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Experiments were designed to reveal the accuracy and precision of four types of automatic sampler prototypes after initial testing indicated that the single tube vibrator sampler was not drawing a complete cross section of the seed flow in a vertical column. These experiments compared the automatic samplers with the trier types and methods used in the Oregon certification program.

Samples were drawn from known closed populations of a ryegrass (*Lolium perenne* L.) seed lot and an alfalfa (*Medicago sativa* L.) seed lot. None of the automatic samplers or the trier samplers proved to be accurate or precise when sampling for all the contaminants in the two types of seed lots.

The results of these experiments indicated that studies are necessary to further modify or redesign one or more of the sampling types in order to achieve a high degree of accuracy and precision in sampling a broad spectrum of grass and legume seed lots.

AUTOMATIC SAMPLING FOR SEED ANALYSIS

by

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AUTOMATIC SAMPLING FOR SEED ANALYSIS

INTRODUCTION

Previous work on seed sampling has indicated a need for improved techniques and devices. Variability between seed tests resulting from non-random variation in sampling has been a serious problem. While the commonly used trier is the best accepted sampler, nearly all studies have shown it to be inaccurate and imprecise. Attempts to improve the trier sampler both in design and method of use have met with failure because of the increased labor requirements and difficulty in proper operation.

The present sampling techniques require that the warehousemen leave aisles between the piles of bagged seed so that the sampler can have equal opportunity to sample all bags. The development of automatic sampling techniques could reduce storage costs, allow bulk handling, reduce sampling time, and expedite the test results by earlier arrival of the sample at the laboratory.

It is the purpose of this research to study and compare the accuracy and precision of the single-tube vibrator automatic sampler and the certification trier. Modified vibrator samplers and other sampling innovations were studied in attempting to develop a more accurate and precise automatic sampler.

The principle of drawing a continuous sample from a complete cross section of the seed flow should, in theory, improve the accuracy and precision of samples.

LITERATURE REVIEW

The importance of the seed sample in the marketing of seed has been discussed by Hardin (5). It was pointed out that the basis for the marketing of seeds was the seed analysis, which could be no better than the seed sample. Discrepencies between tests were due to sampling rather than laboratory analysis (11). Variations in the seed samples drawn from the same seed lot might have caused the seed analysis to vary enough for rejection of seed handled under contract. In the case of governmental regulation of seed there were tolerances on most specifications that made allowance for variation in the seed analysis; but, in the case of extreme variation between tests, this tolerance might not have been sufficient. In the case of noxious weeds, a zero tolerance was often applied (9).

Hardin (5) stated that considerable heterogenity of seed lots occured due to field variations, harvesting patterns, processing equipment, and the methods of handling. These factors were described as follows:

1. The field might have varied throughout due to soil type and drainage which caused seed from one side of the field to be lighter than from another side. In threshing the crop it had not been the usual practice to harvest the field in such a manner as to uniformly mix the lighter seed from one portion of a field with the heavier seed from another portion.

2. Many of our worst weed problems in seed fields were found in small irregular areas in the field rather than in a uniform

pattern covering the entire field (5). It was the practice to cut right through a weed patch, thus contaminating the entire lot with some weed seed in one portion of the lot. If the weed patch had been harvested separately and that seed containing the weed seed kept separate, the cleaning and handling problems would have been minimized as well as the sampling considerations (5).

3. The cleaning process did not alter the relative position of certain components of a seed lot, such as weed seed and other seed of a similar weight and shape. Lighter seeds were gradually shifted toward the tail end of the seed lot. It was noted that those contaminants not removed from the seed were not necessarily scattered uniformly throughout the seed lot, but were more concentrated in certain portions (5).

4. The blending process was a very delicate operation which attempted to create a homogeneous seed lot. Many of our cleaning plants did not have proper facilities for good blending; therefore, attempts at blending a lot within itself or with other lots might well have been in vain. Proper equipment and methods were essential if a good blend was to be obtained (2, 8, 3,).

5. Even if a good blending was achieved, the sacking process itself could have caused at least a partial undoing of the blending. If the seed entered the sack slowly, the lighter seeds and particles tended to flow to the side while the heavier seeds stayed in the center forming a cone (4, 7). This had been prevented by filling the bag with a large fast flow of seeds; often this did not happen because the sacks were filled directly off the last machine in the

cleaning process, and thus the flow into the sack was at the slow speed that was ideal for stratification (5).

These factors may increase or decrease the amount of heterogenity of the seed lot greatly, depending on whether each subsequent operation in the handling of the seed was in a manner to offset previous heterogenity patterns or in a manner which would further increase the heterogenity problems (5).

These sources of heterogenity that were not taken care of prior to sampling were compensated for by the sampling method and equipment (10). Stevens (12) pointed out the important ramifications on seed analysis that these variations had as a result of the method and care with which the seed sample was drawn.

Carter (1) showed that there was a great diversity in the types of seed samplers used throughout the world. The generally accepted method of sampling seed was with a probe called a trier. There were many variations of triers; the most prevalent was the so-called thief trier, which was still used in spite of the fact that research proved it to be an ineffective method of drawing a representative sample. The reason for this was evidently the ease of operation and lack of concern for a representative sample (12). Miles et al (10) reported that triers were biased in sampling for chaffy seeds. The trier over sampled small seeds and under sampled chaffy material.

Several modified probe type samplers were available that would draw better samples than those samplers in use at the present time (1), but use was limited because of the difficulty in operating them. The Nobbescher Probenstecher was an effecient and effective sampler when manipulated properly. The proper method of drawing a sample with this device was essential if the resulting sample was to be representative. This method was so painstaking that it was uneconomical to use (4).

Harmond (6) reported the development of an automatic sampler which would draw a representative sample, thus reducing the human element and mechanical design problems encountered in the hand operated probes presently in use. This sampler consisted of a 3/4 inch tube mounted on a rheostat controlled vibrator. A slot 5/8 inch wide and as long as the diameter of the sacking leg was cut in the top side of the tube. The mechanism was mounted in the sacking leg of a seed processing plant with the tube sticking through the area of down flow of seed. When the shutter was open the vibrator was automatically activated, thus drawing a continuous sample of the seed flowing past the tube. The size of sample was regulated by the rheostat control (5).

METHOD AND MATERIALS

Experiment I. Removal of Seeds from a Column of Seeds by a Single Tube Vibrator Automatic Sampler

Construction of Equipment

The seed column was contained by a square wooden duct with two glass sides eight inches in cross-section and 24 inches in length. The duct was designed for vertical use with a cut-off slide at the bottom. Figure I shows a drawing of the seed duct with the single tube vibrator sampler.

The single tube vibrator sampler consisted of a single 3/4 inch steel tube mounted in place of the regular tray on a rheostat controlled vibrator base. This tube bore a slotted opening along its top surface eight inches in length and 5/8 inch in width (Figure II).

The vibrator sampler rested on a small platform attached to one side of the duct in such manner that the sampling tube passed through the center of one inch openings cut through the immediate and opposite duct walls to accommodate the instrument (Figure I).

Sponge rubber gaskets with 5/8 inch center openings were centered over the openings on the inside walls and glued in place. These stretched around the sample tube tightly enough to prevent seed leakage but loosely enough, considering the characteristics of the material, to permit normal vibration of the instrument.

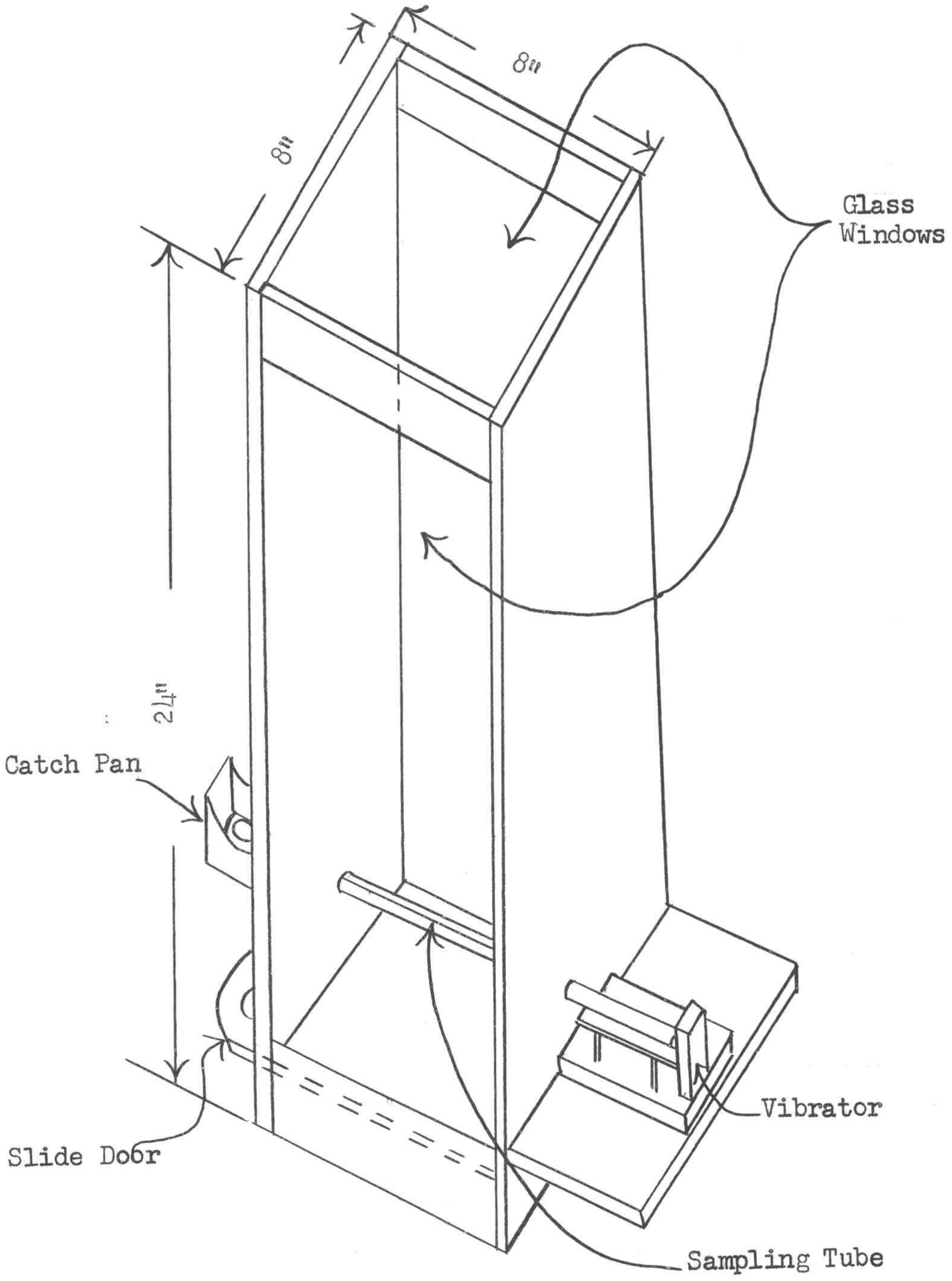

Figure I. Equipment used in Experiment I showing the eight inch by eight inch by twenty-four inch seed duct with glass sides. Inserted through the seed duct was the single tube automatic vibrator sampler.

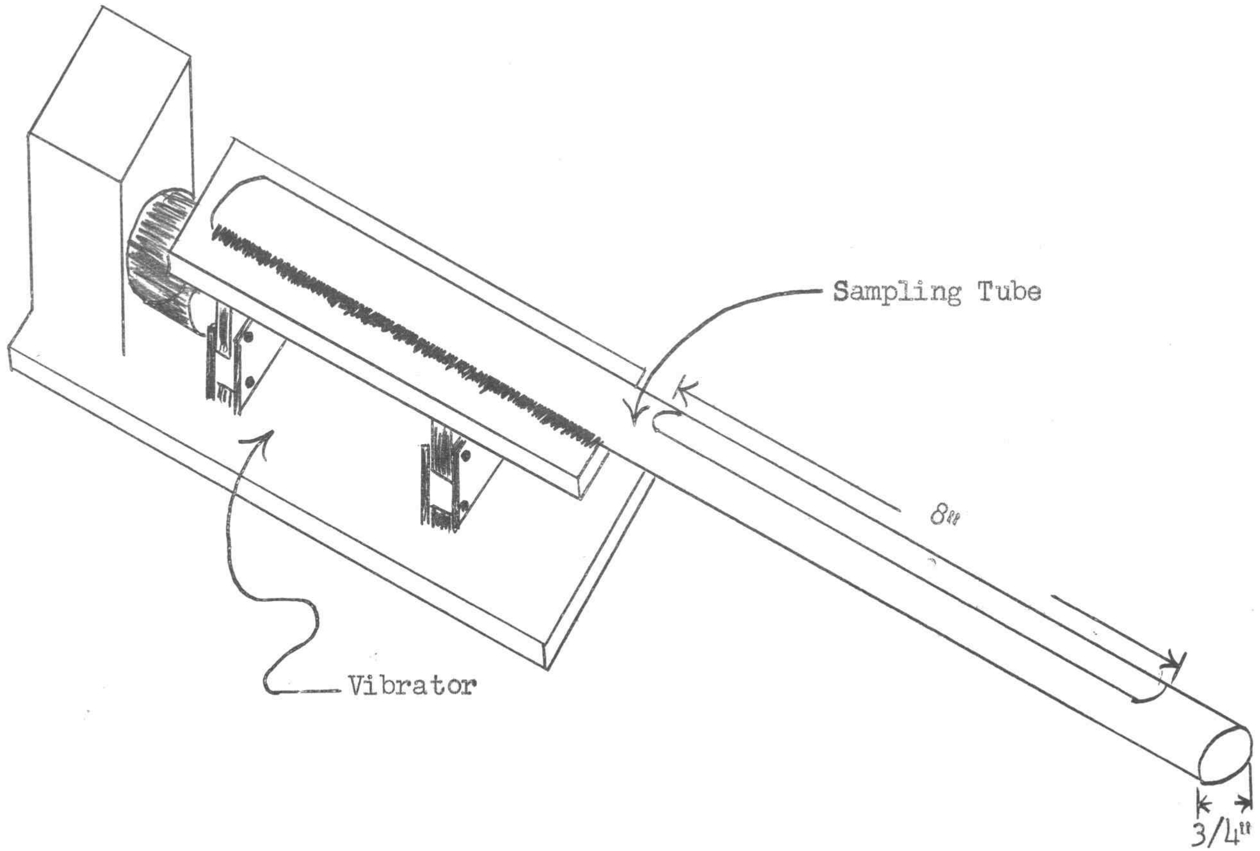

Figure II. Drawing of single type automatic vibrator sampler developed by the U.S.D.A.

When mounted in place, vibration of the tubular sampler would cause seed to enter the top slot and to carry this seed through the duct wall to an outside container. The rate of flow could be adjusted by the rheostat control from a trickle to a full stream.

The Stained Seed Test

This test was made to determine whether seed from a static seed mass would flow into the sampler tube at proportionate rates along the full length of the eight inch slot. The sampling tube was filled with stained alfalfa seed and the duct with unstained alfalfa seed. Six one-minute tests were then run at each of the two rheostat settings. This test was repeated using stained and unstained ryegrass seed.

The Divider Test

Parallel cardboard plates were installed inside the wooden duct above the sampler tube at two inch intervals from the "opposite" or sampling discharge side of the duct. In effect, these vertical plates divided the seed mass above the sampling tube into a four inch segment over the first half of the eight inch slot, and two, two inch segments over the last half of the slot.

The three columns were filled with alfalfa seed and sampling flow tests were run to determine the relative proportion of seed entering the sampler tube from the three static seed columns. This same procedure was repeated using ryegrass.

Experiment II. Sampling for Known Amounts of Contaminants in Alfalfa and Ryegrass Seed

Construction of Seed Handling Equipment

A wooden holding bin 30 inches square and 30 inches deep was constructed with three sides sloping to an eight inch by eight inch flanged discharge opening on the center line of the vertical fourth side (Figure III).

In this study, three seed ducts were constructed like the one described for Experiment I, (Figure I). These were adapted for interchangeable use in an inverted position by attaching the frame of the shut-off slides to the flanged discharge opening of the holding bin with bolts and wing nuts.

New brackets were built to provide for correct installation of sampling units. With this equipment, the holding bin could be filled with seed and its flow could be regulated through the duct bearing the sampling instruments by adjustments of the shut-off slides.

A tote bin 30 inches square and 24 inches deep with a shut-off slide in the sloping bottom was constructed to catch the seed after it passed through the seed duct. This bin was attached to a movable boom by a cable and was raised by a wench (Figure III).

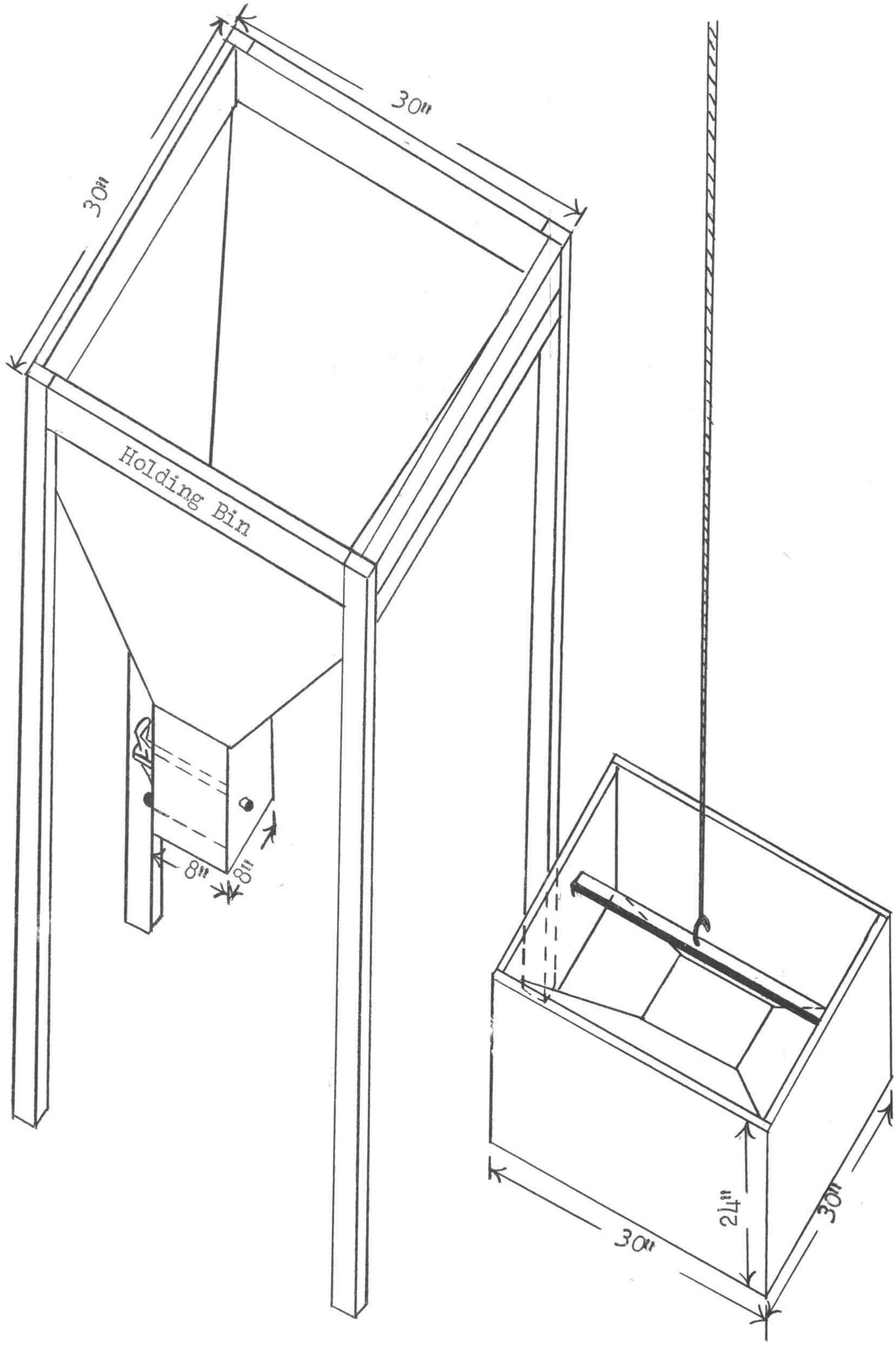

Figure III. Drawing of seed handling equipment showing holding bin with sacking chute attached and the tote bin being lifted by cable attached to a wench (not shown).

The Stratification Test

These tests were to determine degree of stratification, if any, between seed and contaminants resulting from repeated passage through test equipment.

One hundred pounds of Oregon Certified Perennial Ryegrass was placed in the holding bin and sampled by probing with a double tube trier sampler from each corner and the center of the bin. Each sample was weighed and recorded separately for volume and tare. The seed was then dropped through the sampling duct into the tote bin below. This sampling and handling procedure was repeated 20 times so that a measure of stratification could be obtained.

Sampling for Contaminants in Ryegrass

The vibrator sampling device used in this trial consisted of four sampling tubes, each with a 5/8 inch by two inch top opening adjacent to a closed end as shown in Figure IV. These tubes were attached on top of each other with top openings upward in such manner that the closed end of each overlying tube lined up with the forward end of the slot on the tube below. In effect, this provided a separate tube for sampling each two inch column of seed across the eight inch width of the duct. These tubes were attached together in a rigid frame mounted on a single vibrator base. One inch by three and 1/2 inch openings were cut in the duct walls with sponge rubber gaskets to accommodate this four-tube sampling device.

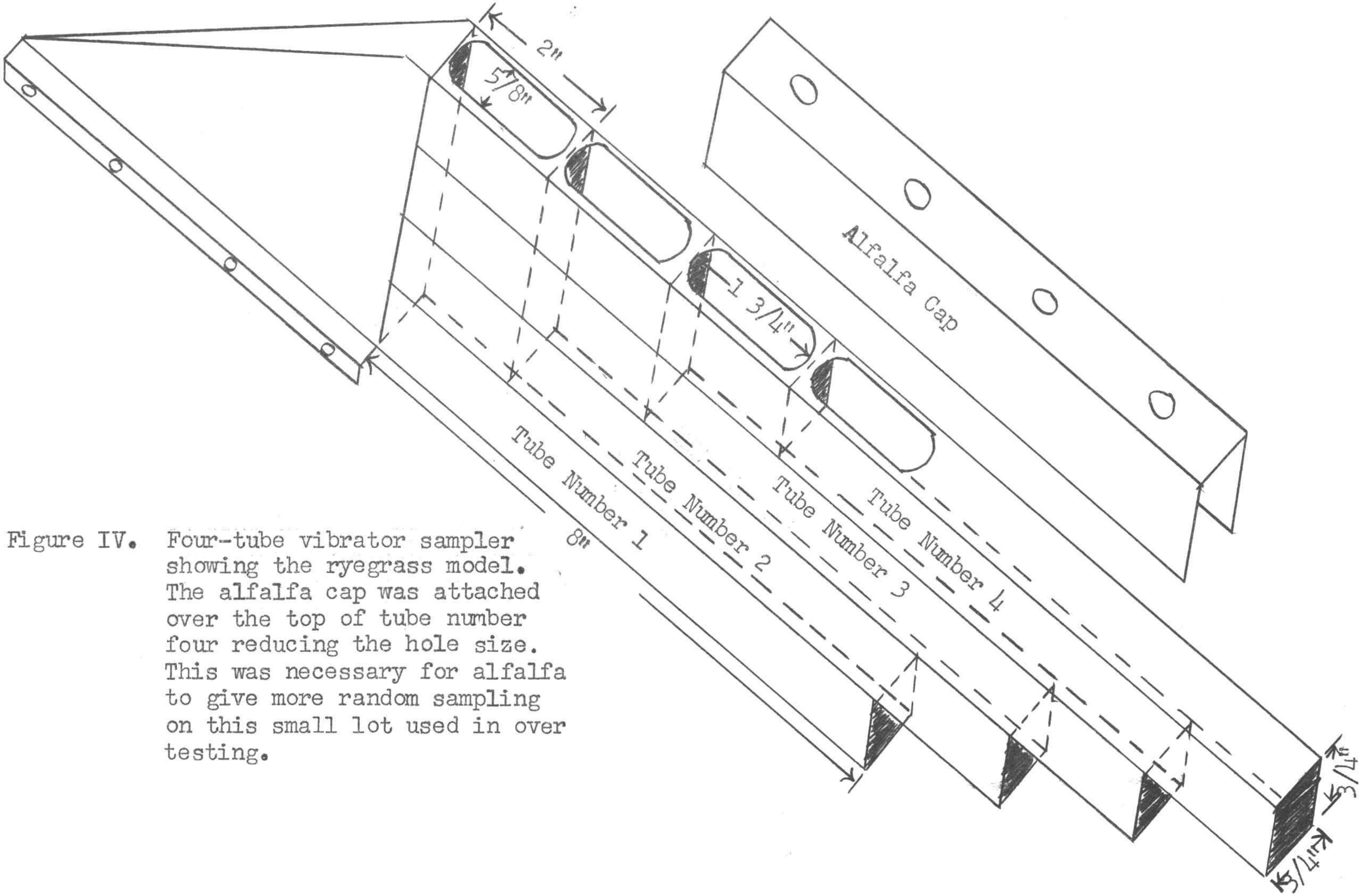

Figure IV. Four-tube vibrator sampler showing the ryegrass model. The alfalfa cap was attached over the top of tube number four reducing the hole size. This was necessary for alfalfa to give more random sampling on this small lot used in over testing.

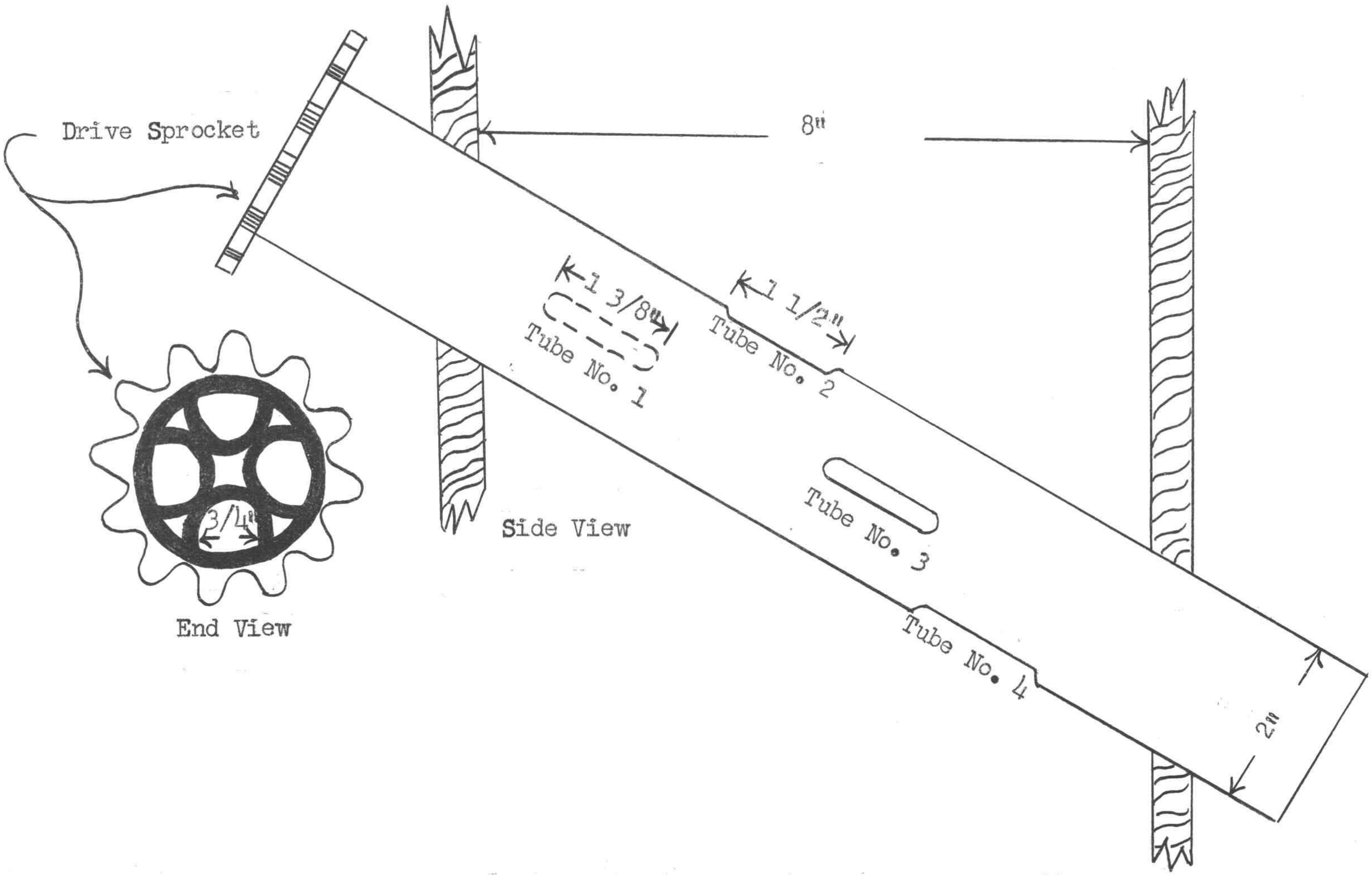

Figure V. Four tube revolving sampler adapted to alfalfa. The ryegrass adaptation had holes two inches by five eights inch.

A second type of multiple sampling tube was constructed by fitting four, 3/4 inch tubes inside a common two inch tube as shown in Figure V. Here 5/8 inch by two inch side openings in each small tube were lined up and permanently attached to matching openings in the large tube spaced at 90° angles and two inch intervals along an eight inch section. This tube sampler was extended through openings in the eight inch duct at a 30° angle with open end downward. A variable speed electric motor with chain drive was attached to the upper end of the device. This revolved the multiple tube sampler within the seed mass, each revolution drawing consecutive samples from each of the four two inch areas extending across the eight inch width of the duct.

The third sampling tube was a one and 1/4 inch diameter tube (Figure VI) inserted through the eight inch duct at a 30° angle in a stationary position. There were six holes in the top side of the ryegrass model, 3/4 inch by one inch with 3/8 inch in between the holes. Thus the seed entered the sampling tube and would slide to the outside container without the help of mechanical movement.

For comparative purposes the standard Oregon Certification ryegrass trier was used as shown in Figure VII. This trier is a tapered tube that averages 3/4 inches in diameter and is 11 inches long. The seed receiving slot is 5/8 inch by three inches and one inch from the end of the probe. When a trier sample was desired the seed was placed in a burlap bag which was sewn with an electric

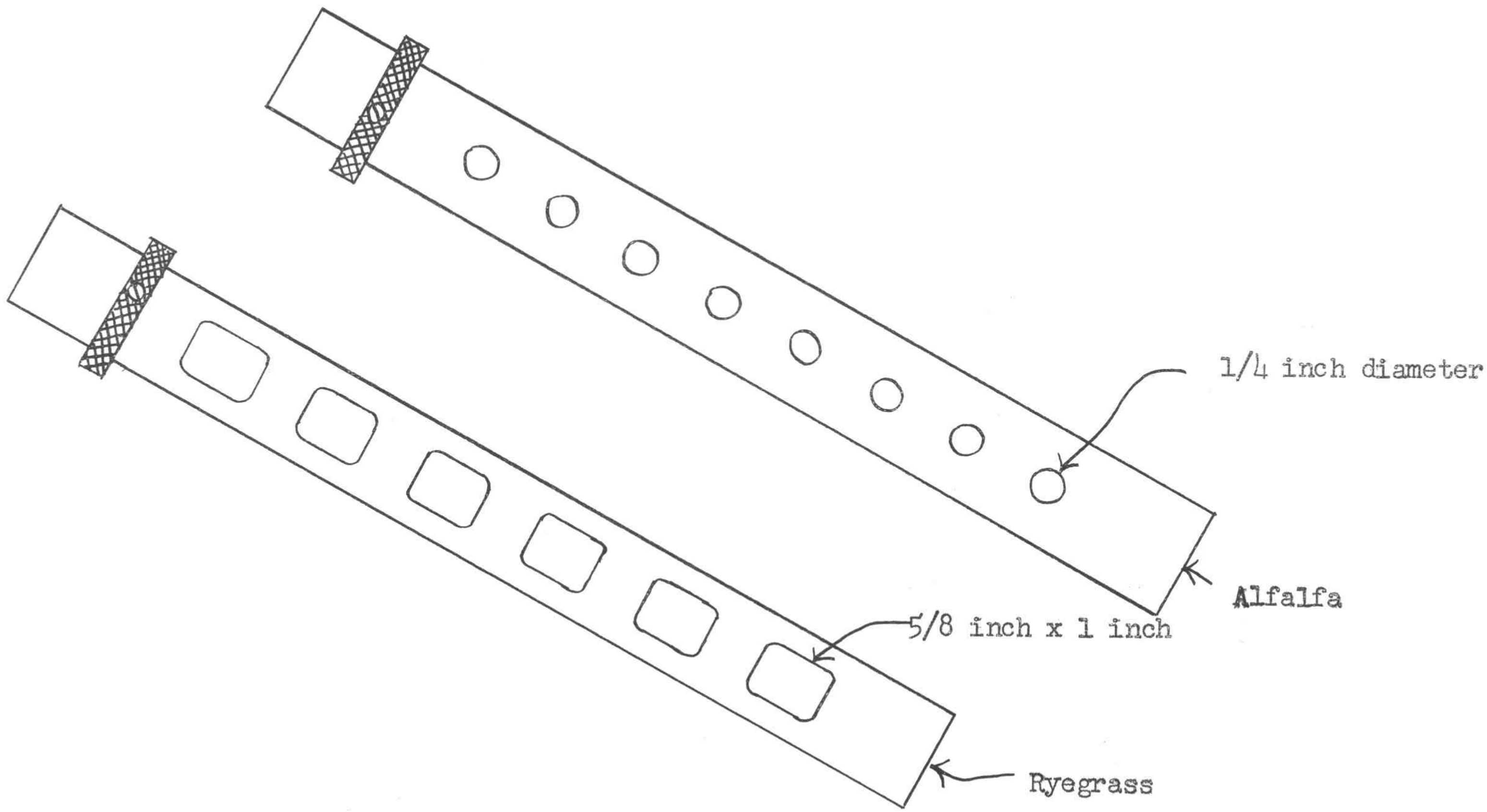

Figure VI. Drawing of alfalfa and ryegrass slide automatic samplers.

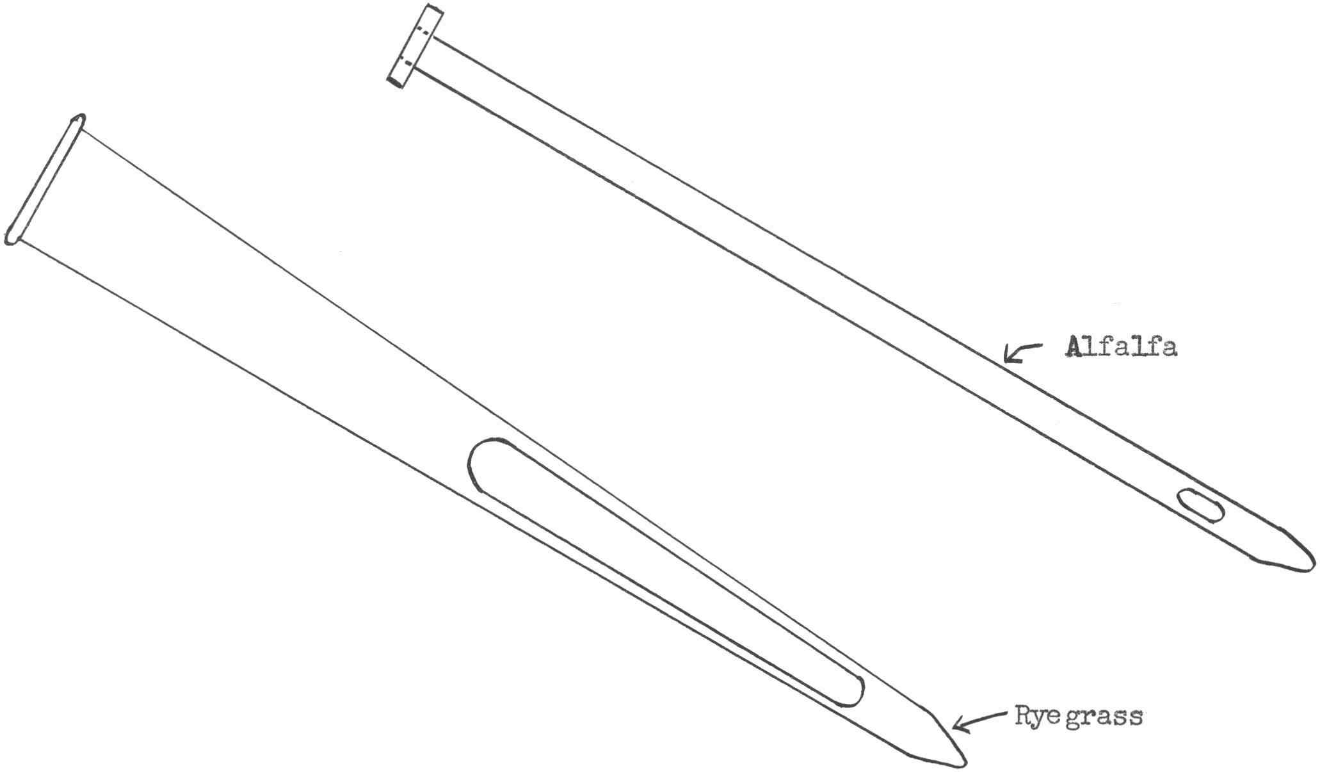

Figure VII. Drawing of the standard certification triers used in sampling alfalfa and ryegrass.

sewing machine and laid on its side to simulate the most common conditions encountered in warehouse sampling. The probe was inserted through the side of the bag and moved back and forth until the desired size of sample was obtained. The samples by the trier were taken randomly so that 1/3 were taken at the top, 1/3 at the bottom, and 1/3 from the side of the bag.

The lot of ryegrass seed consisted of 94.45 pounds of Certified Oregon Perennial Ryegrass (Lolium perenne L.) seed, five pounds of Oregon annual ryegrass (Lolium multiflorum L.) seed, 0.5 pounds of rattail fescue (Festuca myuros L.) seed, 2270 wild garlic (Allium vineale L.) seeds, 2270 quackgrass (Agropyron repens Beauv.) seeds, and 2270 sheepsorrel (Rumex acetosella L.) seeds. All seeds placed in this lot other than the perennial ryegrass seeds were stained to speed analysis by faster identification and to avoid the possibility of other contaminant seeds being confused with those placed in the lot for analysis. The seeds were mixed in five pound portions to approach the homogeneous mixture as close as possible.

The sampling methods were randomized and 12 consecutive samples taken by each sampler. The analysis consisted of removing all stained contaminants from the sample and counting and weighing each component. For the analysis a semi-automatic belt purity board was used to move the seed under the inspection point. The stained seed were picked up by a pair of forceps and placed in container according to kind. After the sample had been analyzed, each contaminant was counted and weighed on an analytical balance and recorded. The sample was then thoroughly mixed and returned to the original lot in the tote bin. The tote bin was then raised and dumped into the holding bin to be ready for the next sample to be taken.

Sampling for Contaminants in Alfalfa.

The four-tube vibrator sampler was modified to have the seed receiving hole in each tube of a 1/4 inch by 3/8 inch size (Figure III). The four-tube revolving type sampler was modified to have the two end holes 1/4 inch wide by one and 3/8 inches long and the two center holes 5/16 inch wide by one and 1/2 inch long as shown in Figure IV. The stationary sampling tube was modified to have eight holes 1/4 inch in diameter spaced across the top side of the tube. The standard certification trier for Oregon certified alfalfa seed was used as a comparison. This trier is 12 inches long and 3/8 inch in diameter with a seed receiving slot of 3/8 inch by one inch and placed one inch from the pointed end (Figure VII).

The alfalfa seed lot contained 98.95 pounds of Idaho Certified Grimm Alfalfa (*Medicago sativa* L.) seed, 0.5 pounds of running mallow (*Malva negelecta* L.) seed, 0.5 pounds of barnyard grass (*Echinochloa crusgalli* Beauv.) seed, 2270 sweetclover (*Melilotus alba* L.) seeds, 2270 dodder (*Cuscuta* spp.) seeds, and 2270 Canada thistle (*Cirsium arvense* Scop.) seeds.

All seeds other than the alfalfa seeds were dyed to speed the analysis. The lot was mixed and the samples were taken, analyzed, and returned to the lot in the same manner as the ryegrass.

Analysis of Data

The stratification data were plotted on graph paper and subjected to the analysis of variance.

The remaining analysis entailed the use of statistical methods to obtain an estimate of the accuracy and the precision of the various samplers. Since the samples were not of the same mass, formula (1) was used to weigh the number of contaminants obtained in a sample.

$$(1)\quad \frac{\text{(weight of sample)(number of seeds)}}{\text{(average weight of all samples from the lot of seed)}} = \text{(weighted number of seeds)}$$

Then the weighted number of seeds had to be transformed from a distribution following a Poisson Curve to a distribution following a Normal Curve so that the analysis of variance to determine precision and the t-test to determine accuracy could be used. The square root transformation was used as shown in formula (2).

$$(2)\quad \sqrt{\text{weighted number of seeds}} = \text{(Individual observation to be used in the statistical evaluation)}$$

Experiment III. Equality of Tubes on 4-Tube Samplers

On each of the 4-tube samplers, a test was run to determine whether each tube contributed equally to the sample. The portion obtained from each tube on the 4-tube vibrator sampler was kept separate on four consecutive runs, weighed, and recorded on both alfalfa and ryegrass seeds.

Since it was not possible to keep the contributions of each tube separate on the 4-tube revolving sampler, three tubes were blocked off and random samples were taken until each tube had contributed four samples which were weighed and recorded. This test was run on both alfalfa and ryegrass seed. The analysis of variance was applied to determine if differences occured.

Experiment IV. Sampling a Seed Mixture with Different Size and Weight Components

A lot of seed containing 54 pounds (90%) of Certified Oregon Perennial Ryegrass (*Lolium perenne* L.) seed and six pounds (10%) of empty florets of bluegrass mixed in the same manner as the seed lots in Experiment II, Part 3, in a completely randomized order. Each sample was placed on a South Dakota Blower and the empty florets were blown out. The two components were weighed, recorded, and returned to the original lot before the next sample was taken. The weights of the bluegrass florets were weighed and transformed as in Experiment II by formulas number (1) and (2). The analysis of variance was used to determine precision and the t-test to determine accuracy.

EXPERIMENTAL RESULTS

Experiment I. Removal of Seeds from a Column of Seeds by a Single Tubular Vibrator Sampler

The Stained Seed Test

After 12 minutes of continuous running of the single tube vibrator sampler 12.4% of the stained alfalfa seed had appeared in the alfalfa sample and 6.3% of the stained ryegrass seed appeared in the ryegrass sample. The percent of stained seed in each consecutive minute sample decreased after the stained seed in the end of the tube near the sample container was removed (Figure IX).

The seed level in the duct at the end of 12 minutes was as diagramed in Figure VIII.

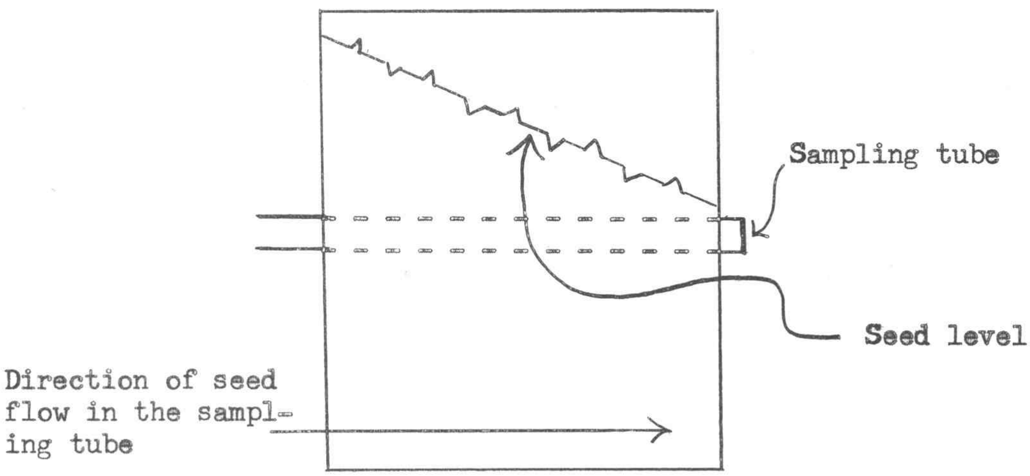

Figure VIII. The side view of the seed level in the duct after 12 consecutive minutes of sampling with the single tube vibrator sampler. This view was representative of both the alfalfa and the ryegrass seed.

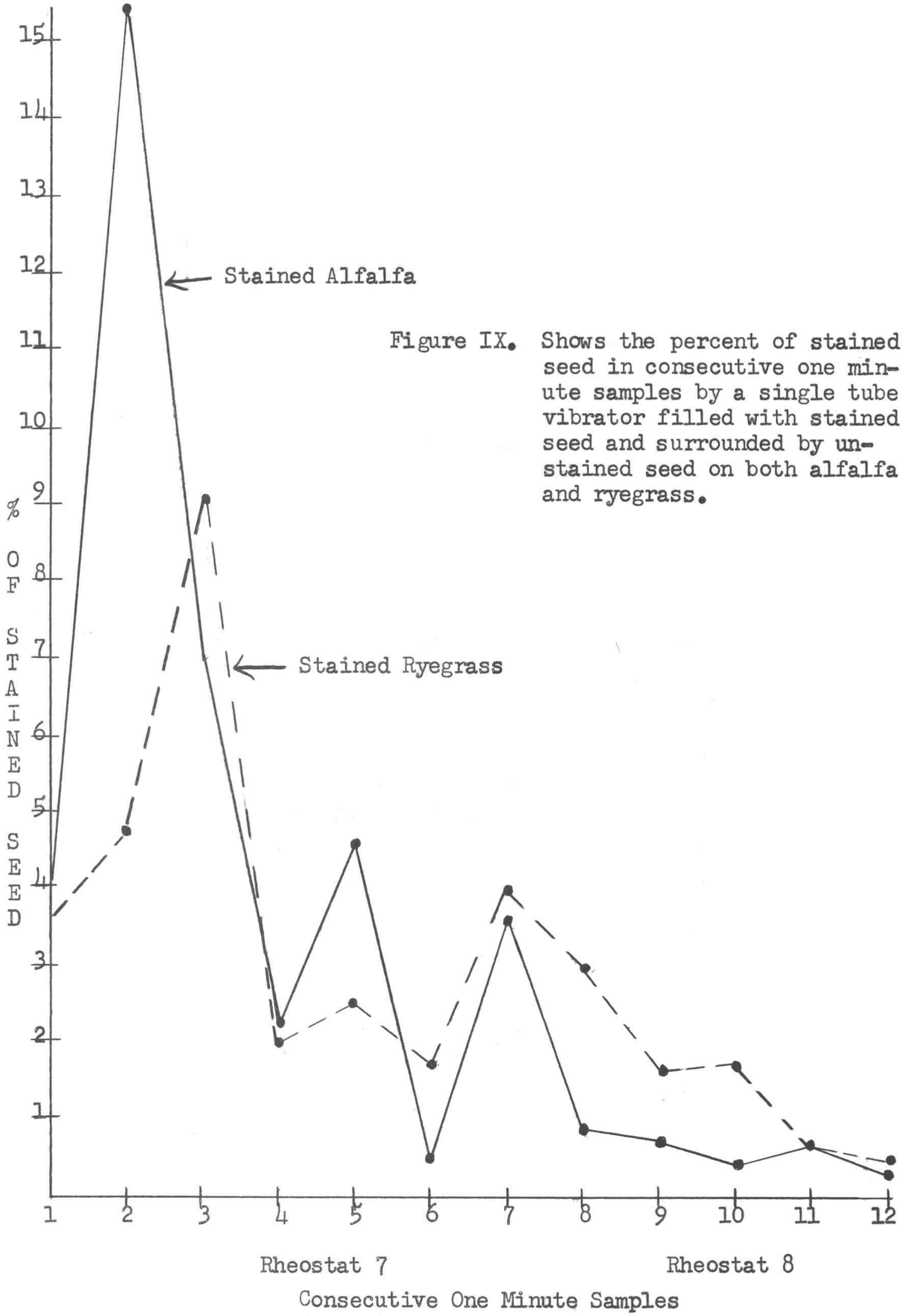

Figure IX. Shows the percent of stained seed in consecutive one minute samples by a single tube vibrator filled with stained seed and surrounded by unstained seed on both alfalfa and ryegrass.

The Divider Test

The seed in the two inches closest to the side of the duct that held the sample receiving container was removed before any of the seed was removed from the other sections of the seed columns as illustrated in Figure X.

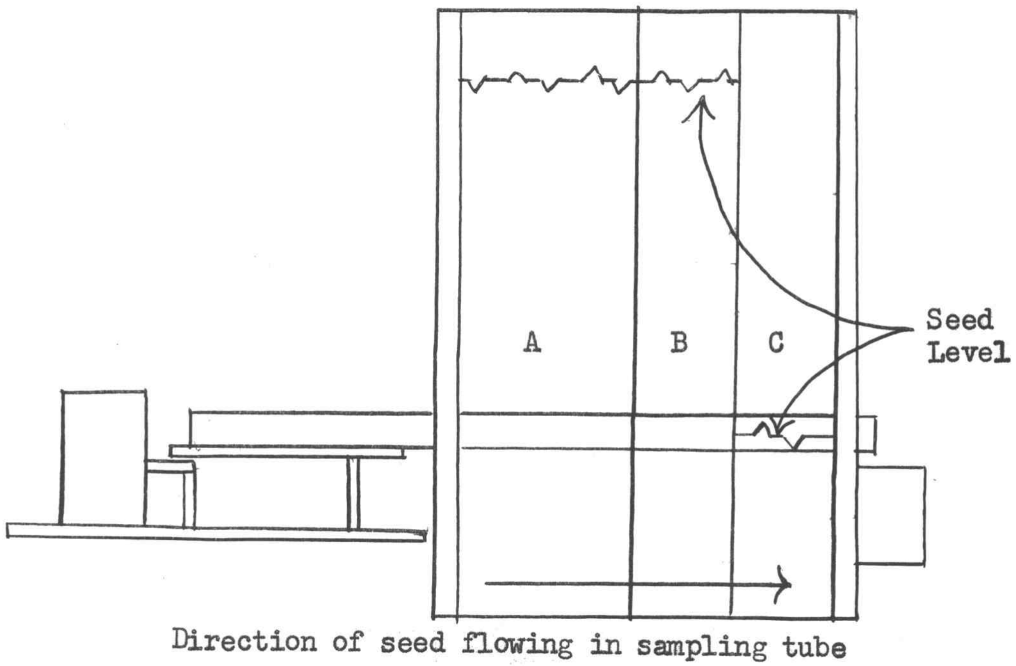

Figure X. Shows the seed level after sampling for several consecutive minutes in a divided static column of seed. The seed was removed to sample tube level from section A before any was removed from section B or C.

Experiment II. Sampling for Known Amounts of Contaminants in Alfalfa and Ryegrass Seed

The single tube vibrator sampler was not included in further study. The automatic sampling device described in the method and materials section of Experiment II was used in this phase of the research.

The Stratification Test

The stratification test which was run on ryegrass did not show any significant differences either between the points of sampling or between the 20 replicates (Figure IV and in Appendix Table I).

Ryegrass and Contaminants Sampling Experiment

All of the samplers drew samples of equal precision when the three contaminants occuring in equal numbers in the lot of seed were compared (Appendix Table II). When the four types of samplers were compared for precision on a particular contaminant, only sampling for rattail fescue was shown to be imprecise (Appendix Table III).

For the contaminant rattail fescue, there were significant differences in precision between samples at the 1% level. The Duncan's Multiple Range Test showed the slide and vibrator samplers to have like precisions, but that the revolving and the trier samplers were different from other samplers tested (Table I).

TABLE I. RESULTS OF THE DUNCAN'S MULTIPLE RANGE TEST SHOWING DIFFERENCES IN PRECISION ON SAMPLING THE PREFABRICATED RYEGRASS SEED LOT FOR STAINED RATTAIL FESCUE.

Method	Slide	Vibrator	Revolving	Trier
Transformed Mean	19.711	19.644	18.309	17.021

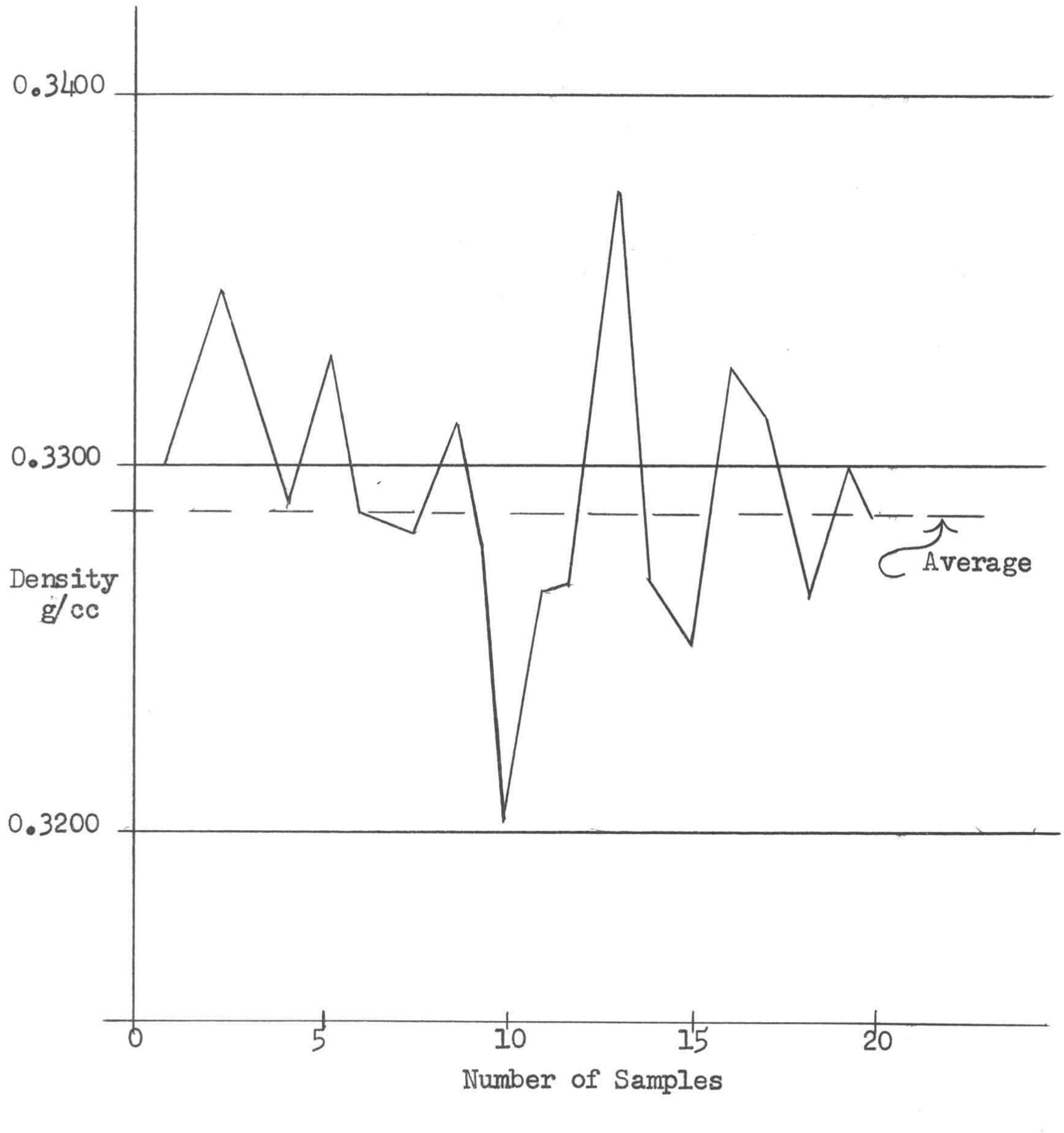

Figure XI. Results of stratification tests showing no progressive or significant weight stratification in ryegrass seed after repeated handling in equipment used to transport the seed in the research.

TABLE II. t-TEST VALUES FOR ACCURACY IN SAMPLING THE PREFABRICATED RYEGRASS SEED LOT FOR STAINED CONTAMINANTS.

Contaminants Sampled	Sampling Methods			
	Slide	Revolving	Vibrator	Trier
Annual Ryegrass	-7.357**	-7.867**	-2.917*	-9.477**
Rattail Fescue	+5.006**	-5.143**	+5.260**	-7.301**
Wild Garlic	-2.557*	-1.495	-3.316**	-1.766
Quackgrass	+0.056	+2.790	-0.900	-3.156**
Sheepsorrel	-0.198	-3.160**	-2.669*	-1.664

* 5% level of significance
** 1% level of significance

Each contaminant has three significant t-values, except the vibrator sampler method, which has four significant t-values (Table II). Some of the values are negative which indicates under-sampling, while others are positive, indicating over-sampling. In all cases, the annual ryegrass and rattail fescue showed significant values meaning that all methods were inaccurate. In the sampling of wild garlic, only the slide and vibrator methods were inaccurate. For quackgrass, the trier was an inaccurate sampling method while both the revolving and the vibrator samplers were inaccurate for sheepsorrel.

Alfalfa and Contaminants Sampling Experiment

The analysis of variance for precision between contaminants in alfalfa shows no differences between sampling devices (Appendix Table 4).

There were no significant differences in the sampling precision of a sample on the three contaminants placed in the lot in comparable numbers. The four samplers had equal precision in sampling for all contaminants except dodder (Appendix Table V).

Only in the case of dodder is a significant difference noted between the precisions of the sampling methods. The Duncan's Multiple Range Test is used to determine which treatments differ. The Duncan's test (Table III) showed that the revolving sampler and the slide sampler were different but both had similar precision to the vibrator and the trier samplers.

TABLE III. DUNCAN'S MULTIPLE RANGE TEST SHOWING DIFFERENCES IN PRECISION ON SAMPLING THE PREFABRICATED ALFALFA SEED LOT FOR STAINED DODDER.

Method	Revolving	Vibrator	Trier	Slide
Transformed Mean	2.336	2.124	1.963	1.680

The results of the t-test for accuracy (Table IV) show that none of the automatic samplers is as accurate as the standard alfalfa trier used in Oregon Certification work. The revolving sampler showed the least accuracy with inaccurate results for both barnyard grass and Canada thistle. The slide was inaccurate on dodder and the vibrator on barnyard grass.

The difference in precision between the slide and revolving samplers is revealed in the t-test values. The slide shows a negative or under sampling tendency when sampling for dodder while the revolving sampler shows a positive or over sampling tendency.

TABLE IV. t-TEST VALUES FOR ACCURACY IN SAMPLING THE PREFABRICATED ALFALFA SEED LOT FOR STAINED CONTAMINANTS.

Contaminants Sampled	Sampling Methods			
	Slide	Revolving	Vibrator	Trier
Barnyard Grass	+0.2125	-2.699*	-3.624**	-0.219
Running Mallow	-0.811	+1.419	-2.125	-1.160
Canada Thistle	-1.548	-2.721*	-0.301	-1.156
Dodder	-2.542*	+2.140	-0.089	-0.980
Sweet Clover	-0.588	-1.168	-1.963	-0.007

* 5% level of significance
** 1% level of significance

Experiment III. Equality of Tubes on the 4-Tube Samplers

The analysis of variance for testing the equality in amount of sample contributed by each tube of the 4-tube vibrator sampler (Figure IV) revealed a significant difference at the 1% level in both alfalfa and ryegrass sampling.

The Duncan's test (Table V) shows that in sampling alfalfa tube one is significantly different from the other three tubes and tube three is significantly different from tube two.

TABLE V. DUNCAN'S MULTIPLE RANGE TEST SHOWING DIFFERENCES BETWEEN THE TUBES ON THE VIBRATOR SAMPLER IN THE AMOUNT OF SEED SAMPLED WHEN USED ON ALFALFA SEED.

Tube	3	4	2	1
Mean	28.5554	25.8486	23.5938	14.7881

In sampling for ryegrass, tubes two and three are shown in Table VI to be significantly different from tube four, but none is significantly different from tube one.

TABLE VI. DUNCAN'S MULTIPLE RANGE TEST SHOWING DIFFERENCES BETWEEN TUBES ON THE VIBRATOR SAMPLER WHEN USED ON RYEGRASS.

Tube	2	3	1	4
Mean	17.8603	17.6124	13.8368	11.3538

Experiment IV. Sampling a Seed Mixture with a Major Weight and Size Difference Between Particles

The analysis of variance test for equality of precision between sampling methods shows an F-value for replication of 4.00** and an F-value for treatments of 36.00** with both being significant at the one percent leve. The Duncan's Multiple Range Test showed all methods to have different precision (Table VIII).

TABLE VIII. DUNCAN'S MULTIPLE RANGE TEST SHOWING DIFFERENCES IN PRECISION BETWEEN THE SAMPLING METHODS USED IN THIS EXPERIMENT.

Method	Trier	Vibrator	Revolving
Mean	1.995	1.9666	1.935

The precision was poorest by the trier as shown by the ranges in Table IX.

TABLE IX. RANGES OF THE WEIGHTED AND TRANSFORMED WEIGHTS OF THE EMPTY BLUEGRASS FLORETS PER SAMPLE.

Sampler	Range	Difference
Revolving	1.908-1.967	0.059
Vibrator	1.959-2.034	0.075
Trier	1.908-2.061	0.153

The results given in Table X on the t-test for accuracy showed that all three methods had a negative inaccuracy at the one percent level of significance. Not one of the observations was equal to the actual percent of inert bluegrass in the original mixture.

TABLE X. T-TEST VALUES FOR ACCURACY OF SAMPLING FOR INERT BLUEGRASS IN A LOT OF RYEGRASS. 11 D.F.

Sampler	t-Test Value
Vibrator	-14.23 **
Revolving	-36.66 **
Trier	- 8.66 **

** Significant difference at the 1% level.

DISCUSSION

To analyze the effectiveness and efficiency of any sampler, two things must be determined about the sample drawn by this device.

1. Precision is indicated by repeatability or the ability of the sampler to draw like samples from a lot of seed.

2. Accuracy is the ability of the sampler to draw correct samples representing the actual lot of seed.

The first test of each sampler used in this study was to ascertain whether it drew from a complete cross-section of the seed flow. This was necessary because of vertical and horizontal stratification that is involved in the flow pattern of seeds. If the entire cross-section is not sampled it is improbable that a sampler can deliver both a precise and accurate sample in actual warehouse conditions.

The stained seed and the divider tests were designed to determine how much of the cross-section the single tube vibrator sampled. Figure IX shows that the major amount of the stained seed that appeared in the samples was drawn in the first few minutes of each sampling period. The unstained seed was moved by gravity into the sampling tube before the stained seed was moved forward in the tube by vibration. This was verified by the fact that the percent of stained seed in the successive one-minute samples decreased even though only a small percent of the stained seed had been removed from the sampling tube.

When the divider plates were placed in the seed column it was found that the seed in the section A, Figure II, was withdrawn before any of the seed in sections B or C. This proved that the single tube vibrator did not draw a complete cross-section of the seed in the duct.

The observations of Experiment I suggested that a vibrator sampler would draw its sample from two inch sections of the seed column. This principle led to the development of the 4-tube vibrator, which has a tube to sample each of the two inch sections in the eight inch rectangular column of seed.

Because of the problems observed in maintaining constant vibration on all parts of the single tube vibrator sampler, other types of automatic samplers were developed using different principles.

The 4-tube revolving sampler was a modification of the old revolving-stationary sampler with the revolving tube inside the stationary tube which caused mechanical damage problems. The 4-tube principle eliminates the mechanical damage problem and yet still allows the entire cross-section to be sampled. This sampler is mounted through the seed stream at an angle so that the seeds slide out of the tube as it revolves.

The slide sampler is a modification of the revolving sampler, but uses only gravity to break the inertia.

These three automatic type samplers, plus a trier used for the particular crop being tested, constituted the samplers used in the remainder of the experiments.

These samplers were built so that they would draw samples of similar size from the lot, thus the statistical analysis would be meaningful.

The stratification test consisted of drawing samples from various portions of the synthetic seed lot in the holding bin after repeated handling of the seed. Since no significant difference was detected, it was assumed that the weight stratification on the synthetic seed lot was minimal and not progressive. Thus sequence sampling by each sampler was used eliminating the frequent changing of the special seed ducts designed to hold each type of sampler.

To obtain a complete statistical analysis on the results, a synthetic sample was developed. Although this had not been done in seed sampling before, it has been proven in studying other areas with statistics that a synthetic closed population is the only way to draw definite conclusions on the accuracy and precision of a sampling device or technique.

Perennial ryegrass, an awnless seed, was chosen as the seed lot to represent the problems of grass seed. The crop contaminant placed in the seed lot was the awned annual ryegrass seed which has given seedsmen problems in their attempts to sample it accurately and precisely. The weed seeds placed in the lot were rattail fescue, a long, narrow weedy grass seed; wild garlic and quackgrass, primary noxious weeds; and sheepsorrel, a secondary noxious weed.

The over sampling which occurs on the slide and vibrator samplers seemed to result from the momentary holding of the seed mass in the sampler thus allowing the long narrow seeds, i.e. rattail fescue, to be forced into the sample in excess of the actual amount present in a given amount of seed. Because of the large size and round shape of wild garlic these same two samplers excluded it and it was under sampled. By the same token the sampling motion of the revolving sampler and the trier achieved the opposite results on rattail fescue as the vibrator and slide samplers.

The synthetic alfalfa seed lot was made up to represent small seeded legumes. Contaminants placed into this synthetic seed lot were sweet clover, which is very similar in seed characteristics, but has a tendency to clump and stick together; Canada thistle, a primary noxious weed; dodder, a secondary noxious weed; and barnyard grass and running mallow, two difficult to sample for weeds.

The vibrator was inaccurate in sampling for barnyard grass, which was probably due to the fluffy nature of the seed and vibration motion of the sampling device. The inequality of the hole size on the revolving sampler was not discovered until the testing was complete. This inaccuracy in design could have caused some inaccuracies in sampling.

The 4-tube vibrator sampler was not designed properly for drawing samples of equal portions from the four segments of the seed column. The sampler was built with a larger seed capacity in tube number one than tube number two and so on down to the lowest capacity of tube four. This did not offset the problem of the distance the seed was moved or the inequality of rigidity throughout the construction.

The bottom tube had less vibration due to the fact that it was closer to the vibrator with less transmission distance to result in whip or increased vibration than the other tubes had. The inequality of amounts sampled by the individual tubes affected the purity analysis dependent upon the amount of vertical stratification.

The revolving sampler was found to draw equal size samples with each tube on ryegrass, but not on alfalfa. The difference in hole size which was indicated earlier as a possible cause did not correlate directly. The sampler was at an angle with the seed flow and the seed tended to move at an angle along the sampler toward the lower end. The smaller hole size at the lower end might be expected to collect a larger sample than the one on the higher end, while the number three tube sampled larger amounts than the number two for the same reason.

Another cause was that after the seed entered the sampling tube, it moved much less distance in tube four than tube three and until the greatest distance was moved in tube one. This did affect the size of sample drawn by each tube as the seed was not moved out of each tube with equal freedom.

The slide sampler was not tested for sampling a seed mixture with a major weight and size difference because of the problems encountered in getting light fluffy material to slide out of the stationary sampler. It was not built at a steep enough angle for gravity to break the inertia without mechanical help.

The comparison of the results of the samplers indicated that none of the experimental samplers was consistantly accurate or precise. They all would need considerable modification if they were to be acceptable samplers.

Unless some method of controlling sample size can be developed for the revolving or slide sampler, it should be discarded. The vibrator sampler would always present problems if the tube vibrates were inserted through the seed stream. Further testing on this device should be concentrated toward developing vertical tubes from the seed stream to a separate mounted vibrator trough to regulate the size of the seed sample.

In order to develop an efficient automatic sampler taking a representative sample from the seed flow, a detailed study of vertical and horizontal stratification will be necessary.

At this time the automatic samplers have not been refined to the point that they could replace the trier.

SUMMARY

The study was initiated to test and redesign the single tube vibrator automatic sampler by comparing precision and accuracy with the standard triers used in the Oregon Certification Program.

These tests were run on specially prepared alfalfa and ryegrass seed lots containing the most prevalent and difficult contaminants to sample. The results of these experiments are summarized as follows:

1. The single tube vibrator sampler did not sample a complete cross-section of the seed column which is the basic requirement for drawing an accurate and precise sample by this method.

2. The slide sampler, designed to use gravity to move the seed, was proven to be the most accurate method of sampling for ryegrass. Problems in getting the seed to move out of the tube were enough to show the need for redesign.

3. The 4-tube vibrator, designed to correct the problems encountered in the single-tube sampler, was shown to be second most accurate in sampling for ryegrass.

4. The revolving sampler, designed to remove the problems encountered with vibrator samplers, showed the least accuracy on alfalfa and only slightly more accurate than the trier on ryegrass.

5. The trier was the most inaccurate on ryegrass and most accurate on alfalfa.

6. Unequal sampling by the individual tubes was shown on both the 4-tube vibrating sampler and on the revolving sampler.

7. Results indicate a need for further designing and research on the automatic samplers.

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APPENDIX

TABLE I. ANALYSIS OF VARIANCE ON STRATIFICATION TEST SHOWING NO SIGNIFICANT DIFFERENCE BETWEEN TREATMENTS.

Grand	1085.0963	1	100	10.8510
Replications	54.2619	20	5	10.8524
Treatments (1)	217.0233	5	20	10.8511
Observations	10.8580	100	1	10.8580
Replication	.0014	19	.000074	1.028
Treatment	.0001	4	.000025	------
Error	.0055	76	.000072	
Total	.0070	99		

(1) Treatments were the five different positions of sampling the bin for stratification after each complete cycle of the seed.

TABLE II. RESULTS OF ANALYSIS OF VARIANCE ON SAMPLERS TO TEST PRECISION IN SAMPLING FOR THE THREE CONTAMINANTS (TREATMENTS) IN RYEGRASS

	F-Value	
Sampler	Treatment (1)	Replication
Trier	-----	1.503
Revolving	-----	-----
Vibrator	2.969	-----
Slide	-----	-----

(1) Treatments are wild garlic, quackgrass, and sheepsorrel.

TABLE III. RESULTS OF ANALYSIS OF VARIANCE ON CONTAMINANTS TO TEST PRECISION BETWEEN SAMPLERS.

Contaminant	F-Value Treatment (1)	F-Value Replication
Annual Ryegrass	-------	-------
Rattail Fescue	50.5686**	1.0893
Wild Garlic	1.1783	1.2354
Quackgrass	1.0375	1.2354
Sheepsorrel	-------	-------

(1) The treatments were the four types of samplers used in the experiment.
** This value is significantly different at the 1% level.

TABLE IV. RESULTS OF ANALYSIS OF VARIANCE ON SAMPLERS TO TEST PRECISION IN SAMPLING FOR THE THREE CONTAMINANTS IN ALFALFA.

Sampler	F-Value Treatment (1)	F-Value Replication
Trier	------	1.639
Revolving	1.766	------
Vibrator	1.376	------
Slide	1.911	------

(1) Treatments are Canada thistle, dodder, and sweetclover.

TABLE V. RESULTS OF ANALYSIS OF VARIANCE ON CONTAMINANTS TO TEST PRECISION BETWEEN SAMPLERS.

Contaminant	F-Value Treatment (1)	F-Value Replication
Barnyard Grass	-------	-------
Running Mallow	-------	-------
Canada Thistle	-------	-------
Dodder	3.9714*	1.2500
Sweetclover	1.4222	-------

(1) The treatments were the four types of samplers.
* Significant difference between means at the 5% level.