

August 8, 1956

To the Graduate Council:

I am submitting herewith a thesis written by Erwin Keith Boyce entitled "A Study of Direct Combine Harvesting of Selected Grass and Legume Seeds." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Engineering.

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A STUDY OF DIRECT COMBINE HARVESTING
OF SELECTED GRASS AND LEGUME SEEDS

A THESIS

Submitted to
The Graduate Council
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

by
Erwin Keith Boyce
August 1956

230

ACKNOWLEDGMENT

The writer wishes to express his gratitude to Professor M. A. Sharp, Head of the Agricultural Engineering Department, for the help, encouragement and consideration that he has shown.

The author is very grateful to the entire staff of the Agricultural Engineering Department: Professor E. J. Matthews; Mr. C. W. Brown, Associate Agricultural Engineer; and Mr. E. O. Kennedy for their assistance and advice in the completion of this work.



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CHAPTER I

INTRODUCTION

Statement of the Problem

The lack of suitable machinery, methods, and techniques in the harvesting of grass and legume seeds to maintain quantity, quality, and viability, has contributed to unstable production, variable quality, and fluctuating prices. Such factors have discouraged farmers in the Tennessee Valley from producing these crops for seed. Improvement in harvesting and processing techniques and equipment will assist materially in eliminating the present difficulties in the production of high quality grass and legume seeds. Increased availability of locally produced seeds will contribute to the acceptance of the grassland farming program. Some of the difficulties encountered in harvest are:

- (1) seed loss due to shattering,
- (2) incomplete recovery of seed during the harvesting operation,
- (3) high moisture content of the harvested material.

These difficulties are intensified by unfavorable weather conditions, lack of proper weed control, and uneven maturity of the crop.

Importance of Study

The first and foremost incentive for this study lies in the value of the seed which is lost each year. The average yield of crimson clover is 110 pounds per acre, of a potential yield of 500 pounds per acre. This

results in a loss of approximately three million dollars which might have been realized by Tennessee farmers with better harvesting practices. A major portion of the 1.5 million dollars of orchardgrass seed imported from Denmark in 1953 was planted in Tennessee. The entire Southeast produces over one-half of the United States' supply of lespedeza, crimson clover, and tall fescue (15).¹ Increased local production of high quality seed can result in a substantial saving and also provide better locally adapted seed (6).

Scope of Study

There are many kinds of grass and legume seeds that are grown in Tennessee, several of which are of considerable economic importance. In order to limit the research to a practical basis, several of these crops were chosen for study. These were orchardgrass, tall fescue (variety, Kentucky 31), and crimson clover.

The work in 1955 and 1956 was limited by crop failures to crimson clover and Kentucky 31 fescue. The crimson clover was grown on the University of Tennessee Morgan Farm in 1955 and on the University of Tennessee Blount Farm in 1956. The Kentucky 31 fescue was grown on the United States Department of Agriculture Cotton Farm near Maryville, Tennessee.

The objectives of this project were as follows:

¹Numbers in parentheses refer to similarly numbered references in bibliography at end of paper.

1. An investigation of seed loss in direct combine harvesting of the subject seeds. This was to include seed loss prior to machine harvest.
2. Determination of criteria for proper machine adjustment for given conditions.

For the successful completion of this project, it was necessary to use a standard commercial combine which was altered to provide easy collection of seed at various discharge points. The use of a standard commercial combine also provided data which would be more applicable for direct farm use.

CHAPTER II

REVIEW OF LITERATURE

Threshing, the forerunner to combining, was first reported in the Bible. From that time until the early twentieth century, the major emphasis has been on the more common cereals--oats, wheat, barley, rye, and other similar types (3). But, with the increasing emphasis on grass-land farming, the need for larger amounts of the special seeds of legumes and grasses has in turn focused the necessity for new machines and techniques to harvest these crops. Only recently research has been applied to the problem of harvesting these small, lightweight seeds.

The investigation of this problem has resulted in two approaches to the subject. Preliminary studies attempted to make use of the commercial combines which were available to the farmer. By development of new operational recommendations and techniques, these new crops might be efficiently harvested. As a result of this research on the possible use of the standard combine, it was apparent that they would not completely solve the problem of harvesting these seeds. This conclusion led to the second approach to the problem, that of the development of new equipment, especially for the harvest of the light seeded crops.

McCuen, et al (12) and Park (15) reported that increased rate of travel resulted in high seed losses due to the overloading of the rack. Table I shows the relation of speed to seed yield. The effect of a low height of cut produces the same overloaded rack condition which increases the grain loss.

TABLE I

DATA OBTAINED BY PARK (15) IN EXPERIMENTS
TO MEASURE EFFECT OF GROUND SPEED ON
CLEAN SEED YIELD OF CRIMSON CLOVER

Ground Speed	Yield-Pounds per Acre
134 Ft./Min.	300
185 Ft./Min.	260
222 Ft./Min.	225
272 Ft./Min.	195

Gowder and Martin (7) mentioned the problem of rack overloading as effected by a weedy crop. The combine efficiency relative to clean and weedy crops is shown in Table II. The combine efficiency is that per cent of clean seed which falls into the seed bin as compared to the total amount of seed taken into the combine. Throughout the report, this value is represented by the seed recovered in the seed bin plus that seed falling into the tailing auger. The tailing seed is re-run through the combine and eventually ends up in the seed bin.

The date of harvest can also adversely affect the combine efficiency. If the crop is to be combined from the windrow, it is recommended that it be cut at the soft dough stage. Direct harvest usually requires a hard dough stage of seed development. Some research has indicated a preference toward combining from the windrow (20).

Bunnelle, et al (2) conducted many experiments on combine cylinder characteristics. They noted that the peripheral speed of the cylinder is the most important factor in seed damage. The critical speed varies greatly with different seeds. Wolff (21) mentioned the use of angle bars or rasp bars on the cylinder as being superior to spike teeth. The spike teeth chop the straw excessively.

Harrison (10) reported the relative efficiency of the combine in harvesting alfalfa. The first pass through the combine resulted in a recovery of 60 per cent of the total potential seed. By catching the combine discharge and passing it through the combine a second time an additional 20 per cent of the potential seed was saved. A fourth pass of this same material produced a 4 per cent yield.

TABLE II

DATA REPORTED BY GOWDER AND MARTIN (7) ON THE
EFFECT OF WEEDS IN A SEED CROP ON
COMBINE EFFICIENCY

Source	Per Cent Material	
	Clean Crop	Weedy Crop
Grain Caught in Bin	95.9	87.0
Cylinder Loss	0.1	0.3
Rack Loss	0.1	5.6
Shoe Loss	0.5	2.9
Cutter Bar Loss	<u>3.4</u>	<u>4.2</u>
	100.0	100.0

Burnelle, et al (2) found that the cleaning shoe load varies directly with the seed loss over the cleaning shoe. The ratio varies widely with different crops. The cleaning shoe is composed of two components; the shoe chaffer which is an adjustable lip, separating rack, and the shoe sieve which is a metal sieve having either round holes or slots for the clean seed to pass through. The shoe chaffer is located above the shoe sieve.

The subject of air control on the combine produces agreement from all sources--use of a minimum airflow to prevent seed from being blown out of the combine. This is a particular problem with grasses and legumes whose seed are light and small. Orchardgrass averages 532,000 seeds per pound; Kentucky 31 fescue, 527,000; and crimson clover, 140,000 (20).

Stoesz (18) (19) used broom corn bats attached to the standard reel, to brush the standing crop and the shattered seed from the cutter bar onto the apron of the combine. He also recommended the extending of the combine platform to decrease its angular relationship to the ground.

To further reduce the cutter bar shatter loss, a wind reel has been developed which replaces the conventional rotating unit (16). The new device consists of a large fan, which by means of ducts and small vertical pipes in front of the cutter bar, directs a strong blast of air onto the combine apron. This air blast causes the shattered seed to be blown onto the combine apron. The loss due to cutter bar shatter ahead of the combine can be excessive as the harvest season progresses.

MacGregor (13), Robertson, et al (17), and Atkins (1) developed small pan-type harvesters for use on crop breeding plots. Kneebone (11) modified a hammermill to process the grass seed harvested by the pan-type harvesters.

Dexter and McKibben (4) in 1945 reported the development of a vacuum-type harvester for clover seed. A large industrial exhaust fan was used to pick up clover seed through a three-foot wide harvest head. Dexter and Sheldon (5) rebuilt the original machine to increase the harvest head to six feet in width. A crop beater was used in conjunction with the harvest head to facilitate easy pickup of the seed.

Hanna (8) (9) in 1952 reported the vacuum harvester to be more efficient than the conventional combine. The velocity of air necessary for vertical and horizontal transportation was calculated for many common seeds.

Mullen et al (14) in 1953 reported the development of a vacuum-type harvester to harvest hard-to-get seeds such as nodding stipa and purple stipa.

CHAPTER III

METHODS

Test Equipment--1955

Combine

The selection of a combine for use on the project was influenced by several important factors. The use of a standard combine, belonging to the Experiment Station, was considered for the project. The structural changes required in the combine and possible conflicts of use ruled out the possible use of such a machine. These requirements plus low initial cost thus dictated the purchase of a used standard combine for the especial use of the project.

A second important consideration was the combine size. Use of the combine for most experimental purposes would be restricted to small plot areas in order to replicate tests. This in turn determined that the combine would have to be of minimum size.

Both requirements, low cost and small size were fulfilled in the purchase of an Allis-Chalmers Model 40 combine. This combine, built in 1940, has a thirty-nine inch width of cut and incorporated all the features of the larger combines (see Appendix B). A rubber bar type combine cylinder is standard equipment and is recommended for threshing of grasses and legumes.

The purchased combine was completely dismantled and all broken or worn parts replaced. Several structural and functional changes were made

on the combine to facilitate collection of material and to provide for better field operation.

The main combine under-frame, tractor hitch and power take-off drive shaft were removed. A new, heavy under-frame was built to allow the combine to be side mounted on the tractor (Figure 1 and 2). A detachable hitch was designed to provide for trailing the combine for road travel or conventional pull behind operation.

The tractor power take-off drive was replaced by a separate engine mounted on the right side of the combine. An Onan two-cylinder, four-cycle gasoline engine, rated at ten horsepower, was selected to power the combine, (Figure 3). The gasoline tank for the engine was mounted on the left side of the combine as a safety precaution against fire (Figure 4). Through the use of a jack shaft (Figure 5), the high engine speed was reduced to a level consistent with proper combine requirements. The drive between the engine and jack shaft utilized a slack belt and a hand activated idler pulley as a clutching device to control the combine operation. The use of a jack shaft also provided space for supplemental drives for accessory equipment, such as a blower and an air compressor.

In order to have a more compact machine, the grain bagging spouts and platform were moved to the right rear of the combine (Figure 6).

As most of the experimental research on the project would be on a small plot basis, it was necessary to provide some means of collecting the clean seed and tailing material, other than through the conventional auger and elevator. A removable false bottom and a sliding tray was placed under the tailing and clean seed augers (Figure 7). By removing the false bottoms,



Figure 1. Front View of Allis Chalmers Model 40 Combine
Side Mounted on Ford-Ferguson Model 9N Tractor



Figure 2. Three-Quarter Front View of Experimental Combine,
Side Mounted on Tractor



Figure 3. Right Side View of Combine Showing Location of Onan Engine



Figure 4. Left Side View of Combine Showing Location of Gas Tank

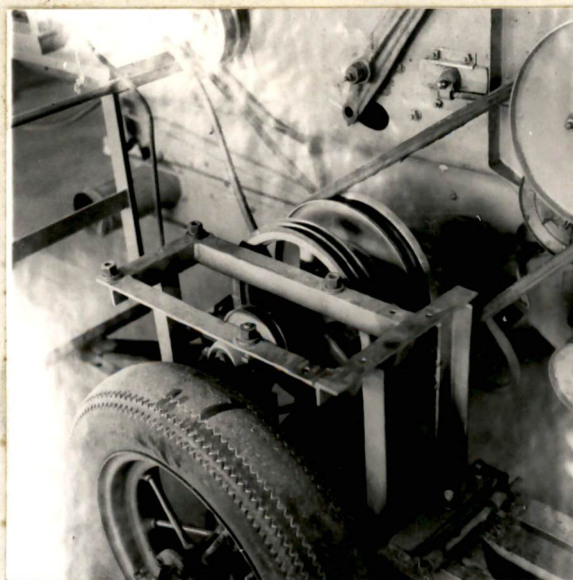


Figure 5. Combine Power Drive Jack Shaft

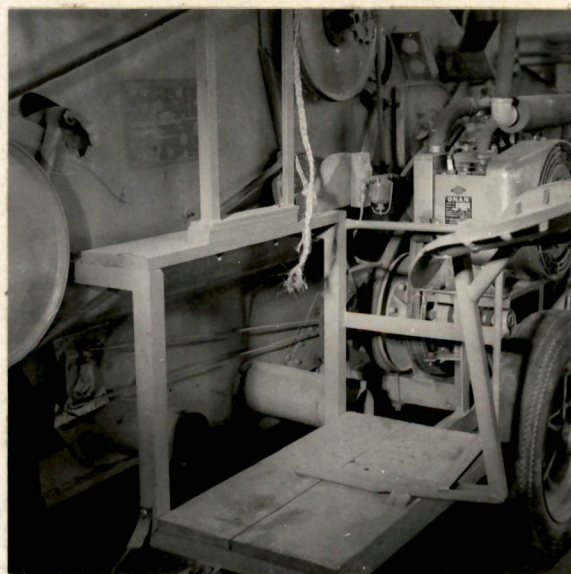


Figure 6. Grain Bagging Platform on Right, Rear Side of Combine

the collected material would fall through the augers directly into the trays below. This provided a fast, efficient method of collecting materials on each short combine run.

A hinged bottom was installed under the front roller of the conveyor apron of the combine header (Figure 8). This provided a means of collecting seed that was lost over the conveyor apron and cutter bar.

Suitable fasteners were provided at the rear of the combine to attach two canvas sheets to collect the material discharged by the combine rack and shoe (Figure 9 and 10).

The standard four bat reel was replaced by a six bat reel to give a more even support to the standing crop. Crop lifter attachments were used on the cutter bar to permit combining of lodged crops.

Provision was made for mounting an air compressor on the combine, driven from the jack shaft, to provide air to clean the combine between test runs.

The height control of the combine header was converted from manual to hydraulic control. A small hydraulic cylinder was mounted under the header platform and connected to a hydraulic pump and control system on the tractor.

An air blast wind reel was built for experimental use on the combine. A Model 2V American blower with a six-inch discharge pipe was mounted on the right side of the combine, adjacent to the engine, and belt driven from the engine. By means of flexible connections and six-inch ducts, the air was conducted to a plenum chamber in front and slightly above the cutter bar (Figure 11 and 12). Slotted orifices in the plenum chamber distributed the air across the cutter bar and on to the combine apron (Figure 13). Air



Figure 7. Sliding Trays Under Grain Bin Auger and Tailing Auger, For Collection of Seed Samples

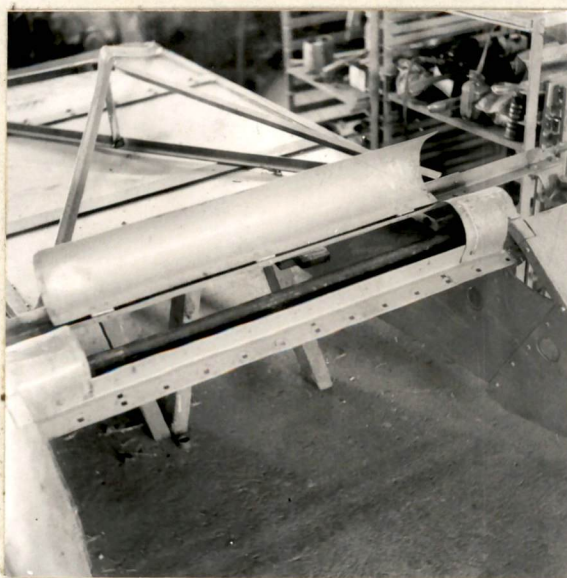


Figure 8. Hinged Bottom Under Combine Front Apron Roller, for Collection of Seed Samples



Figure 9. Canvas Sheets Attached to Rear of Combine to Collect Discharged Material



Figure 10. Field Operation of Combine Showing Collection of Combine Rack and Shoe Discharge on Canvas Sheets

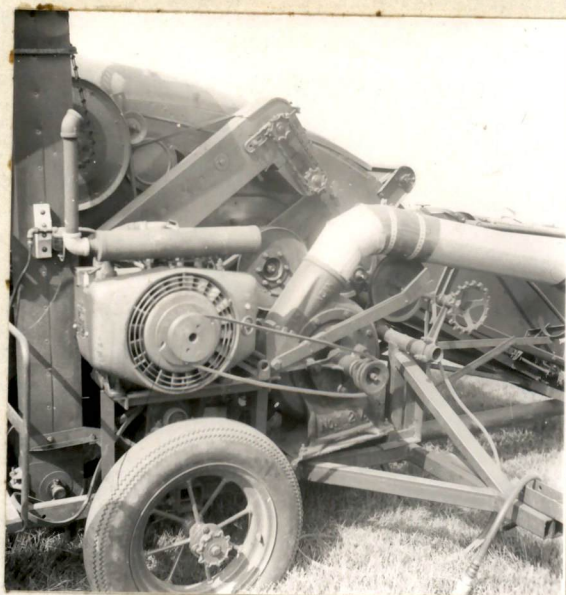


Figure 11. Right Side View of Combine Showing Blower for Air Blast Wind Reel



Figure 12. Three-Quarter Right Front View of Combine Showing Blower and Duct System for Air Blast Wind Reel

velocity across cutter bar was 1600 feet per minute. Air-volume control consisted of two sliding gates on the inlet side of the blower.

Tractor

A Ford-Ferguson Model 9N tractor was used as tractive power for the combine. A rectangular frame was bolted to the tractor rear axle and front motor supports. The main frame members were made of four-inch pipe to support the weight and side thrust of the combine. Quick hitching of the combine to the tractor was accomplished by use of a ball and socket hitch (Figure 14).

A self-contained hydraulic pump and control unit was attached to the rear of the tractor with a direct drive from the power take-off shaft. This unit provided a two-cylinder, double acting system for a control of the combine header.

Test Equipment--1956

Combine

The combine used for the tests in 1956 was the same basic machine used in 1955. Several changes were made to improve the ease of operation. The combine side hitch was replaced by a conventional trailing hitch to facilitate operation on soft or rough ground. The distributing auger in the tailings system was reworked to provide a more positive feed to the combine cylinder.

Two detachable wedges were used on the combine rack to impede the passage of straw to provide better separation. The standard six bat reel



Figure 13. Plenum Duct of Air Blast Wind Reel With Slotted Orifices



Figure 14. Front View of Combine, Side Mounted on Tractor, Showing Tractor Support Frame, Combine Ball and Socket Hitch

was used in all tests in 1956.

The combine platform was lengthened eighteen inches to decrease its operating angle with the ground, providing a more even flow of material to the threshing cylinder.

Tractor

The Ford-Ferguson Model 9N tractor used in 1955 was used again for the tests in 1956.

Seed Cleaner

In order to simplify the collection of complete data on the combine tests, it was necessary to process the combine discharge in the field immediately after each test run. To carry out this plan, a Model 2B Clipper Cleaner was used (Figure 15). Use of an electric motor drive for this unit and a small portable gasoline engine-electric generator set (Figure 16), made it possible to clean the seed as each test was run.

Miscellaneous Equipment

Two weighing devices were used to measure the material collected from each test plot. A large platform scale with a special wooden extension was used to weigh the combine rack and shoe discharge (Figure 17). A small balance was used to weigh the smaller seed samples. Several seed pans and hand sieves were used to prepare the seed samples for weighing (Figure 18).

To determine the total seed potential of the various plots, a measuring frame was used. This frame, three feet square, was used to mark off areas to be hand harvested.



Figure 15. Field Operation of Seed Cleaner



Figure 16. Gasoline Engine, Electric Generator Used to Provide Power for Seed Cleaner



Figure 17. Platform Scale with Special Extension to Weigh Combine Rack and Shoe Discharge Material



Figure 18. Hand Sieves, Balance Scales, and Trays For Preparation and Measurement of Combine Seed Samples

Field Methods and Procedures---1955

Crimson Clover

In 1955, plots of crimson clover and orchardgrass were seeded for use of combine and spray curing tests. The spray curing tests involved the use of several chemical desiccants to evaluate their effect on various crops. A total crop failure of the orchardgrass, and a partial crop failure of the crimson clover left only a small area available for test. The combine tests were run in conjunction with the spray curing tests on the same crops. Visual observation of combine operation and seed loss was noted.

The crimson clover plots were on the University of Tennessee Morgan farm. The field was laid off in one-hundreth of an acre plots. These plots were one combine cut in width, thirty-nine inches by one hundred thirty-four feet long. The combine was set to the manufacturer's recommendation for the crop. The cylinder speed was set to 1600 R.P.M. Two concaves were used and the grate was closed. The combine grate consists of an adjustable screen mounted directly behind the combine cylinder. When the grate is open, threshed seed may fall directly from the combine cylinder to the cleaning shoe. The shelling plate and concave plate clearance were set at three-sixteenth inch. A five thirty-seconds by three-quarter inch slotted seive was used. The adjustable chaffer was set to one-third open. The air control valves were shut and a cloth cover placed over the fan intake (Figure 19).

The threshed seed was collected for each run in the pan under the combine. The tailings material, collected in a separate bin, was re-run



Figure 19. Left Side View of Combine Showing Cloth Cover
on Blower Intake Screen

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once through the combine at the end of each test. After each test the combine was run with all controls wide open to clean the machine prior to the next plot. The engine driven air compressor furnished air to blow trash and seed out of the combine. No combine analysis other than visual observation was made on this crop.

Kentucky 31 Fescue

After the failure of the orchardgrass plots, a five-acre field of Kentucky 31 fescue was located on the United States Department of Agriculture cotton farm, which was available for experimental use. The field was divided by several gullies and the crop stand was very uneven, which made it impossible to lay out replicated plots for accurate tests. In order to use the field for test work it was required that the entire crop be harvested. This prevented use of the seed and tilling pans on the combine and required use of the conventional augers, elevators and sacking attachment. This situation allowed only preliminary observation of the combine action in the crop.

The combine was adjusted to the manufacturer's recommended setting for the crop. The cylinder speed was set at 1600 R.P.M. Two concaves were used and the grate was closed. The shelling plate and concaves were set to three-sixteenth inch clearance; chaffer and adjustable sieve set one-third open. A five thirty-second by three-quarter inch slotted sieve was used. In order to reduce air volume to a minimum, both air control valves were closed and a cloth cover placed over the fan intake.

The tests were made during the course of harvesting the five acres of Kentucky 31 fescue. The first test involved the use of the conventional

reel. As the combine made the circle of the field, four test runs, determined by twenty combine tire revolutions (128 feet) were completed. While the combine was traveling the twenty tire revolutions, the seed discharging from the seed bagging spout was collected. This test was replicated once.

A second test to observe the operation of the wind reel was made. Lack of suitable area restricted this test to two measured runs of 265 feet. While traveling the measured distance, the rack and shoe discharge were collected and later hand threshed to determine the relative combine efficiency.

Field Methods and Procedures---1956

Crimson Clover

The crimson clover crop in 1956 was on the University of Tennessee Blount farm. As in 1955, the area available for test provided space for the spray curing tests but none for the separate combine tests. However, all of the combine discharge material was collected to get some indication of losses and efficiency under the one set of operating conditions. The standard six bat reel was used and the combine adjusted to the recommended settings which were used in 1955 for crimson clover. All plots were harvested without change of combine adjustment. The rack and shoe discharge was run through the seed cleaner and the various seed weights determined. Hand harvested three-foot square plots were utilized to determine potential seed available and as a basis for comparison of combine yields.

Kentucky 31 Fescue

The orchardgrass crop failed in 1956 as in 1955 and the same field of Kentucky 31 fescue was again used. In order to make better use of the available crop, three plot areas were laid out. Each plot area was 200 feet long. The combine making two passes per test to give a total plot length of 400 feet. Seven different combine adjustments were used and three replicate trials of each adjustment were made with one exception. Lack of space allowed only two replications on the seventh test. Hand harvested, three-foot square plots were used to determine the total seed potential and as a basis for comparison of combine yields.

All combine discharge materials were run through the seed cleaner immediately after each test. Weights of the material collected, and clean seed were taken on every test. Tests one through five were made on June 21. A rain intervened after these tests and it was June 25 before the balance of the crop was dry enough to combine. The following is a description of the combine condition on each test.

Test 1

The combine cylinder speed was 1600 R.P.M. The shelling plate and concave space was adjusted to one-fourth inch with the cylinder grate in place. The height of cutter bar above the ground was fourteen inches. The air control valves were both set full closed and a cloth cover placed over one air intake. The shoe chaffer was set to one-fourth open position.

Test 2

The combine grate was removed for this test. All other conditions were duplicates of test number one.

Test 3

The height of cut was lowered from fourteen inches to eight inches. All other conditions were duplicates of test number two.

Test 4

The shoe chaffer was full open position for this run. All other conditions were duplicates of test number two.

Test 5

The shoe chaffer was set to one-half open position. All other conditions duplicate test number two.

Test 6

This test is a re-run of test number five, four days later. Rain fell on the crop between test five and test six.

Test 7

All the air on the cleaning shoe was cut off by means of cloth covers over both air intakes on the fan. All other conditions duplicate test number five.

CHAPTER IV

DISCUSSION OF RESULTS

Crimson Clover Tests--1955

The use of the combine in crimson clover was limited to the evaluation of the spray curing tests. In order to properly evaluate these tests, it was necessary to set the combine to the manufacturer's recommendation and to allow no further change in the combine. Further tests had been originally planned for combine evaluation but were not possible due to crop failure and lack of uniformity of stand. Crown rot and heavy weed growth were encountered.

Although no exact data were collected on crimson clover, several important facts were observed. Due to heavy rains prior to harvest, the crimson clover crop was seriously lodged on many plots. Appendix A shows the incidence of rain and weather conditions for both 1955 and 1956. This condition created a problem in lifting the crop high enough for the combine cutter bar to pass under the material. The mechanical crop lifters which were attached to the cutter bar successfully lifted the crop to allow passage of the cutter bar.

The threshing action of the combine cylinder was satisfactory, as checked by visual inspection of the rack discharge. Random collection of tailing, rack, and chaffer discharge material showed an excessive loss of clover seed. The standard closed position of the air on the combine blew a visible amount of seed out of the combine. It was necessary to place covers over the fan air intake screens to further limit the air flow.

An attempt was made to count the seed loss on a square foot basis on the ground, before and after combine passage. Some seeds were visible, but it was found to be impractical to accurately determine seed loss in this manner.

Kentucky 31 Fescue Tests--1955

The five-acre field of Kentucky 31 fescue used in the combine tests was originally planted as a cover crop. The crop stand was very uneven, the field shape was irregular, long and narrow with several deep gullies running across the field. Part of the land was level, while other areas were moderate to steep slopes. In every aspect, it was a poor field for combine tests.

Several acres were combined and various adjustments made to find optimum settings as determined by samples collected behind the combine. As with crimson clover, the air inlets to the fan were covered to restrict air flow.

After the optimum settings were made, the first test was run, using the conventional reel. Table III shows that on the basis of four runs of 128 feet each, repeated once, the seed collected from the bagging spout averaged 128.7 pounds of seed per acre. This seed yield gave no consideration to the cutter bar loss or loss from inefficient combine operation. A second test provided further data to determine the relative losses which occurred within the combine. Table IV illustrates the breakdown of the rack and shoe loss and gives some indication of the combine efficiency. The clean seed yield of 128.7 pounds per acre in the first test represents

TABLE III

YIELD OF KENTUCKY 31 FESCUE BY COMBINE HARVEST
1955

Replication	Yield Pounds per Acre
1	118.9
2	<u>138.4</u>
Mean	128.7

TABLE IV

EFFECT OF OPERATION OF COMBINE ON SEED
LOSS AND COMBINE EFFICIENCY
KENTUCKY 31 FESCUE
1955

	Per Cent
Rack Loss	25.6
Shoe Loss	55.5
Seed Collected in Bin (Combine Efficiency)	18.9

only one-fifth of the seed that the combine harvested, based on the second test of combine efficiency. The high rack and shoe losses together with a definite clogging of the chaffer and sieves indicated an overloaded condition.

In all tests, the threshing action of the cylinder was observed to be adequate for the crop conditions.

Crimson Clover Tests--1956

The crimson clover plots, 0.15 acre each, were the subject of three treatments: five were sprayed with Dow-General; five were sprayed with Endothal, and five were check plots. The recommended combine adjustments were made and all plots were combine harvested with the one setting. Table V indicates the average combine efficiency of the test. The heavy, lodged mass of crop which must be handled quite roughly, could contribute to a high cutter bar loss. The shoe and rack losses were very low. A breakdown of the division of seed on the combine is shown in Table VI. From this data it is noted that almost half the seed must pass back through the combine cylinder by way of the tailing system before it is recovered as clean seed. In the determination of the combine efficiency, the seed passing into the tailing auger was assumed to be eventually recovered as clean seed; therefore, the weight of seed in the tailing auger was added to the clean seed to determine the combine efficiency.

The hand-harvested plots are compared with the combine-harvested plots in Table VII. The combine harvest is the total of all seed that is recovered from the machine: clean seed, tailing seed, shoe, rack and

TABLE V

EFFECT OF COMBINE OPERATION ON SEED
LOSS AND COMBINE EFFICIENCY
CRIMSON CLOVER
1956

	Per Cent
Cutter Bar Loss	11.9
Rack Loss	2.6
Shoe Loss	7.3
Seed Collected in Bin (Combine Efficiency)	77.9

TABLE VI

EFFECT OF OPERATION OF COMBINE ON DIVISION
OF SEED ON COMBINE SHOE
CRIMSON CLOVER
1956

Condition	Per Cent Division		
	Over Rear of Shoe (Loss)	Into Tailing Auger	Clean Seed Bin
1. Check	4.7	44.2	51.1
2. Sprayed-Dow General	13.2	53.1	33.7
3. Sprayed-Endothal	<u>8.8</u>	<u>46.4</u>	<u>44.8</u>
Mean	8.9	47.9	43.2

TABLE VII

YIELD OF CRIMSON CLOVER SEED BY COMBINE
AND HAND HARVEST METHODS
1956

Plot	Treatment	
	Combine ¹	Hand Harvest
3	298 (pounds per acre)	277
5	151	277
7	356	576
11	306	320
13	373	533
15	322	523
Mean	301	418

¹Total of rack, shoe, cutter bar, seed bin and tilling auger.

cutter bar seed. This data would indicate that the combine collected within itself, 72 per cent of the seed available to the machine and then lost 20 per cent of that amount to rack, shoe, and cutter bar losses. Several factors could influence this relationship between the hand harvest and the combine harvest. The hand plots were nine feet square compared with 1300 square feet in the combine plots. The seed weights on the hand plots were in the vicinity of twenty to forty grams. The small plot size and the seed weights could magnify greatly any error to a significant value on an acre basis. Nevertheless, on the basis of six replicated tests there is considerable field loss indicated before the crop enters the combine, either due to natural weather shatter, the lodged condition of the crop, or mechanical cutter bar shatter with the seed falling ahead of the combine instead of on the conveyor apron.

Kentucky 31 Fescue Tests--1956

The combine harvest of the Kentucky 31 fescue in 1956 provided the first opportunity to make combine adjustments, and to attempt an evaluation of their effect. Of the seven tests, it was possible to make five basic comparisons in regard to each effect on seed yield. Each of these five relationships were analyzed statistically. Combine losses and harvesting efficiencies were calculated for each test. With the exception of one comparison, each was analyzed on three separate bases: the total amount of seed taken into the combine; the amount of seed in the tilling auger plus the clean seed in the bin; and the clean seed in the combine bin.

The analyses of the grate effect, Tables VIII, IX, and X showed a significant increase in seed yield only in the seed bin with the grate open. Table XI shows that the division of seed over the combine shoe between the tailing auger and the seed bin changed slightly with more seed going directly into the seed bin when the grate was removed. The complete cutoff of air flow within the combine resulted in the largest diversion of seed directly into the seed bin. The relative seed loss and harvesting efficiencies are shown in Table XII and XIII. In both cases the harvesting efficiency was less than 50 per cent.

Tables XIV, XV, and XVI indicate there was no significant change in seed yield achieved by a change in height of cut. The data mean values varied considerably but were not statistically significant due to the small number of replications and treatments coupled with some heterogeneous plots. There probably is a difference between the two treatments but such data does not lend itself to an analysis of variance due to the previously mentioned conditions. Table XVII shows the seed losses and combine efficiency for this test.

The date of harvest had a significant effect on the total amount of seed the combine handled. Tables XVIII, XIX, and XX record this data. The mean difference was 622 grams while a LSD at the one per cent level was 216 grams. The rain which fell between June 21 and June 25 could account for the decrease in seed yield. The weather data, Appendix B, records three days of rain between these two tests.

The tests which involved the effect of the shoe chaffer, when analyzed, Tables XXI, XXII, and XXIII showed a significant effect of seed yield on all three bases. Tables XXIV and XXV also indicated a

reduction in shoe seed loss and an accompanying increase in combine efficiency when the shoe chaffer was half or full open.

Test seven, Table XXVI, with the combine air control completely closed showed no significant total seed yield increase, but Tables XXVII and XXVIII do indicate a radical change in material flow within the combine and a good combine efficiency. When the air flow is cut off both the seed loss over the rear of the shoe and the flow of seed into the tailing auger is decreased greatly. The cleaning sieves and chaffer were clogged severely at the completion of the test.

The seed yield comparison of the small hand-harvested plots to the larger combined plots is shown in Table XXIX. The factors of small plot size and seed sample could account for some of the difference between the hand-harvested plot yields and the yield based on combine harvest.

TABLE VIII

EFFECT OF COMBINE CYLINDER GRATE ON YIELD OF KENTUCKY 31 FESCUE
SEED AS COLLECTED IN COMBINE SEED BIN
TEST NUMBER ONE AND TWO
1956

Replication	Treatment	
	Grate Closed	Grate Open
1	12 (grams)	33
2	19	34
3	25	46
Mean	18.6	37.6

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Variance	F Value
Total	5	731.0		
Treatment	1	541.6	541.6	91.8 *
Replication	2	177.5	88.8	15.1 ns ¹
Error	2	11.9	5.9	

*Treatment significant $LSD_{05} = 12.2$ grams

Single asterisk refers to significance at five per cent level, double asterisk, one per cent level
1 ns refers to no significance

TABLE IX

EFFECT OF COMBINE CYLINDER GRATE ON YIELD OF KENTUCKY 31 FESCUE
 AS COLLECTED AT TAILING AUGER AND SEED BIN
 TEST NUMBER ONE AND TWO
 1956

Replication	Treatment	
	Grate Closed	Grate Open
1	509 (grams)	563
2	589	575
3	561	605
Mean	553	581

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Variance	F Value
Total	5	5408		
Treatment	1	1176	1176	1.74 ns
Replication	2	2884	1442	2.14 ns
Error	2	1348	674	

TABLE X

EFFECT OF COMBINE CYLINDER GRATE ON YIELD OF
 KENTUCKY 31 FESCUE AS COLLECTED AT ALL
 COMBINE DISCHARGE POINTS¹
 TEST NUMBER ONE AND TWO
 1956

Replication	Treatment	
	Grate Closed	Grate Open
1	1165 (grams)	1350
2	1232	1293
3	1385	1199
Mean	1260.6	1280.6

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Variance	F Value
Total	5	37724		
Treatment	1	600	600	0.03 ns
Replication	2	1453	726	0.04 ns
Error	2	35671	17835	

¹Total of rack, shoe, cutter bar, seed bin, tailing auger

TABLE XI

EFFECT OF OPERATION OF COMBINE ON DIVISION
OF SEED ON COMBINE SHOE
KENTUCKY 31 FESCUE
1956

Test Condition	Per Cent Division	
	To Tailings Auger	Clean Seed Bin
1. Recommended Setting (Shoe One-fourth Open)	96.6	3.4
2. Cylinder Grate Removed	93.5	6.5
3. Low Height of Cut	85.3	14.7
4. Shoe Full Open	89.7	10.3
5. Shoe One-half Open	76.4	23.6
6. Air Completely Cut Off	7.3	92.7

TABLE XII

EFFECT OF COMBINE OPERATION ON CLEAN SEED
LOSS AND COMBINE EFFICIENCY
RECOMMENDED ADJUSTMENT
KENTUCKY 31 FESCUE
1956

	Per Cent
Cutter Bar Loss	2.0
Rack Loss	5.4
Shoe Loss	47.0
Seed Collected in Bin (Combine Efficiency)	45.6

TABLE XIII

EFFECT OF COMBINE OPERATION ON CLEAN SEED LOSS
AND COMBINE EFFICIENCY CYLINDER GRATE REMOVED
KENTUCKY 31 FESCUE
TEST NUMBER TWO
1956

	Per Cent
Cutter Bar Loss	6.2
Rack Loss	7.4
Shoe Loss	41.0
Seed Collected in Bin (Combine Efficiency)	45.4

TABLE XIV

EFFECT OF HEIGHT OF CUT ON YIELD OF KENTUCKY
31 FESCUE SEED AS COLLECTED IN COMBINE SEED
BIN TESTS NUMBER TWO AND THREE
1956

Replication	Treatment	
	Stubble Height 14 inches	Stubble Height 8 inches
1	33 (grams)	62
2	34	67
3	46	146
Mean	37.7	91.7

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Variance	F Value
Total	5	8919		
Treatment	1	4373	4373	5.49 ns
Replicate	2	2954	1477	1.85 ns
Error	2	1592	796	

TABLE XV

EFFECT OF HEIGHT OF CUT ON YIELD OF KENTUCKY 31 FESCUE
SEED AS COLLECTED AT TAILING AUGER AND SEED
BIN TESTS NUMBER TWO AND THREE
1956

Replication	Treatment	
	Stubble Height 14 inches	Stubble Height 8 inches
1	563 (grams)	626
2	575	506
3	605	735
Mean	581	622

ANALYSIS OF ERROR

Source	Degrees of Freedom	Sum of Squares	Variance	F Value
Total	5	29740		
Treatment	1	2563	2563	0.5 ns
Replication	2	16925	8462	1.65 ns
Error	1	10252	5126	

TABLE XVI

EFFECT OF HEIGHT OF CUT ON YIELD OF KENTUCKY 31 FESCUE
SEED AS COLLECTED AT ALL COMBINE DISCHARGE POINTS¹
TESTS NUMBER TWO AND THREE
1956

Replication	Treatment	
	Stubble Height 11 inches	Stubble Height 8 inches
1	1350 (grams)	1304
2	1293	1088
3	1199	1302
Mean	1280.7	1231.3

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Variance	F Value
Total	5	46098		
Treatment	1	3651	3651	0.3 ns
Replication	2	18728	9364	0.8 ns
Error	2	23719	11859	

¹Total of rack, shoe, cutter bar, seed bin, tailing
auger.

TABLE XVII

EFFECT OF COMBINE OPERATION ON CLEAN SEED LOSS AND
COMBINE EFFICIENCY--LOW HEIGHT OF CUT
KENTUCKY 31 PESCUE
TEST NUMBER TWO
1956

	Per Cent
Cutter Bar Loss	7.6
Rack Loss	6.9
Shoe Loss	35.0
Seed Collected in Bin (Combine Efficiency)	50.5

TABLE XVIII

EFFECT OF DATE OF HARVEST ON YIELD OF KENTUCKY 31 FESCUE
SEED AS COLLECTED AT ALL COMBINE DISCHARGE POINTS¹
TEST NUMBERS FIVE AND SIX
1956

Replication	Treatment	
	Harvest June 21	Harvest June 25
1	1597 (grams)	1011
2	1547	1232
3	1615	650
Mean	1586.3	964.3

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Variance	F Value
Total	5	755421		
Treatment	1	680309	680309	205.6 **
Replicate	2	68498	34249	10.4 ns
Error	2	6614	3307	

¹Total of rack, shoe, cutter bar, seed bin, tailing
auger.

**Treatment significant $LSD_{01} = 216.2$

TABLE XIX

EFFECT OF DATE OF HARVEST ON YIELD OF KENTUCKY 31 FESCUE
SEED AS COLLECTED IN COMBINE SEED BIN
TESTS NUMBER FIVE AND SIX
1956

Replication	Treatment	
	Harvest June 21	Harvest June 25
1	240 (grams)	254
2	255	153
3	404	111
Mean	299.7	172.7

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Variance	F Value
Total	5	51439		
Treatment	1	24194	24194	2.01 ns
Replicate	2	3214	1607	0.1 ns
Error	2	24031	12015	

TABLE XX

EFFECT OF DATE OF HARVEST ON YIELD OF KENTUCKY 31 PESCUE
SEED AS COLLECTED IN TAILING AUGER AND SEED BIN
TESTS NUMBER FIVE AND SIX
1956

Replication	Treatment	
	Harvest June 21	Harvest June 25
1	1290 (grams)	736
2	1204	938
3	1310	537
Mean	1268	737

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Variance	F Value
Total	5	509688		
Treatment	1	422942	422942	13.4 ns
Replicate	2	22087	11043	0.3 ns
Error	2	64659	31553	

TABLE XXI

EFFECT OF COMBINE SHOE CHAFFER POSITION ON YIELD OF KENTUCKY
31 FESCUE SEED AS COLLECTED IN COMBINE SEED BIN
TESTS NUMBER TWO, FOUR, AND FIVE
1956

Replication	Treatment		
	Shoe One-fourth Open	Shoe Full Open	Shoe One-half Open
1	33 (grams)	164	240
2	34	96	255
3	46	94	404
Mean	37.6	118	299.7

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Variance	F Value
Total	8	127822		
Treatment	2	108100	54050	14.1 *
Replicate	2	4382	2192	0.6 ns
Error	4	15340	3835	

*Treatment significant--LSD₀₅ = 140.4

TABLE XXII

EFFECT OF COMBINE SHOE CHAFFER POSITION ON YIELD OF KENTUCKY
31 FESCUE SEED AS COLLECTED AT TAILING AUGER AND SEED
BIN TESTS NUMBER TWO, FOUR, AND FIVE
1956

Replication	Treatment		
	Shoe One-fourth Open	Shoe Full Open	Shoe One-half Open
1	563 (grams)	1240	1290
2	575	1105	1204
3	605	1080	1310
Mean	581	1142	1268

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Variance	F Value
Total	8	824363		
Treatment	2	802266	401133	108.3 **
Replicate	2	7279	3639	0.98 ns
Error	4	14818	3704	

** Treatment significant $LSD_{01} = 228.6$
Replicate not significant.

TABLE XIII

EFFECT OF COMBINE SHOE CHAFFER POSITION ON YIELD OF KENTUCKY 31
 PESCUE SEED AS COLLECTED AT ALL COMBINE DISCHARGE POINTS¹
 TESTS NUMBER TWO, FOUR, AND FIVE
 1956

Replication	Treatment		
	Shoe One-fourth Open	Shoe Full Open	Shoe One-half Open
1	1350 (grams)	1540	1597
2	1293	1313	1547
3	1199	1283	1615
Mean	1280.6	1378.6	1586.3

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Variance	F Value
Total	8	199766		
Treatment	2	146162	73082	12.2 *
Replicate	2	29644	14822	2.5 ns
Error	4	23960	5990	

¹Total of rack, shoe, seed bin, tailing auger.

* Treatment significant LSD₀₅ = 175.7
 Replicate not significant.

TABLE XXIV

EFFECT OF COMBINE OPERATION ON CLEAN SEED LOSS AND
COMBINE EFFICIENCY SHOE CHAFFER FULL OPEN
KENTUCKY 31 FESCUE
TEST NUMBER FOUR
1956

	Per Cent
Cutter Bar Loss	5.7
Rack Loss	7.2
Shoe Loss	4.3
Seed Collected in Bin (Combine Efficiency)	82.8

TABLE XXV

EFFECT OF COMBINE OPERATION ON CLEAN SEED LOSS AND
COMBINE EFFICIENCY SHOE ONE-HALF OPEN
KENTUCKY 31 PESCUE
TEST NUMBER FIVE
1956

	Per Cent
Cutter Bar Loss	5.3
Rack Loss	3.4
Shoe Loss	11.4
Seed Collected in Bin (Combine Efficiency)	79.9

TABLE XXVI

EFFECT OF COMBINE AIR CONTROL ON YIELD OF
 KENTUCKY 31 FESCUE SEED AS COLLECTED
 IN TAILING AUGER AND SEED BIN
 TEST NUMBER SEVEN
 1956

Replicate	Treatment	
	Air Partial Open	Air Full Closed
1	736 (grams)	546
2	938	714
3	537	(Missing Plot)
Mean	737	630

ANALYSIS OF VARIANCE

Source	Degrees of Freedom	Sum of Squares	Variance	F Value
Total	4	108253		
Treatment	1	13739	13739	0.5 ns
Replicate	2	65115	32557	1.11 ns
Error	1	29399	29399	

TABLE XXVII

EFFECT OF OPERATION OF COMBINE ON THE
DIVISION OF SEED ON THE COMBINE SHOE
KENTUCKY 31 PESCUE
1956

Condition	Per Cent Division		
	Over Rear of Shoe (Loss)	Into Tailing Auger	Clean Seed Bin
1. Recommended Combine Setting (Shoe one-fourth Open)	50.7	47.6	1.7
2. Cylinder Grate Removed	47.6	49.0	3.4
3. Low Height of Cut	41.1	50.2	8.7
4. Shoe Full Open	4.9	85.3	9.8
5. Shoe One-half Open	12.5	66.8	20.7
7. Air Completely Cut Off	1.0	7.2	91.8

TABLE XXVIII

EFFECT OF COMBINE OPERATION ON CLEAN SEED
LOSS AND COMBINE EFFICIENCY AIR
KENTUCKY 31 FESCUE
TEST NUMBER SEVEN
1956

	Per Cent
Cutter Bar Loss	7.5
Rack Loss	2.8
Shoe Loss	0.8
Seed Collected in Bin (Combine Efficiency)	88.9

CRANES  CREST

TABLE XXIX

YIELD OF KENTUCKY 31 FESCUE SEED BY COMBINE
AND HAND HARVEST METHODS
1956

Date	Replication	Treatment	
		Combine Harvest ¹	Hand Harvest ²
June 21	1	89.6 (Lbs./acre)	183.9
	2	94.6	160.2
	3	91.1	
	4	101.9	
	5	<u>117.2</u>	_____
	Mean	98.9	172.1
June 25	1	71.3	106.9
	2	<u>53.3</u>	_____
	Mean	62.3	106.9
	Total Mean	80.6	139.5

¹Total combine intake--rack, shoe, cutter bar, seed bin, and tilling auger.

²Each value represents average of four hand harvested plots.

CHAPTER V

CONCLUSIONS

A commercial combine was modified for experimental purposes and was used to harvest crimson clover and Kentucky 31 fescue in 1955 and 1956.

The combine harvest of crimson clover did not provide any specific data on the comparative effect of various combine adjustments. It was noted that a combine efficiency of seventy-eight per cent was achieved. The hand-harvested plots yielded an average of 413.2 pounds of crimson clover seed per acre compared with the combine-harvested plot yield of 146.2 pounds of seed per acre; a difference of 267 pounds of seed per acre. This would indicate a shatter loss due to weather and passage of the combine through the crop. This loss could be influenced by small hand-harvest plot size; small hand-harvest seed sample; and seed loss in cleaning the combined seed.

The effect of combine adjustment on Kentucky 31 fescue seed yield and the flow of seed within the combine was observed. The combine grate showed a significance effect only on the seed falling directly into the seed bin. Height of cut had no effect on the seed yield or combine operation.

A difference of four days in harvest time showed a significant decrease in total combine seed intake. A rain fell during three of the four days which would account for part of the decrease in seed yield.

The effect of the shoe chaffer control was analyzed and showed a significant difference between the various positions from one-quarter

open to full open. The one-half open position showed a significant seed increase over either the full open or the one-fourth open position. The full open position allowed all the trash and seed to fall directly on to the sieve which was not able to handle the overloaded condition.

This cut off of air flow through the combine caused a high per cent of seed to pass directly into the seed bin. This condition could only be temporary as the lack of air caused complete clogging of the shoe chaffer and sieve by the end of the test run. This would indicate the necessity for a certain minimum amount of air flow to keep the trash flowing freely from the combine.

The hand-harvested plots yielded more Kentucky 31 fescue seed than was collected by the combine. On June 21 the combine plots yielded an average of 98.9 pounds of seed per acre as compared with the hand-harvest plot yield of 172.1 pounds per acre. Four days later, on June 25, the combine plots yielded 62.3 pounds per acre compared with the hand-harvested plot yield of 106.9 pounds per acre. During the four-day interval, rain fell three of the days.

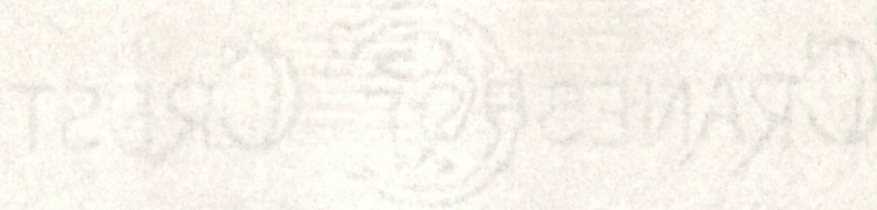
The data collected indicates a need for continuation of this study. Further study of air volume and shoe chaffer effect is necessary before complete knowledge of the functional operation of a combine is known.

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APPENDICES

APPENDIX A

DAILY WEATHER REPORT DURING COMBINE HARVEST SEASON AT
KNOXVILLE, TENNESSEE
MAY, 1955

Month	Day	Minimum Temp.	Maximum Temp.	Rain Fall (inches)
May	1	48	82	
	2	48	84	
	3	49	85	
	4	53	89	
	5	57	90	
	6	53	84	
	7	58	87	
	8	58	81	
	9	46	81	
	10	49	84	.06
	11	58	84	
	12	60	76	1.38
	13	63	79	.25
	14	60	77	
	15	60	78	
	16	56	70	
	17	56	82	
	18	56	83	
	19	60	81	
	20	58	85	.61
	21	64	81	
	22	64	78	.39
	23	64	83	
	24	67	78	
	25	66	82	.65
	26	62	88	
	27	65	89	
	28	66	88	.44
	29	65	77	.02
	30	56	73	
	31	50	76	
				3.80

APPENDIX A

DAILY WEATHER REPORT DURING COMBINE HARVEST AT
KNOXVILLE, TENNESSEE
JUNE, 1955

Month	Day	Minimum Temp.	Maximum Temp.	Rain Fall (inches)
June	1	51	82	
	2	54	84	
	3	54	85	
	4	55	85	
	5	62	88	
	6	64	85	.26
	7	63	72	.45
	8	54	60	.93
	9	54	74	
	10	62	71	.82
	11	59	73	
	12	58	72	.04
	13	58	70	
	14	56	75	
	15	52	80	
	16	55	84	
	17	58	88	
	18	59	86	
	19	64	86	.02
	20	64	87	
	21	64	90	
	22	63	87	.36
	23	62	78	.20
	24	60	86	.20
	25	66	78	.87
	26	62	83	
	27	60	84	
	28	63	80	
	29	66	83	
	30	66	86	
				4.15

APPENDIX A

DAILY WEATHER REPORT DURING COMBINE HARVEST SEASON AT
KNOXVILLE, TENNESSEE
MAY, 1956

Month	Day	Minimum Temp.	Maximum Temp.	Rain Fall (inches)
May	1	60	80	.52
	2	61	78	.36
	3	63	70	.52
	4	63	79	
	5	58	83	
	6	65	75	.24
	7	60	77	.06
	8	52	77	
	9	53	76	
	10	56	81	
	11	62	85	
	12	64	87	
	13	66	87	
	14	70	88	.12
	15	62	84	.12
	16	51	68	
	17	44	80	
	18	56	78	
	19	49	81	
	20	56	84	
	21	54	86	
	22	61	91	
	23	62	88	.23
	24	56	66	.04
	25	54	71	
	26	57	74	
	27	62	77	
	28	61	85	.27
	29	61	88	
	30	68	86	
	31	65	88	.79
				3.27

APPENDIX A

DAILY WEATHER REPORT DURING COMBINE HARVEST SEASON AT
KNOXVILLE, TENNESSEE
JUNE, 1956

Month	Day	Minimum Temp.	Maximum Temp.	Rain Fall (inches)
June	1	58	72	.49
	2	50	60	
	3	43	69	
	4	49	73	
	5	52	81	
	6	55	85	
	7	58	87	
	8	59	87	
	9	66	90	
	10	62	92	
	11	67	92	
	12	66	90	
	13	65	91	.03
	14	65	86	.08
	15	67	87	1.07
	16	67	88	
	17	68	90	
	18	68	89	.02
	19	68	90	
	20	67	78	.23
	21	68	84	
	22	69	90	.01
	23	70	90	.10
	24	68	90	.66
	25	69	88	
	26	69	88	
	27	70	88	
	28	62	91	
	29	69	92	
	30	68	92	
				2.69

APPENDIX B

SPECIFICATIONS OF ALLIS-CHALMERS MODEL 40 COMBINE

Distance between divider points	45"
Length of cutter bar	40"
Right or left hand cut	Left
Sickle front or to side of Cyl.	Front
Header hinged or rigid	Hinged
Range cutting height	2" to 25"
Canvas conveyor or spiral	Canvas
Width canvas or Diam. spiral	36"
Reel ground or power drive	Ground
Reel adjust. from trac. seat	Yes
No. of bats on reel	4
Type of cylinder	Rubber Bar
Width of cylinder	36"
Diam. of cylinder	15"
Speed range of cylinder	425-1600
Width thresher rear	37"
Length, separator surface	75"
Type of thresher	Unit Rack
Width and length chaffer sieve	22" x 39"
Length adj. chaffer extension	10"
Width and length cleaning sieve	22" x 29"
Recleaner available?	Yes
Power T-O or Engine drive	Power Take-off
Drive to cylinder	V-Belt
No. of wheels	2
Tire size, main wheel, tank side	5.00-16
Tire size, main wheel, grain side	5.00-16
Cylinder bearings	Ball
Beater bearings	Ball
Fan bearings	Roller
Main wheel bearings	Bronze
Length with trac. hitch	16'3"
Width overall, cutting	7'10"
Width overall, transport	7'10"
Height over elevator	7'1"
Capacity grain bin, Bu.	11
Gravity or elevator dump	Elevator
Shipping wt., standard equipped	1730

APPENDIX B

COMPARATIVE ANALYSIS OF FUNCTIONAL FEATURES OF
THE ALLIS-CHALMERS MODEL 40 COMBINE

Combine Specification	Combine Model			
	Allis Chalmers 40	Case F	IHC 64	Oliver 15
Width of Cut (inch)	39	48	72	68
Type Cylinder	Rub Bar	Rub Bar	Rasp	Rasp
Width of Cylinder (inch)	36	28	64	35
Diameter of Cylinder (inch)	15	16	15	15
Peripheral Area of Cylinder (Sq. Ft.)	11.8	9.8	21.7	11.5
Area of Separation Surface (Sq. Ft.)	19.3	15.7	34.6	23.7
Area of Cleaning Sieve (Sq. Ft.)	4.4	5.8	10.4	6.1
Sq. Ft. of Separating Surface per Inch of Cutter Bar Length	0.48	0.32	0.48	0.35
Inches of Cylinder Width per Inch of Cutter Bar Length	0.90	0.58	0.89	0.52
Square Feet of Cleaning Sieve per Inch of Cutter Bar Length	0.11	0.12	0.14	0.09