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EXPERIMENTS IN
FIELD TOPPING, BULK HARVESTING AND HANDLING OF
YELLOW SWEET SPANISH ONIONS

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HARVESTING AND BULK HANDLING YELLOW SWEET SPANISH ONIONS
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For the past several years the Agricultural Engineering Department has been cooperating with the Parma Branch Experiment Station in studies involving harvesting, handling, and storing Yellow Sweet Spanish onions. From this work it has been learned that these onions can be stored to depths of about 7 feet without excessive bruise damage. These onions can be completely mechanically cured in storage. Yellow Sweet Spanish Onions can be handled mechanically if extreme care is taken to keep damage to a minimum. Potato loaders can be used to load onions from the field, but present mechanical topping methods are not satisfactory. Equipment isn't presently available for loading and unloading bulk stored onions into and out of storage. The results of these experiments have been reported in the Idaho Experiment Station Bulletin No. 479.

Work in 1966 dealt with the following areas:

(1) The design, construction, and testing of a field onion topper.

(2) Design, construction, and testing of a system for loading and unloading onions into and out of storage.

(3) Work to evaluate sidewall pressures and pressure within the onion mass.

(4) Modification and testing of a potato loader to adapt it for loading onions from a windrow.

(5) Field evaluation of a farmer-modified potato loader equipped with a commercial onion roll-topper.

(6) Preparation of a questionnaire involving harvesting and storage practices and costs for distribution to the onion growers in southwestern Idaho and eastern Oregon.
Design, Construction, and Testing of a Field Onion Topper

There is a definite need for a field onion topper which will give satisfactory performance on Sweet Spanish Onions. One approach is to top the onions while they are still in the ground. Previous attempts to do so resulted in the design and construction of a flail-type topper which used air and mechanical lifters to hold the tops erect prior to topping. This machine was only partially acceptable.

Design. During the fall of 1965 a timed-wheel pick-up unit was designed and tested. This unit was ground driven and used two tined wheels per row to pick the tops up so they could be topped by a horizontal blade. During the summer of 1966, a six-row field onion topper was designed using the tined-wheel principle and six, 18-inch rotary blades. The rotary blades were very close to the tined wheel so the top could be cut before the tined wheel released the top. Four-gauge wheels were used to maintain a uniform cutting height. The gauge wheels ran on top of the onion bed. The machine was designed to allow as many adjustments as possible such as the horizontal and vertical angle of the tined wheels, gauge wheel height and blade height. The tined wheels were mounted so they would ride on the ground with provisions for lifting the wheels when turning, backing, or for road travel.

The machine was constructed in the agricultural engineering shop. The completed topper is shown in Figure I.
Figure 1. A rotary blade field onion topper. Large tined wheels pick up the tops and hold them while they are cut. The small tined-wheels clean the cut tops from the lifters.

Testing. Preliminary tests were conducted late in August. During these tests the tined wheels became plugged with tops. Small tined wheels which were power driven were added to clean the cut tops from the large tined wheels. Several days were required in the field to get the machine properly adjusted and for minor field modifications. The machine was officially tested on September 9, 1966, at Caldwell, Idaho.

The machine was evaluated by determining the percentage by weight of tops removed and by the percentage by number of onions which were damaged by the topper. This information is summarized in Table 1.

Forty samples consisting of six different treatments were placed in storage in sacks. Onions which were visibly damaged by the topper were rejected from these samples. The treatments
TABLE 1. FIELD LOSSES - UNIVERSITY OF IDAHO TOPPER - 1966

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Percent of tops removed by weight</th>
<th>Percent of onions damaged by number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand topped</td>
<td>100%</td>
<td>0</td>
</tr>
<tr>
<td>Machine (Single pass)</td>
<td>91.4%</td>
<td>2.5</td>
</tr>
<tr>
<td>Machine (Double pass)</td>
<td>93.6%</td>
<td>3.1</td>
</tr>
</tbody>
</table>

consisted of hand-topped onions, single-pass machine-topped onions, and double-pass machine-topped onions. Half of the samples were field cured and half were mechanically cured. All samples were removed from storage on December 6 and graded. The results of these tests are summarized in Table 2.

TABLE 2. STORAGE RESULTS OF ONIONS TOPPED BY UNIVERSITY OF IDAHO TOPPER - 1966

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Percent of Rots After Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand topped field cure</td>
<td>12.0</td>
</tr>
<tr>
<td>Single pass field cure</td>
<td>4.5</td>
</tr>
<tr>
<td>Double pass field cure</td>
<td>11.7</td>
</tr>
<tr>
<td>Hand topped mech cure</td>
<td>5.1</td>
</tr>
<tr>
<td>Single pass mech cure</td>
<td>14.2</td>
</tr>
<tr>
<td>Double pass mech cure</td>
<td>14.9</td>
</tr>
</tbody>
</table>
**Test Results.** Many problems were encountered during the topping tests. A considerable amount of time was required to adjust the machine in the field. Variations between fields and within a field required frequent adjustment of the machine.

One of the problems encountered was plugging of the entire housing with tops. The machine would become almost entirely clogged with tops in about 50 feet of operation. Much of this problem could be overcome by re-design of the housing to make it more self-cleaning. However, clogging with a machine of this type will probably always be a major problem.

Another serious problem encountered was lifting the entire onion bulb from the ground with the lifter wheel or with a sweep which was used to pick up the tops before the tractor wheel ran over them. Some of the field was badly infected with pink root disease, which was partially responsible for this trouble.

By making a second pass with the topper in the opposite direction, a few more tops could be removed. However, this probably wouldn't be justified due to the increased losses encountered and the increased time required.

**Conclusions.** The topping performance of the machine is not commercially acceptable. Test results indicate machine topping with this unit can expect to increase overall field and storage loss by about 10 percent over hand topping. Field efficiency with this machine was very low due to the time required for field adjustments and the time required for cleaning the machine. While improvements in design can increase field efficiency and perhaps increase the topping efficiency and reduce the losses,
it is questionable whether a machine working on this principle will ever be commercially acceptable. Further work to improve this machine would probably be worthwhile. However, the time might better be spent on evaluating other topping principles. No plans have been made to continue work on this machine.

The Use of a Potato Loader for Loading Sweet Spanish Onions

Potato loaders have been used successfully for loading onions from the field into bulk trucks or tote boxes. Chief problems with potato loaders have been: (1) Generally the row spacing will not accommodate the tractor wheels satisfactorily, (2) Use of potato loaders doesn't eliminate the topping problem, (3) Onions that are topped before they are elevated tend to roll down the pick-up thus decreasing capacity and causing some mechanical damage. A modified "Curl" potato loader was tested on the Harry Kawahara farm at Caldwell, which largely overcame these problems.

Much of the cost of topping is due to the cost of bagging or crating the onions as they are topped. Topping cost can be reduced from about 9 cents per stub to about 3 cents per stub if the onions are topped into windrows. Onions to be machine loaded were topped into windrows with three rows per windrow. Loading three rows into one windrow also eliminated the wheel spacing problem and provided enough onions to crowd the pick-up elevator. This reduced the tendency for the onions to roll down the elevator which reduced mechanical pick-up damage. Figure 2 shows the field loading operation and how the onions were crowded up the pick-up elevator.
Figure 2. Three rows of onions formed one windrow. This provided a tremendous load for the elevator which resulted in a minimum of injuries to the onions.

Modifications to the machine were made to improve its performance for loading onions. An eliminator chain conveyor was used over the clod rollers to move the onions over these rollers. Without the chain the onions will roll between the rollers which reduces the capacity and causes skin damage. The conveyor speed was reduced about 50 percent to a speed of about 100 feet per minute by changing drive sprockets. Two horizontal sections of stiff belting were hung over the pick-up elevator to reduce the tendency for the onions to roll back down the conveyor. Pieces of belting were also used to cushion the onion fall on both sides of the clod roller section. The
onions could be loaded at a rate of about 30 tons per hour with a ground speed of about 100 feet per minute. (1.14 mph) Performance of the machine was very good.

By crowding the onions into the elevator, very little damage was caused by the loading operation. The onions were loaded directly into a bulk truck. A skillful operator can adjust the discharge spout low enough into the truck so practically no mechanical damage is done in this operation. Only the first few onions dropped into the truck land directly on the truck bed.

Samples taken directly from the truck were placed into storage so the losses after storage for machine loading could be compared with losses for hand loading. For field cured onions the average storage loss for hand loaded onions was 9.9 percent and for machine loaded onions was 14.2 percent. As storage losses were generally quite high for all the experiments this year the increase of storage losses of 4.3 percent of the onions was not considered excessive.

Onions were also loaded into 4' by 4' by 2½' tote bins for comparison with the bulk handled onions.

**Bulk Loading, Unloading, and Storage Test**

The primary objective of this test was to develop an economical method for loading and unloading onions into bulk storage. This also provided an opportunity to study sidewall pressure in a bulk storage and pressure distribution within the bin as well as to obtain further data on bulk storage losses.

A removable slatted floor ventilation system for a bulk onion storage with provisions for loading and unloading onions was designed last year. The experiment this year provided an
opportunity to test the design. A large bulk bin was constructed in a commercial storage owned by J.C. Watson Co. in Parma, Idaho. The bin was 24 feet long, 17 feet wide, and 10 feet high. Cables were placed horizontally across the bottom and top of the bin to carry the lateral pressures.

Onions for this experiment were underwritten by Idaho-Eastern Oregon Onion Committee and the J.C. Watson Company.

Slatted Floor System. The floor system consisted of removable sections made up of short stud walls each eight feet long. The panels were covered with one-fourth inch plywood to form the sides of the air duct. Four-by-eight foot sheets of one-fourth inch plywood formed the top of the duct. These sheets are connected to the side panels using 20 penny nails as pins dropped through drilled holes. This provides for rapid and easy assembly and dis-assembly of the floor system. Two-by-six inch boards were used to form the slatted floor. The alley was eight feet wide which was wide enough to back the truck into. All of the floor system and duct system except that of the alley can be assembled prior to filling the bin; the alley boards can be installed as the bin is filled. A section of the completed floor is shown in Figure 3.

Orifices in the sides and tops of the ducts are used to meter air into the area under the slatted floor. This is necessary because uniform air distribution cannot be obtained in a long storage by merely passing air under the slats as the slat spacing cannot be adjusted accurately enough to act as a metering system and the onions offer very little opposition to air flow. Figure 4 shows the bulk experimental storage bin.
Figure 3. A floor system was used to provide an air distribution system and to facilitate loading and unloading the onions. The entire floor is easily removable.

Figure 4. Exterior view of the 24 foot by 17 foot bin which was used for the bulk handling and storage experiment. Other treatments were stored in sacks in the ventilated tote bins.
The slatted floor system shown in Figure 3 illustrates the principles involved; however, each design would have to be adapted to the type of storage structure and the equipment used for loading and unloading the storages.

The floor system shown in the accompanying drawing has the following characteristics:

1. The entire floor system can be easily dis-assembled and stored in a small area without the removal of nails, bolts or other fasteners.

2. The floor section is modular and is easily adapted to various lengths and widths.

3. The sections can be easily assembled as the storage is being filled thus eliminating long conveyors.

4. The entire system is above ground including duct system and conveyor; therefore, it can be adapted to any storage.

5. Positive control of the air-flow is possible from adjustable gates or orifices in the ducts.

6. The same piler can be used for unloading and loading. The onions won't have to drop more than one foot in either loading or unloading and will fall directly on a conveyor.

7. The cost of the floor and duct system would be about $1500 for a 40 ft. by 150 ft. storage.

Loading Onions into the Bulk Bin. The bulk bin was filled with 120,680 pounds of uncured onions on September 17 and 18, 1966. It was impossible to evaluate the time required to fill an ordinary storage by this method because it was necessary to take samples continuously during the filling period. Much difficulty was encountered in filling the bin due to space limitations within the storage. It was impossible to back the truck directly into the bin alley and unloading had to be done at right angles to the piler. This caused much difficulty and was largely responsible for most of the damage caused by the loading operation.
Samples for later evaluation were put in sacks and placed throughout the onion mass. Samples were taken both before and after the onions went over the piler. These were compared with samples of hand loaded onions which were stored both in bulk and in tote bins. Figure 5 shows how samples were placed within the onion mass. Samples were placed near the top, center, and near the bottom of the bin in 15 locations across the bin.

Figure 5. Samples for grading were placed in sacks and stored throughout the pile so damage from pressure bruises could be evaluated.

The piler used for loading and unloading the onions was furnished by the Southwestern Idaho Onion Growers Association and is shown in Figure 6. It was constructed by Parma Water Lifter Company and is completely hydraulically controlled and hydraulically propelled. The piler had a cleated rubber conveyor belting which kept damage to a minimum.
Figure 6. This hydraulically operated piler was constructed by Parma Water Lifter Company and furnished by the Southwestern Idaho Onion Growers Association for the bulk handling experiment.

One difficulty of the loading operation was due to the small angle of repose of the newly piled onions. This angle of repose was measured several times and found to be about 34 degrees. The need of a longer piling elevator is evident from Figure 5. The piler worked very well with the exception of its length limitation. A swivel-type extension on the piler would increase its length and make it possible to distribute onions to both sides.

Unloading Onions from Bulk Storage: On November 21 and 22, 114,000 lb. of onions were removed from bulk storage. The same piler was used to unload the onions from storage. Space limitations hampered the unloading operation just as it had the loading operation. Because of this an additional cross-conveyor, as shown in Figure 7, was needed until the bin was nearly emptied.
Figure 7. Because of the space limitations for the experiment it was necessary to load and unload at a right angle to the truck. This required an extra cross-conveyor for unloading.

After the onions had settled, considerable difficulty was encountered in getting them to feed into the conveyor. The angle of repose was measured several times during the unloading operation and found to be about 60 degrees. Figure 8 shows the unloading operation. Two men were required to feed onions into the piler. Improvements are needed to facilitate easier unloading. A method to make the onions flow more easily is needed.

**Bulk Storage Ventilation System.** The ventilation system for the bulk storage test was capable of providing an air-flow rate of 5 cfm per cubic feet of onions. An air-flow rate of approximately 3 cfm was used from September 17 to September 27. This is higher than necessary for in-storage curing. The high air-flow rate was used because the onions which went into the bin
Figure 8. Onions being unloaded directly into the piler. After the onions settled, the angle of repose was very steep. A considerable amount of hand labor was required to feed the piler.

were extremely green. On September 27, the air-flow rate was reduced to about 1.5 cfm and maintained at that value through the test.

The temperature was automatically controlled using a modutral control motor to operate a damper motor which mixed inside and outside air. The onion temperature was reduced gradually from a temperature of 65°F on September 27 to 45°F on October 27. The temperature remained at about 45°F throughout the test. Abnormally warm temperatures in early November prevented the fans from operating for several days at a time. An electrical failure blew the motor overload protection fuse sometime in early November and no ventilation was provided at all during the last two weeks of the experiment.
Bulk Storage Experiment Storage Treatments. The five treatments used in 1966 to evaluate the harvesting, mechanical handling, and storage experiment are listed below:

1. Bulk storage, mechanically cured, handled by hand
2. Bulk storage, mechanically cured, machine loaded and piled
3. Bulk storage checks (stored in tote bins) - mechanically cured, machine loaded and piled
4. Field cured, tote bins, handled by hand
5. Field cured, tote bins, machine loaded

The onions for the mechanically cured treatments were topped and windrowed by hand on September 16 following undercutting the same day. These onions were loaded into bulk trucks using the modified potato loader on September 17 and went directly into storage where they were unloaded mechanically using apiler. Samples were sacked as they came over the piler and put into the pile for late evaluation. Hand-topped, hand-loaded, and hand-unloaded samples were also placed in the pile for comparison. Samples of each of these two treatments were stored in sacks but not in the bulk storage to evaluate the affect of bulk storage. These onions were cured until September 27.

Results. The onions were inspected periodically during the storage season. They were found to be very well cured out in early October and extremely dry. Shortly after November 1, the weather warmed up and a long rainy period began. The fan was set on automatic and operated only a negligible amount after November 1. Due to a leak in the roof a large portion of the rain falling on the roof was funneled into the bulk bin; however,
other samples remained dry. During the first week in November the electrical failure occurred which stopped the fan. Inspection on November 20 indicated the onions were wet, rotting, and should be taken out of storage immediately.

The onions were removed from storage on September 21 and 22 and graded. The results of the storage test are summarized in Tables 3, 4, 5, and 6. Approximately 3000 kw-hr of power were used to cure and store about 65 tons of onions. Normally about 7 to 10 kw-hr per ton-month of electrical energy will be required to operate the fans.

Analysis of Results and Conclusions of the Bulk Storage Tests. Losses were unusually high for the experiment. These can be attributed to (1) the greenness and immaturity of the onions when they went into storage, (2) a generally poor storage season, (3) lack of fan operation during November, (4) rain leaking directly into the bulk storage, and (5) rough handling in the piling operation due to the lack of space to maneuver the piler. Despite the high losses, many conclusions can be drawn from the results. These can be summarized as follows:

1. From Table 3 it can be seen that the depth of storage didn't materially affect the amount of rotting. Bruise damage was negligible at a depth of 4.5 feet and only 6.8 percent at a depth of 7 feet.

2. Losses are high for all onions handled by the piler regardless of how they were stored. Table 4 shows that losses were slightly higher for onions stored in tote boxes than those stored in bulk where both received the same machine handling.
### TABLE 3. BULK STORAGE EXPERIMENT - 1966

Mechanically Cured - Machine Loaded - Machine Piled

<table>
<thead>
<tr>
<th>Depth</th>
<th>Percent Rots</th>
<th>Percent Bruise</th>
</tr>
</thead>
<tbody>
<tr>
<td>2'</td>
<td>34.5</td>
<td>0</td>
</tr>
<tr>
<td>4.5'</td>
<td>36.4</td>
<td>0.75</td>
</tr>
<tr>
<td>7'</td>
<td>41.6</td>
<td>6.8</td>
</tr>
<tr>
<td>Ave.</td>
<td>37.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

### TABLE 4. BULK STORAGE EXPERIMENT - 1966

Mechanically Cured - Machine Loaded - Machine Piled

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Percent Rots</th>
<th>Percent Bruises</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Storage</td>
<td>37.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Tote Bins (identical mechanical treatment)</td>
<td>40.3</td>
<td>0</td>
</tr>
</tbody>
</table>
TABLE 5. BULK STORAGE EXPERIMENT - 1966
Mechanically Cured

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Percent Rots</th>
<th>Percent Bruise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand harvested, hand loaded</td>
<td>18.1</td>
<td>3.3</td>
</tr>
<tr>
<td>Machine harvested, machine loaded - pilfer</td>
<td>37.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

TABLE 6. MECHANICAL CURED VS FIELD CURED
All hand handling - Stored in sacks

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Percent Rots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanically Cured</td>
<td>5.1</td>
</tr>
<tr>
<td>Field Cured</td>
<td>9.9</td>
</tr>
</tbody>
</table>
3. Table 5 shows that the losses for hand handling and harvesting were only about half of what the losses were for complete machine handling. Other results indicate that most of this damage was due to how they were handled in storage using the piler.

4. Table 6 shows that losses were low for hand-handled onions whether they were mechanically cured or field cured. Mechanically-cured onions had significantly fewer losses than the field-cured onions although both losses were low enough to be acceptable.

**Evaluation of a Home-made Onion Topper-Loader**

The Wakasugi roll-type topper was evaluated again this year with respect to field losses. The Wakasugi machine consists of an obsolete "Lockwood" Potato Harvester with the horizontal cross conveyor removed and a twelve-roll Bruner topping bed installed in its place. The harvester is mounted on a "Massey-Ferguson 65" tractor and is shown in Figure 9.

![Diagram of Wakasugi harvester](image)

**Figure 9.** Plan view of Wakasugi harvester -- arrangement of components
Considerable modification of the "Lockwood" unit was necessary to adapt it to onion harvesting. Mr. Wakasugi reported he spent about 300 man-hours building the machine in his farm shop.

The onions are undercut with a conventional blade two weeks prior to harvest. At least two weeks drying is required to reduce the moisture content of the tops to a level necessary to insure the successful operation of the topping rolls.

The machine picks up three rows of onions and elevates them via the pickup conveyor to a short set of rubber rollers. As the onions pass over the rubber rollers a blast of air from a fan separates dirt, weeds, and other trash from the onions before they fall onto the topping bed.

The Bruner topping bed consists of a series of parallel steel rolls with adjacent rolls turning in opposite directions. Every other roll has a one-quarter inch steel spiral welded the full length of it.

When the onions fall onto the rolls the tops are caught in the spirals and are pulled off. The operation is much the same as the husking rolls on a corn picker. The spirals also push the topped onions across the rolls and onto the final conveyor.

The topping bed is driven by a variable speed v-belt sheave. The speed at which the topping rolls are operated is very critical. At very slow speeds the onions pile up on the topping rolls and are bruised. If the topping rolls are operated at a very high rpm, the spirals cause the onions to bounce and as a result the onions are bruised and cut.

The final conveyor is composed of two sections. The first section is a constant slope conveyor that elevates the
onions to a height about eight feet above the ground. The second section elevates the onions down into the tote boxes. The vertical distance from the end of the final conveyor to the tote boxes is controlled by a hydraulic cylinder. Proper operation of this cylinder minimizes onion damage as the onions fall into the tote boxes. The filled tote boxes are left in the field to cure for about two weeks before they are stored.

The average ground speed of the tractor was about one mile an hour. Speeds up to one and one-half miles per hour were tried but the higher speeds resulted in an overload condition at the topping bed. The pickup conveyor and the final conveyor handled the onions well at the higher ground speeds. At a ground speed of one mile per hour, about one-half acre of onions was harvested each hour.

The main problem encountered with this machine was mud building up on the topping rolls. This was caused by a combination of dirt and juice from the onion tops.

The pickup conveyor picked up a large number of big clods with the onions. It was necessary to have two people ride on the machine and remove the clods as they entered the topping bed. Failure to remove the clods would result in a rapid build up of mud on the topping rolls and also would cause a clod problem in the tote boxes.

Samples were taken as the onions came over the topping rolls and again after they were in the tote bin. These samples were placed in bags and the bags were in turn stacked in a tote box. This box was field cured for two weeks, then placed in a conventional storage with the rest of Wakasugi's sacked onions. Grading and evaluation of losses was done when the
onions were removed from storage.

This year the pick-up unit and topping rolls were responsible for considerable damage. Table 7 summarizes the results of the two-year's work.

TABLE 7. WAKASUGI MACHINE EVALUATION

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Percent Rots</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1965</td>
</tr>
<tr>
<td>Hand topped</td>
<td>1.6</td>
</tr>
<tr>
<td>Pick-up and topping rolls</td>
<td>2.7</td>
</tr>
<tr>
<td>Final elevator into tote bin</td>
<td>2.9</td>
</tr>
<tr>
<td>Total machine loss</td>
<td>5.6</td>
</tr>
</tbody>
</table>

Work Planned for Next Year

If possible, the bulk storage test will be repeated. The bin will be turned around so the trucks can be unloaded directly into the piler. An extension will be designed and constructed for the piler so it will be possible to reach farther back into the pile and distribute the onions to the sides of the bin.

An attempt will be made to measure the pressure distribution within the bin and to determine how the pressure changes during the settling period.

Bulk stored field cured onions will be compared with bulk stored uncured onions. More attention will be given to evaluating field-loading damage separate from the piler damage.

An attempt will be made to determine the susceptibility of uncured onions to mechanical damage and bruise damage as compared to field-cured onions.
New harvesting equipment will continue to be evaluated with respect to field efficiency and losses. The questionnaire which has been distributed to the growers will be evaluated.