

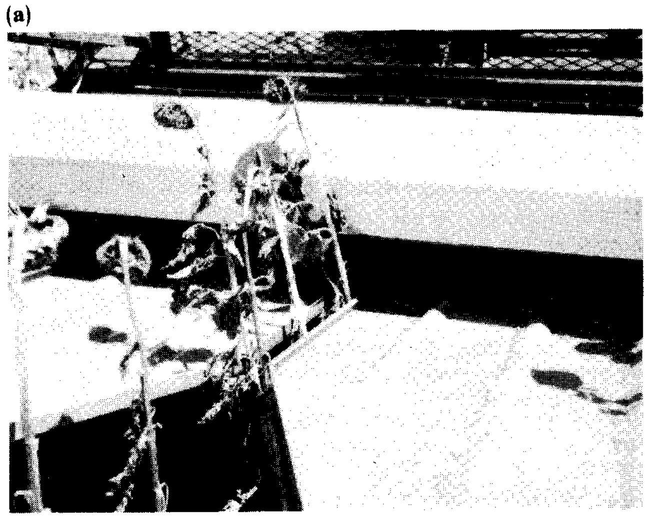
†The attachment was manufactured by Anderson and Bigham Sheet Metal, Inc., Lubbock, TX.

‡The small shielded-reel attachment was manufactured by Wylie Mfg. Co., Petersburg, TX.

FIG. 2 Combine-thresher with shielded small reel sunflower heading attachment and stalk-walker shaft under the cutter bar.



(a)



(b)

FIG. 3 (a) Seed gathering pans and shield covering the small diameter reel; (b) During operation, the adjustable shield permits only a minimal length of stalk to enter with the head.

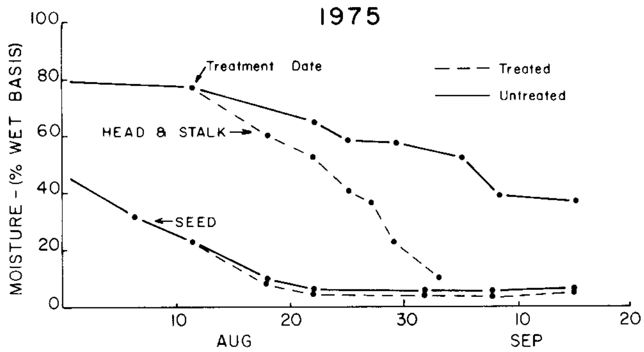


FIG. 4 Sunflower plant drying pattern at the end of the 1975 growing season.

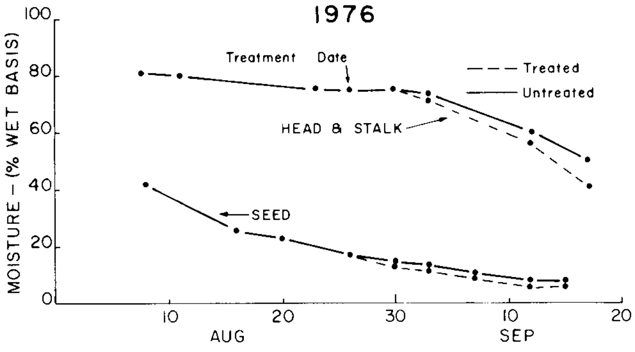


FIG. 5 Sunflower plant drying pattern at the end of the 1976 growing season.

place of the large reel (Figs. 2 and 3). The shield was designed to allow only heads to enter the auger and to prevent excessive lengths of stalk from entering the separator. A forward rotating shaft with teeth attached (stalk-walker) was mounted below the cutter bar to help keep stalks from being pulled up by the roots and plugging the slots between seed pans. The small reel was designed to operate at 200 rpm (2.4- to 3.0-reel index) and the stalk-walker shaft at 280 rpm with a 5.0- to 6.5-km/h travel rate. We operated the small reel at about 125 rpm (2.4-reel index) during the slower 4.0-km/h plot test runs.

Before each test, the machine was operated and checked outside of the plot area. For header loss sample collection, drop cloths 1.6 m^2 were placed ahead of the combine before each run. During each run, the combine was stopped at a point where the cutter bar had passed over the drop cloth but the drive wheels had not. The machine was then backed up about 2 m for access to the sample. Separator tailings were caught during runs on a drop tarp 6.6 m^2 and bagged (Nave et al., 1972). Tailing samples were later processed by hand separating and sieving to determine seed carryover and loss. Seed trash content (percentage by weight) was determined by the Amarillo Grain Exchange from samples using standard procedures. Yields were determined from four (30-m) combine passes per treatment.

RESULTS AND DISCUSSION

Plant Drying

The pattern of plant drying in the 1975 test is shown on Fig. 4. The tests began about 30 days after bloom and subsequent petal drop, when physiological maturity was nearly complete. The moisture content of the seed decreased rapidly to 10 percent while that of the head and upper stalk remained near 70 percent (wet basis). Seed moisture, after reaching the 10 percent range, leveled off at 6 to 7 percent, while the untreated head and stalk moisture decreased slowly from about 70 to 25 percent during a 30-day period. Application of paraquat, at 25 percent seed moisture, speeded head and stalk drying by 7 to 10 days but speeded seed drying only 1 to 2 days.

In 1976, small daily rain showers in mid-August delayed application of the desiccant until seed moisture had decreased to 18 percent (Fig. 5). Neither seed nor head and stalk drying was significantly affected by the treatment. After August 30, dry weather aided natural drying, so the untreated sunflower dried more rapidly near the end of the season in 1976 than in 1975. This explains why the desiccant affected drying less in 1976 than in 1975.

Fig. 6 shows the results of the 1977 test. Paraquat was applied twice, at 26 and 18 percent seed moisture. The second application date corresponded to the weather-delayed treatment in 1976. The first application speeded seed drying by about 1 day. The second application had no measured effect on seed-moisture. The first application speeded head and stalk drying 6 to 8 days, the second, 3 to 4 days. Plant drying patterns with and without desiccation were similar in 1975 and 1977. For all 3 yr, drying curves showed that seed dried more rapidly than heads and stalks.

Thresher Adjustment

During pretest adjustment runs, the cylinder speed and concave spacing were set so that threshed heads came through only slightly broken and only blank seed remained in the head. Higher than optimum cylinder speeds or closer than optimum concave clearance, or both, resulted in excessive dehulling of seed and head breakage. This increased the load of small particles on the chaffer and sieve which increased seed trash. Sunflower seed are relatively light (360 to 390 g/L), about one half the weight of corn or wheat, and are easily blown over the chaffer and sieve with excessive cleaning air. Optimum fan speed (cleaning air) and related chaffer and sieve adjustments were selected to minimize seed carryover and seed trash.

The range of combine separator settings found optimum for the study are listed in Table 1. Optimum cylinder speed (300 to 350 rpm) was relatively slow, about one-third that normally used for threshing wheat. Optimum settings resembled those used by experienced

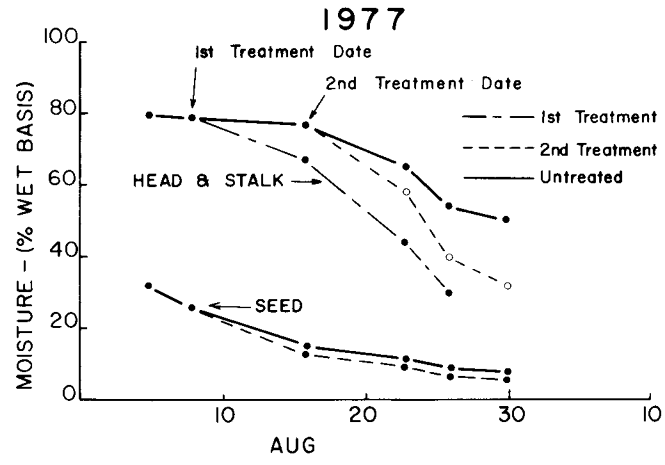


FIG. 6 Sunflower plant drying pattern at the end of the 1977 growing season.

TABLE 1.
RANGE OF OPTIMUM COMBINE SETTINGS DETERMINED DURING PRE-TEST ADJUSTMENT RUNS

Thresher function	Field determined optimum
Cylinder speed, rpm	300 - 350
Fan speed, rpm	350 - 400*
Chaffer opening, cm	0.80 - 0.95
Sieve opening, cm	0.65 - 0.80
Concave clearance, cm	1.6 - 1.9

*Approximately 50 percent of maximum fan capacity.

sunflower growers in the northern area (Klevberg, 1975). Threshing losses for each test are reported as percentages of the total seed yield. Yields averaged 2 000 and 2 130 kg/ha in 1975 and 1976, respectively, and were greatly reduced in 1977 to 610 kg/ha by severe rhizopus head rot. Seed yield and oil content were not affected by the desiccant treatments.

Harvesting

Open-Reel Machine. In 1975, we unsuccessfully attempted to harvest at 9 to 10 percent seed moisture with the open-reel machine (Fig. 1). Our attempt failed because the treated heads and upper stalks were too moist (65 percent) to feed into the machine. About 7 days later, stalk moisture decreased to 40 to 50 percent and stalks would feed into the machine. When stalk moisture was above 50 percent, moist green plant fragments entered the bin and increased the seed moisture content above the 10 percent safe storage level. The open reel performed satisfactorily on short plants (less than 1.5 m) in 1975 (Fig. 1a). The taller plants (more than 1.8 m), common with irrigated sunflower, caused excessive amounts of stalk to be fed into the separator (Fig. 1b). The extra stalk and leaf material, broken up by the cylinder, placed more load on the chaffer which added to seed carryover and seed trash. With tall plants, the large reel flipped a few stalks with heads out of the header which were lost.

Seed losses, measured during the 28-day test in 1975, are shown in Table 2. Total losses ranged from 2.6 to 4 percent with largest losses occurring after plants passed optimum dryness. The largest part of the losses, 70 to 80 percent, was at the header. Seed loss from heads missed by the header was relatively constant, so the average value is listed. Header shatter on desiccated plots increased during the test, whereas on untreated plots, it varied only slightly, averaging 0.75 percent. When head and stalk moisture on desiccated plots decreased below 15 percent, an excessive amount of heads were broken up by the cylinder, which added to seed trash and carryover. Thus, desiccation can increase seed loss if harvest is delayed. Separator losses were relatively constant, averaging 0.8 percent of the yield.

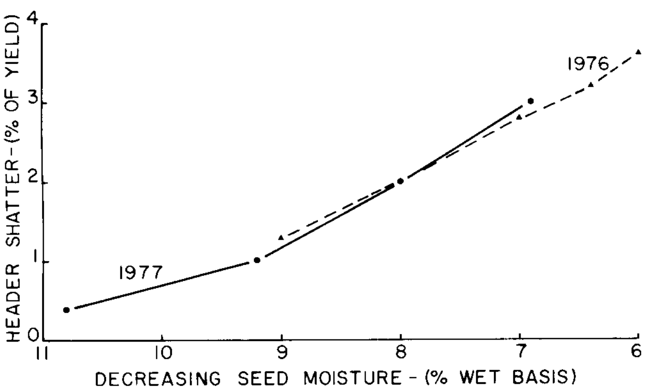


FIG. 7 Sunflower header shatter with decreasing seed moisture.

TABLE 2. SUNFLOWER HARVEST SEED LOSSES, STALK MOISTURE, AND SEED TRASH WITH AND WITHOUT PARAQUAT TREATMENT, SEVERAL DATES IN 1975, USING THE OPEN-REEL MACHINE

Date	Chem. treat.	Seed trash	Seed loss: Heads missed	Header shatter	Separator	Total	Head and stalk moist.
		Percent					
8-27	Yes	3.0	1.3	0.7	0.8	2.8	36
9-3	Yes	2.7	1.3	0.8	0.7	2.8	15
	No	4.1	1.3	0.6	0.7	2.6	53
9-8	Yes	5.1	1.3	1.1	0.8	3.2	10
	No	6.7	1.3	0.8	0.8	2.9	45
9-15	Yes	4.9	1.3	1.5	0.9	3.7	<10
	No	3.3	1.3	0.7	0.8	2.8	38
9-25	Yes		1.3	1.9	0.8	4.0	<10
	No		1.3	0.8	0.7	2.8	25

Shielded-Reel Machine. In 1976 and 1977, the small diameter shielded-reel attachment (Fig. 3) permitted threshing as soon as seed moisture reached about 9 percent, although head and stalk moisture remained near 65 percent (Table 3). This was 5 to 7 days earlier than was possible with the open-reel machine in 1975, when harvesting had to be delayed until head and stalk moisture were below 50 percent. The threshed seed was cleaner with the shielded-reel header because less stalk material accompanied seed heads into the machine. Seed trash averaged about 1 percent with the shielded reel in 1976 compared with 4.2 percent for the open-reel in 1975. The head rot infestation in 1977 increased seed trash slightly above 1976 amounts and averaged 2.1 percent. Seed prices usually are reduced if trash exceeds 2 percent.

The stalk-walker, mounted under the cutter bar, reduced plugging of stalk slots between seed pans. The teeth on the forward rotating shaft provided a downward pull on the lower stalk which reduced uprooting and the resultant plugging. In one test, when the stalk-walker was disengaged, stalk plugging increased noticeably.

As in 1975, 70 to 85 percent of the total seed losses occurred at the header. The shielded small-reel header

TABLE 3. SUNFLOWER HARVEST SEED LOSSES, SEED AND STALK MOISTURE, AND SEED TRASH, SEVERAL DATES IN 1976, USING THE SHIELDED-REEL MACHINE

Date	Seed trash	Seed loss: Header shatter	Separator	Total	Moisture: Seed	Head and stalk
	Percent					
9-8		1.3	0.5	1.8	9.0	67
9-10	0.9	2.0	0.5	2.5	8.0	63
9-13	0.9	2.8	0.5	3.2	7.0	60
9-15	1.0	3.2	0.6	3.8	6.4	55
9-21	1.1	3.6	0.6	4.2	6.0	45
9-24	1.2	4.0	0.6	4.6	6.0	38

missed very few heads so those are included as header shatter in Table 3. Loss patterns, using the shielded-reel machine in 1977, were similar to those in 1976. Fig. 7 shows the effect of decreasing seed moisture upon header loss for the 1976 and 1977 tests. Header losses increased rapidly as the seed moisture decreased from 9 to 6 percent. Much of the increase in loss came from seed shatter when drier than optimum heads contacted the relatively high-speed small reel. Timeliness of harvest is important in reducing harvesting loss, especially with a shielded small-reel machine. The optimum threshing period lasts 3 to 5 days, after which header loss can increase to more than 3 percent and total seed loss to more than 5 percent of the seed yield.

SUMMARY AND CONCLUSIONS

Sunflower seed, after reaching physiological maturity, dried much faster than heads or stalks. The heads, stalks, and leaves remained near 70 percent moisture until after the seed, at 10 percent moisture, were dry enough to thresh and store. Applying a desiccant (paraquat) at physiological maturity speeded plant drying by 7 to 10 days but speeded seed drying by only 1 to 2 days. Seed yield and oil content were not affected by desiccation.

A small-diameter shielded-reel heading attachment on a combine-thresher permitted harvesting 5 to 7 days earlier at higher stalk and head moisture than an open-reel attachment because less stalk was handled. Threshing less stalk also resulted in cleaner seed. Timeliness was important in minimizing harvest losses with a shielded-reel header. Header shatter losses increased rapidly from 1 to 3 percent within about 6 days after the seed was dry enough to harvest and store. Total threshing losses averaged lessl than 5 percent of the seed yield with both headers. About three-fourths of the losses occurred at the header.

Under the Southern Plains conditions tested, there was no net advantage to pre-harvest chemical desiccation of plants when a shielded-reel header was used. The gain of slightly earlier seed drying after desiccation was offset by chemical application costs (about $25/ha), the increased seed shatter loss if harvesting was delayed, and the ability of the shielded-reel header to harvest sunflower earlier.

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