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Harvesting Seed of Grass and Small-Seeded Legumes

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SUMMARY

Growers of grass and small-seeded legumes for seed have been losing 50 percent or more of their crop before and during harvest. The Agricultural Research Service, in cooperation with State agricultural experiment stations in many parts of the United States, has been studying these losses and devising ways of reducing or eliminating them. The research is continuing.

Studies so far have been concerned with cultural practices, time of harvest, methods of harvest, combines, combine components and operation, and their individual and aggregate effect on yield and quality of seeds. In addition, new harvesting techniques have been evaluated and a machine to reclaim shattered seed has been designed, tested, and found effective.

This report discusses these and other aspects of seed harvesting.

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HARVESTING SEED OF GRASS AND SMALL-SEEDED LEGUMES

Farmers who grow grass and small-seeded legumes for seed often sustain significant losses before and during harvest. In Oregon, for example, less than 40 percent of a crop of crimson clover seed may actually find its way into the bin. In Michigan, loss percentage for alsike clover and alfalfa is about the same as Oregon's for crimson clover. In Alabama and South Carolina, crimson clover losses approach those of Oregon; lespedeza seed loss ranges between 40 and 50 percent.

Most of these losses are chargeable to field shatter or to inefficient harvesting. Field shatter occurs naturally--usually when the florets that hold the seed dry up and break away from the plant as the seed mature. Some plants, however, shatter free seed. Rain, wind, or any physical or mechanical shock to the plant accelerates shattering. Inefficient harvesting mostly reflects growers' dependence on standard harvesting methods and equipment--combines, mowers, windrowers, and swathers--for harvesting small, light grass and legume seed that weigh only 1/10 to 1/30 as much as grain.

Agricultural Research Service scientists and their collaborators in State experiment stations in many parts of the United States have been studying seed harvesting for years and have made some important advances. This report describes how these scientists approach the study of seed loss and how agricultural leaders and others who are interested in efficient seed production can apply the solutions found.

One point merits special attention: Ideally harvested seed are fully mature, free of blemishes, cracks, or abrasions that might affect germination, and are uncontaminated by weed seed or other extraneous seed or material.

The continuing emphasis on the use of forage grasses and legumes in livestock production and their obvious value for soil improvement and conservation stress the need for adequate seed supplies at all times. As early as 1635, prospective settlers of Maryland were urged to bring "a good store of Claver grasse seede, to make good meadow."

CULTURAL PRACTICES INFLUENCE HARVESTING

Any cultural practice that results in good, uniform growth contributes to efficient harvesting. A smooth seedbed, for example, greatly facilitates the harvesting of any seed crop, especially a low-growing crop. The use of cultipacker seeders buries most of the rock in a field and removes a source of damage to combines and other equipment. Good cultural practices also include effective weed control and the removal of other extraneous vegetation.

For example, ARS scientists and their collaborators recently solved a cultural problem that is common to Oregon, and which may occur in other seed-producing States. The problem was infestations of hairy vetch in crimson clover being grown for seed. Seed of hairy vetch and crimson clover germinate at practically the same time, but vetch grows more rapidly and soon forms a canopy that covers the clover. The canopy causes the clover to lodge and reduces the yield of harvestable seed. When crimson clover is ready for harvest, hairy vetch is still green and causes threshing difficulties because it tangles and contains too much moisture.

The scientists found that spraying the rapidly growing vetch plants when their shoots were 10 to 12 inches long with 1/4 pound of MCPA (2-methyl-4-chlorophenoxyacetic acid) in 40 gallons of water per acre successfully controlled the vetch. At that time, crimson clover is 3 to 4 inches high. The treatment injures the clover temporarily, but it recovers to produce a normal crop of seed.

HARVESTING CROPS THAT SHATTER SEED IN THE FLORET

Crimson clover, subterranean clover (subclover), alta fescue, the lespedezas, and many other crops fall into this category. Although suction seed reclaimers (see page 9) can be used to reclaim their shattered seed taking the seed directly from the plant usually results in higher quality seed and fewer postharvest cleaning problems. Consequently, the techniques discussed below are primarily aimed at harvesting this type of crop before shattering becomes excessive.

Time-of-Harvest Recommendations

Early as possible harvests are recommended in the Southeast because rain at harvesttime, especially during spring harvest, is always an imminent hazard can shatter 30 percent or more of a mature crop. But several "ifs" govern the selection of a harvest date that is early enough but not premature:

1. If the field can be harvested in 1 day, and if the crop ripens uniformly, direct combining should begin when 5 to 10 percent of the seed are still immature.

2. If the crop ripens uniformly, and if 2 to 3 weeks are needed to combine, direct combining should begin when 15 to 20 percent of the seed are immature.

Twenty percent immaturity is the maximum allowable. Combining when more than 20 percent of the seed are immature usually results in low yields, high combine losses (especially in crimson clover), low germination, and too much seed moisture, which could cause heating in storage. If the unharvested seed become extremely dry, however, excessive seed injury can occur during late harvests.

Southeastern growers who mow their seed crops and subsequently combine from the swath or windrow cannot generally harvest successfully much sooner than growers who combine directly. Under the same conditions, a standing crop is dry enough to combine at almost the same time as a swathed crop that was not cut before it was physiologically mature. But mowing, swathing, or windrowing may have advantages at times in the Southeast.

Frost is an important factor to consider when harvesting Kobe or sericea lespedeza. If a killing frost occurs just as the crop is becoming mature, combining should then be done within 2 or 3 days. Frost kills and dries out plants rapidly and weather shatter soon becomes excessive.

In the West, ARS-State scientists found that by the time seed crops were normally harvested by conventional methods the production peak has passed and field shatter was high. Subsequent studies of crimson clover, Alta fescue, and subclover showed that earlier than "normal" harvests were practical and that windrow-combining about 1 week before the usual time put more live seed in the bin. Moisture content of the three crops at these earlier than usual harvests was about 36 percent, 44 percent, and 27 percent, respectively. A single trial of mowing subclover 3 weeks earlier than usual, windrowing, and combining gave a 55 percent increase in live seed. This interesting result has prompted further studies on time of harvest for subclover.

Because seed as they mature gradually lose their moisture, moisture data may hold the key to improved harvesting. For instance, if the moisture content of a sample could be accurately determined, the state or stage of maturity could be inferred, and optimum harvest dates based on quantitative measurements rather than on judgment could be established. Scientists are now trying to adapt moisture-measuring electric meters to the job of accurately predicting harvesting dates.

Harvesting Methods

Direct combining when properly timed appears to be the most practical way to harvest grass and small legume seed in the Southeast when acreages are small and can be harvested before field shatter becomes excessive. The highest yields attained during a 5-year trial in this area came from direct combining. But after the optimum yield date is past, direct combined yields decrease faster than swath or windrow yields.

Swathing or windrowing, before the crop begins to shatter, may be preferred over direct combining in the Southeast if harvesting must be delayed past the optimum yield date for direct combining. Swathing or windrowing may also be preferred if the crop retains green foliage and matures slowly, or if the crop continues to grow during and after seed harvest. Seed harvested from swath or windrow are drier and cleaner and normally store and germinate better than direct combined seed. Such quality gains, however, may not offset the extra expense and trouble that swathing or windrowing entails in small fields.

Swaths dry faster and usually yield more than concentrated windrows and are therefore generally preferred in the Southeast. Mowing at night or when plants are wet with dew reduces mechanical shatter. Draper-type windrowers can often be used advantageously to concentrate light growth and speed up a harvest. It is usually necessary to narrow a conventional swath to accommodate most combines. A grass board on each side of the mower cutterbar works satisfactorily under some conditions, but the use of a "Roto-Windrower"[1] narrows the swath without concentrating it too much and causes less mechanical shatter.

In the West, most grass and small legume seed crops have to be mowed, windrowed, and combined from the windrow, if earlier than usual harvest recommendations are followed. Direct combining during most years without using a suction seed reclaimer, results in seed yields that are about the same as those obtained by combining from the windrow at the usual time. In areas where strong winds, rain, and low humidity menace seed production, preharvest chemical spraying to cure the crop for direct combining may be practical.

Method-of-harvest studies in the West for crimson clover, subclover, and similar crops were discontinued in 1959 because it appears that answers have been found to enable growers to reduce their field shatter losses. The answers for crimson clover are: (1) Harvest at the earlier than usual time and obtain about 22 percent more seed than at the usual time, or (2) combine the crop directly using a suction seed reclaimer as a harvesting adjunct and obtain about 26 percent more seed than by normal methods. For subclover: Harvest at the earlier than usual time and obtain 37 percent more seed, or directly combine, using a suction reclaimer, and obtain 184 percent more seed.

These good results from harvest time studies also have prompted research attention aimed at developing more efficient mowing methods for both subclover and crimson clover. The studies were urgently needed because of high crop moisture usually encountered during earlier than usual harvests and because crops at this stage of growth are green and tough. Tested were rotary field choppers, different types of mowing bars, and swath dividers.

The choppers were equipped with vertical, rotating, flat cutters and were adjusted to just touch the ground. Their use in subclover gave an estimated 27.5 percent increase in yields. While this increase was not the maximum attained, it shows that increased yields are possible with the proper type of equipment.

The several types of mowing bars were tested in subclover because subclover is probably the most difficult of any crop to mow when being harvested for seed. It develops its seed near the surface of the ground and has to be mowed close to and sometimes under the surface of the ground. Single sickle mowers plug up quickly when they dig into the ground or cut dense subclover close. Earlier than usual harvests, when the crop is green and tough, aggravate these difficulties.

Of the mowing bars tested, a 7-foot, double-sickle (both moving) bar with sickle blades spaced 3 inches apart and with a 1 1/2-inch oscillation was the only one that cut a 230-foot test swath without plugging and

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[1] This attachment, as used in tests in South Carolina, was patterned after a similar attachment developed and tested at the Ontario Agricultural College, Canada.

without leaving any uncut material. Cutting height was between 1/2 and 1 inch. Also, the 7-foot bar put more live seed in the windrow, which is perhaps a more accurate indication of a bar's capabilities.

Of the swath dividers tested, the rolling colter (supported separately from the tractor, and positioned and weighted to cut through the crop just ahead of the outer end of the mowing bar) was the only one that divided a swath of green subclover consistently.

HARVESTING CROPS THAT SHATTER FREE SEED

Birdsfoot trefoil is a good example of this type of crop. Its seed cannot be harvested efficiently by the methods discussed because (1) suction reclaimers are not, as yet, refined enough to pick up free seed efficiently, and (2) even though the crop is mowed early and windrowed in the usual way, shatter or germination losses may still be excessive. Research, however, has worked out other ways of harvesting the seed of free-seed shattering crops, like birdsfoot trefoil.

The preferred method is to delay harvest until field shatter approaches 10 percent, then mow, form the swaths into loose, rectangular bales, and subsequently combine the bales. Harvesting birdsfoot trefoil in this manner, as opposed to conventional methods, increases field germination and reduces combine-germination losses. It also keeps shatter loss at a minimum. Overall gains in live seed yields have amounted to about 23 percent.

Another method of harvesting free-seed shattering crops (still in the experimental stage) utilizes tined bars that are mounted on the mower cutterbar and that rolls the material as it is cut in a continuous windrow onto wide plastic or paper sheets. The sheets are laid down as the tractor moves forward from a roll connected to the tractor by chains on each end of a shaft inserted through the roll. The sheets catch and hold the shattered seed.

After the crop is cured, combining the crop and rewinding the sheets go on simultaneously. The rewinding attachment connects to the combine pickup and consists of a wooden reel and an auxiliary wheel that is driven by a 3-inch belt that is controlled by a spring-loaded slip clutch. The action of the clutch is not severe enough to tear the sheets, but it has enough force to keep slack out of the rewinding sheets and to allow the operator to stop the combine without tearing the sheets. As the sheets rewind, they help carry the material with the shattered seed into the combine. The practicality of this method depends on the longevity of the sheets. If they can be used for several years, the seed saved (up to 32 percent in Oregon trials in birdsfoot trefoil) might offset the extra harvesting expense.

In 1959 tests, seed saved on black plastic did not lose any germination even though the temperature of the black plastic (154°F.) was from 20° to 54° higher than the temperature of clear plastic and paper used in similar tests. These 1959 results did not confirm the results of previous years.

The advantages accruing to this method of harvest may be limited in areas where strong winds prevail during harvesttime because strong winds can turn the windrows over and dump on the ground seed caught by the plastic.

COMBINES, COMPONENTS, OPERATION[2]

The advantages gained from harvesting early, from efficient mowing, from using a suction machine to reclaim shattered seed, or from baling or windrowing onto plastic sheets cannot be fully realized unless the crop is efficiently combined. ARS-State scientists have explored this facet of seed harvesting and the exploration results now make it possible to define some of the elements of an ideal combine, to delineate how best to adjust and operate combines, and to list other factors that should be considered when seed are combined. A general review of how combines function will make the presentation of the other information more meaningful.

How Combines Function

The combine header, consisting of the reel, the cutterbar with sickle, an endless canvas or an auger, and other parts that make up the platform cuts and feeds the crop into the machine. Various mechanisms can be used to accomplish the feeding function. These include canvasses, augers, feed cylinders, and slatted conveyor chains. When harvesting from swath or windrow, the header may be replaced by a pickup attachment.

The rubbing and beating action of the cylinder against the concaves, which are stationary but may vary in number, remove seed from pods, hulls, or florets. Grates, either between the concaves or behind the cylinder or both, separate much of the threshed seed from the straw at the cylinder. A beater, just back of the cylinder, may be provided to strip the straw from the cylinder and deflect it onto racks that move it to the rear or side of the machine for disposal and at the same time agitate it to shake out the threshed seed. Threshed seed, unthreshed seed hulls or pods, short pieces of straw, chaff, and any extraneous material (weed seed, foreign seed) fall on or are carried onto the chaffer. The chaffer may be mesh wire, a lip sieve, an adjustable sieve, or combinations of these. Devices agitate it and a fan and shutter, or fan and vane, assembly direct a current of air through it.

Threshed seed and small extraneous material work through the chaffer onto another sieving assembly. Specific sieves for specific crops are usually attainable or an adjustable sieve is used. Chaff and other light material are blown off the chaffer and out of the machine. Some seed, unthreshed hulls or pods (the tailings) work to the back of the chaffer and fall into the tailings elevator, which carries them back to the cylinder to be rethreshed. Threshed seed and other material are again subjected to air blasts and agitation, which separate seed from any extraneous material. Threshed seed, now cleaned, fall into the grain elevator and are carried to the grain bin, truck, or sacking attachment.

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[2] Additional details about combines appear in Farmers' Bulletin 1761, "Harvesting With Combines," available from the Office of Information, United States Department of Agriculture, Washington 25, D. C.

Some Elements of an Ideal Combine

The ideal combine for harvesting grass and small legume seed is small and is pulled by a tractor. It has a tined reel that is ground driven.

Header controls are sensitive and are capable of lifting the platform and cutterbar high enough to clear obstacles, especially when terraces have to be crossed. The header is not so steeply angled that it contributes to or aggravates feeding problems.

The cylinder is fitted with angled bars covered with rubber. The concaves also are covered with rubber. Cylinder adjustments (rate of rotation and clearance between bars and concaves) can be accurately and conveniently made. Some means are provided to cover the grates if high losses from this source are encountered.

Cleaning air through the chaffer and sieve is controlled by saw-toothed vanes. The amount and quality of material carried by the tailings elevator can be quickly and easily checked at any time.

Combining Representative Crops

Crimson clover

Maximum cylinder speed is necessary when threshing crimson clover and other hard-to-thresh crops. Speeds between 5,000 and 6,180 feet per minute are practical and the gain in threshed seed more than offsets damaged-seed losses as cylinder speed is increased. But the higher cylinder speeds needed in the Southeast may damage seed excessively under very dry conditions in the West. Cylinder spacing is not critical. In tests changing the spacing from 1/4 inch to 1/16 inch damaged only about 1 percent more seed, and increased unthreshed seed loss only about 4 percent. The maximum number of concaves should always be used.

Grates should be closed. The use of clip-in strips for this purpose in tests saved about 10 percent more seed.

High cleaning losses occurred only in those machines that did not use an endless canvas to carry material from the cylinder to the chaffer. Sieves generally recommended for clover are definitely too small. Larger (lespedeza) sieves should be used.

A ground speed of about 1.5 miles per hour appears to be the most practical under most conditions in the Southeast. In the West, where seed-crop growth is apt to be dense, ground speeds as low as 3/4 miles per hour are practical.

Fescue

Threshing and cleaning losses are usually low in fescue and similar crops. Aggressive cylinder action is not necessary. Chaff should be carefully examined from time to time as harvesting progresses. The many glumes in the chaff (which do not contain seed) sometimes give a false impression that seed are being blown out and may induce the operator to reduce air volume too much. A chaffer opened too wide and air too low may result in the tough fescue stems clogging the tailings elevator.

Rescue

Because rescue grass seed are light and fluffy: (1) Grain elevators may plug and limit ground speed, (2) chaffers and sieves have to be opened fairly wide otherwise enough material enters the tailings auger to plug the tailings elevator, (3) air volume must be low, and (4) since chaffer and sieve must be fairly wide open, trash cannot be kept out of the grain bin--this condition worsens in low-yielding fields. Threshing and cleaning losses are usually low in rescue; cleaning losses may appear to be high, but close examination usually shows few mature seed in the chaff, if the machine is adjusted properly.

Lespedeza

Cutterbar shatter losses are usually significant in lespedeza and similar crops. However, an attachment invented by a South Carolina grower increased harvested yields by 10 to 25 percent. It consists of a small trough and auger that mounts below the sickle and a chain-driven elevator. Slots, cut just behind the sickle, let the shattered seed fall into the auger trough. They are then augered onto the elevator and carried to a sack.

Threshing and cleaning losses are usually low, if the crop is mature and if the machine is adjusted properly. Generally, wide spacing between cylinder and concaves and low cylinder speed leave a minimum of unthreshed and hulled seed. The chaffer should be adjusted to return few seed in the tailings. Seed in the tailings are affected by cleaning air. A critical point exists where a slight increase in air greatly increases amount of seed in the tailings. High ground speeds often cause less cutterbar shatter than slow speeds.

Standard guards are recommended for the cutterbar, if the fields to be harvested contain excessive straw from previous crops.

Birdsfoot trefoil

Excessive seed germination losses because of faulty threshing occur often, even though unthreshed seed losses are usually negligible. A slow-as-possible cylinder speed should reduce this type of loss.

Other Considerations

Draper-type pickup attachments, which utilize an endless, slatted canvas, are better than other types for harvesting swaths or windrows because seed shattered by the pickup fingers are carried into the combine by the canvas.

In some tests, windrows and swaths were combined without special pickup attachments by using a tined reel and a live sickle. In heavy growth, this method was usually as good as attachment methods and sometimes proved superior. It is cheaper than the other methods because no attachments have to be purchased or changes made on the combine. However, in average or light growth, or when rain had fallen on the swaths or windrows, pickup losses were greater by the no-attachment method than by other methods.

Although swaths or windrows can be picked up in either direction, picking up against the heads of the plants is cleaner and causes less shattering. All mowers and windrowers have their cutterbars on the right side but some combines have their headers on the right and some on the left. In harvesting windrows or swaths with left-handed combines against the heads, it is necessary to harvest from the inside toward the outside of a field, and further necessitates traveling over unharvested seed. Such restrictions contribute to mechanical shatter and cause much trouble and loss of time at the turns, especially in irregular and terraced fields.

SUCTION SEED RECLAIMER[3]

This machine was developed by ARS-State scientists in Oregon, but it can be used anywhere in the United States to improve seed-harvesting efficiency. Its use has reduced shatter losses in crimson clover and similar crops to about 5 percent and in subclover and similar crops to about 10 percent. Shatter loss for these crops when they are conventionally harvested usually average about 31 percent and 68 percent, respectively. Commercial models of the reclaimer have been developed.

Several types of suction reclaimers preceded the Oregon model, but none were absolutely satisfactory. They left too much seed on the ground or the seed reclaimed had a low rate of germination. These limitations in the Oregon reclaimer have been overcome by agitating the seed while suction is applied and by removing the reclaimed seed from the airflow before they reach and are damaged by the suction fan.

The reclaimer can be mounted on a trailer that is pulled by a tractor. Its use then is an additional harvesting operation following combining. Mounting the reclaimer on the combine, however, eliminates this extra operation. It also eliminates rehandling the seed because the seed recovered can be threshed along with the crop being cut. In addition, preliminary removal of threshed straw from the field is not necessary since the reclaimer nozzle is located below the combine, behind the cutterbar, and ahead of the straw discharge. The nozzle thus picks up seed from the ground while the material being cut is going through the combine.

CHEMICAL DEFOLIATION

The results of many tests in treating grass and small-seeded legume plants with chemicals as an aid to seed harvest reveal that the practice may pay in the West; that it probably will not in the Southeast.

In California, use of chemical defoliants has apparently caused an increase in the direct combining of grass and small legume seed crops since 1955. Studies made at the University of California Experiment Station at Davis initially established the feasibility of the practice.

[3] Details of the design and operation of the reclaimer appear in ARS 42-24, "Suction Reclaimer for Shattered Seed," available from the Agricultural Research Service, United States Department of Agriculture, Washington 25, D. C.

The California studies revealed that crop characteristics influence the use of defoliants. Crops that are open and erect usually permit adequate penetration and greater net gains. Those that are thick and matted may require two or more applications, the first to treat outside growth and expose the lower, protected growth and the subsequent to treat this lower growth. Enough time must elapse between treating and harvesting to permit the plant to dry adequately, but not enough time for shattering or regrowth.

In the Southeast, use of chemicals on crimson clover reduced threshing and cleaning losses and reduced seed moisture, and thereby significantly increased harvested yields in 2 of 4 years. In sericea lespedeza, harvested yields were 3 to 10 percent higher and moisture content of seed was significantly lower in each of 4 years. In evaluating these results, the scientists concluded that the gains were not large enough (even though they were statistically significant) to justify chemical defoliation as a general practice.

The use of chemical defoliants on clover and alfalfa seed crops has been extensively investigated in England by the National Institute of Agricultural Botany. Dinitro-ortho-cresol, sulphuric acid, pentachlorophenol, and sodium monochloroacetate are some of the chemicals used by the English investigators. Because these chemicals act only by contact, high spraying pressure is needed. Maximum effect is usually seen within a week of application; 3 to 5 days should elapse between application and combining. The chemicals arrest crop and seed development. It is therefore important not to spray too early otherwise a high proportion of immature seed will be harvested. Viability of mature seed is not impaired. When dinitro-ortho-cresol or other poisonous chemicals are used, no part of the crop can be fed after threshing, and stock has to be kept out of the treated fields for some time after harvest.

RESEARCH FOLLOWUPS

Using a suction seed reclaimer, harvesting early, and employing other techniques may cut in half the losses normally sustained during seed harvest. But if losses are to be further reduced, better combines will have to be designed and better ways of operating them will have to be worked out. The study of these twin necessities forms a large part of the research planned by ARS and State experiment stations during ensuing years. Specific items to be investigated include an experimental wind reel and multiple threshing cylinders, which, it is hoped, will increase harvesting and threshing efficiency.

Mowing subclover 3 weeks earlier than usual gave such encouraging results that time-of-harvest studies for this crop are being continued. Concomitants include determining the best type mower and cutter assemblies to use. Specific items to be investigated include chrome and conventional steel sickle blades and their relative merits under adverse field conditions.

The use of moisture meters to determine degrees of maturity appears to be better than relying on judgment or stage of growth, if the necessary calibrations can be accurately established through additional research.