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CLEANED, TREATED AND TESTED SEED FOR COLORADO

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and G. E. EGGINTON

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CLEANED, TREATED AND TESTED SEED FOR COLORADO

W. W. ROBBINS, H. E. VASEY and G. E. EGGINTON

I. CLEAN, PURE, VIABLE SEED—ITS NEED.

The main object of this Bulletin is to point out the great need of having all seed cleaned, treated and tested before it is planted. It urges the placing of clean, treated and tested seed in the soil.

This year there is going to be a scarcity of some kinds of seed. Therefore, it is all the more urgent that the seed we do plant be in the best condition possible when sown. We are not placing special emphasis here upon the planting of more seed so much as we are the use of seed of high quality. There being a seed scarcity, every effort should be made to raise the quality of the seed we have on hand. This can be done by extra care in cleaning and treating. By testing, we hope to find out and eliminate seeds of low quality, be in a position to advise recleaning when found necessary, and give data which will guide the planter of seed as to how much to sow per acre.

We must get the most out of the seed we have, the most out of the acreage we have, and the most out of the labor we expend. We must not have crop failures nor low yields this year through any negligence of our own—through any negligence to make the conditions of which we have control the very best. Weather is beyond our control, but we can see to it that the seed we place in the ground is of the very best quality obtainable, that the soil in which it is sown is in the very best condition for germination, and that the plants are properly cared for from youth to maturity, and harvested at the proper time, and in the correct manner.

It is disheartening to the farmer to prepare his field with the greatest care for sowing, expending much labor and valuable time of man and beast, and subjecting his machinery to wear and tear, to find that the seed sown does not germinate well, or that the crop is accompanied with a vigorous growth of weeds, which growth increases the labor expended in caring for the crop, decreases the yield, causes the farmer to suffer an unnecessary dockage at the mill, and contaminates his seed and soil for the following crop season. The acreage in such a year does not live up to its productive capacity.

Pure, Live Seed Helps to Make Big Crops.—Even the most fertile soil, the best seed bed and the most careful cultivation will be useless unless pure, live seeds are planted. It is safe to say that with the same acreage and with the same cultural methods, and with the same care in harvesting, the yields of the crops in Colorado can be increased 10% to 15% by simply giving *unusual attention to the use of pure, clean, sound and vigorous seed.* Poor seed is often the only cause of crop failure. Poor seed is largely responsible for weedy farms. Weed control will be useless unless more attention is given to the use of pure seed.

Is the seed purchased alive? Will it germinate vigorously? Is the seed purchased filled with dirt, chaff and the seeds of such noxious weeds as wild oats, dodder, bindweed, poverty weed, cheat, sow thistle, wild barley and others? These are questions which give the farmer much concern.

The grades of seed for seed purposes and the cost of the same should be largely determined by the percentage of live seeds they contain and by their percentage of purity.

Clearly, there is but one way to find out the true value of a lot of seeds, and that is to give it a thorough test and analysis. It is usually impossible to judge of the quality of seed even by careful examination of handful after handful. The outward appearance of the seed will give one little idea of the vitality of the germ inside. Moreover, there are a number of weed seeds which are often associated with and may be easily mistaken for certain field seeds. For example, the seeds of alfalfa, yellow trefoil, white and yellow sweet clover and dodder have very much the same appearance and may be very easily confused.

That good seed is one of the most important factors in crop production no one can deny. How to secure pure seed and how to make it possible to know whether the seed is reasonably pure or not is another question.

It should be unnecessary to emphasize the need of pure seed. Everyone knows, or should know, that poor seed is the worst of economy; that low-priced seed is often the poorest economy. One lot of poor seeds carrying noxious weeds has made many a farmer years of work in eradicating them. It is recognized that the heaviest tax on a farm is its weeds. We have probably seen cases where a single carload of seed infested with noxious weeds has wrought havoc in a whole community.

When seed is tested, one gains reliable knowledge of one more factor in crop production. The farmer is in search of knowledge of as many of these factors as possible. Every farmer should know how his seed tests before he places it in the soil. The amount to plant per acre depends largely upon the result of this test. In the

case of an extremely bad lot of seed, it would prevent a complete failure and the loss of labor and land.

A farmer several years ago planted twelve acres presumably to rape. His stand was a heavy, luxurious crop of wild mustard, one of our most noxious weeds. An analysis of the seed would have saved his labor and land and loss of the crop for that year.

High-priced seed is usually the cheapest seed. Someone has gone to the trouble to clean the seed, to remove from it various impurities such as dirt, stones, chaff, broken seeds and noxious weed seeds, and consequently a better price must be asked for such seed. However, we have seen low-priced seed with a quality as high as that of high-priced seed. *Testing determines the actual quality of the seed exposed for sale or intended for planting.*

Actual Planting Value of Seed.—The quantity of seed to plant per acre varies widely and is determined by a large number of different conditions. In this Bulletin emphasis will be placed upon the relation between quality of seed and the proper amount to plant per acre. This brings us to the consideration of the *actual value* of a lot of seed.

There are two chief factors in considering the quality of seed. *First, purity.* That is, its degree of freedom from sticks, stones, chaff, dirt, weed seed and other seeds. *Second, vitality.* That is, its power to germinate readily and produce vigorous sprouts. If both purity and vitality are high, the amount of seeds necessary to plant per acre in order to secure a heavy stand will be less than if either the purity or vitality, or both, are low.

The *actual planting value* of a lot of seed is secured by multiplying the percentage of purity by the percentage of germination of pure seed.

Let us illustrate with specific cases: Wheat of standard purity has a purity percentage of 99. Standard germination of wheat is 90% to 95%. Let us assume that the seed wheat is up to standard, with a germination of 93%. The actual planting value of this standard wheat will be 99 times 93, or approximately 92%. That is, on the basis of seed that contains no impurities and with every grain viable, we may expect to get 92% value from the seed. In other words, for every 100 pounds of seed sown, one would sow but 92 pounds of good seed.

Let us take a case now in which the germination is down to 90% and the purity down to 90%. This seed would not be considered hopelessly bad, but its actual planting value is only 81% as compared with 92% for seed giving a test considered standard. Let us take a case in which the yield from planting standard seed wheat is 40 bushels per acre. This year the value of an acre of $2.20 wheat would be $88.00. If we planted the seed with an 81% planting

value at the same rate per acre as we did that of the 92% value, the yield per acre would be 35.2 bushels. The value of this acre of wheat would be $77.44, a loss of $10.56 per acre. With 80 acres of wheat, this loss would amount to $844.80. But this does not represent the entire loss. By the use of seed low in purity, carrying weed seeds, weeds have been introduced into the field, which make cultivation more difficult, rob the crop plants of soil nutriment, possibly harbor insect and fungous pests, furnish a crop of seeds which infests the soil for another year and infests as well the crop seeds taken from that field.

Let us compare the planting value of high grade and low grade alfalfa seed. Alfalfa with a germination of 87% and purity of 98% may be considered standard quality. The actual planting value of this seed is (87x98) 87.2%. Let us suppose that it takes 10 pounds per acre of this seed at 22 cents per pound. The cost of the seed necessary to plant an acre will be $2.20. Seed with the same germination, but with a purity of 90% will have a planting value of (87 times 90) 78.3%. If 10 pounds of standard quality seed were used per acre, how much of the inferior quality of seed should be used in order to scatter on each square rod the same number of seeds per acre? It will require 10.9 pounds per acre which, if sold at the same price per pound as the high quality seed, would give an acre cost of $2.40. Upon the same basis, alfalfa seed with a germination of 60% and a purity of 90%, which is not unusual, will have a planting value of (60 times 90) 54% and will need to be seeded at the rate of 16 pounds per acre, which will give an acre-cost of $3.52.

These illustrations are taken to show the great necessity of using the best of seed; moreover, the great need of having seed tested before planting in order to have a guide as to how much seed to plant per acre. If the actual planting value is low, more seed will necessarily have to be planted per acre to secure a good stand than when a standard, high quality of seed is used.

Every farmer should make it a rule to test for himself, or have tested for him, all seed before it is planted. The farmer in the case above lost $844.80 on his 80 acres of wheat; most of this might have been avoided by using better quality of seed or by planting greater amounts per acre of the lower grade of wheat.

More emphasis should be placed upon the actual planting value of seed. This value is secured by multiplying the percentage of germination by the percentage of purity. It is only by making a test of the seed that we can know of its planting value.

It is far better to use some seed as feed rather than seed. If a germination test shows the seed to be of low viability, or if it is heavily infested with noxious weeds which are difficult of removal, surely such seed should be used for some other purpose than seeding.

Character of Impurities in Seed.—We should know more than the purity percentage of seed, however. Two lots of seed may both have a purity of 98%; in the one case the 2% of impurities may be largely dodder, a most pernicious and destructive weed; in the other case the 2% impurities may be made up of harmless inert matter such as broken sticks, gravel, etc. Again, a lot of seed with a purity of only 90% may be superior to one with 98%, having the same germinability, if the purity in the first case is of harmless material and that in the second is of noxious weed seeds. The purity reports as issued by the Colorado Seed Laboratory give, not only the percentage of purity, but the percentage of noxious weeds, the percentage of other seeds, the percentage of inert matter and the number per pound of each kind of noxious weed seeds. This is information that should be in the hands of every seller and purchaser of seed.

Seed True to Variety.—Care should be used to plant seed true to variety. Mixed seed results in a crop that is not uniform. The stand is uneven. The plants of the different varieties mature at different times. Consequently, there may be considerable loss from shattering or from immaturity.

If seed of a given kind (wheat, for example) from a number of growers is dumped into a bin elevator, it is sometimes the case that such a lot represents a mixture of varieties. There are many farmers in Colorado who are buying such mixtures of seed wheat. And, the rather prevalent practice of mixing strains of cereals is resulting in a positive loss to the State.

Extravagant Claims of Seed Promoters.—We need to be cautious of extravagant claims of seed promoters. From time to time varieties of wheat have been introduced on the market which are said to give yields of enormous crops, much above the ordinary. For other varieties it is claimed that but small amounts of seed need be planted per acre, and this claim is made to justify the exorbitant price for such seed. As a general proposition, it is advisable to use home grown seed that has been tried and found to give satisfactory yields when its purity and viability are high and when proper cultural methods are used, and the seed is acclimated.

Cleaning Seed.—The fanning mill should be made greater use of by farmers. There are a number of excellent kinds of fanning mills on the market, some of which are of such a price as to be within reach of individual growers. Many farmers are equipped with such mills. Occasionally, several farmers of a neighborhood join in the purchase of a fanning mill. With the small cereals the fanning mill will remove chaff, wild oats, light and shriveled seed, smut "balls" and many weed seeds, and thus secure a much larger percentage of plump, vigorous seeds.

It has been demonstrated that running seed grain once through the fanning mill will often result in an increase of from 2 to 5 bushels per acre.

The cleaning of seed can be done during the winter days when there is a let-up in farm work, and before the rush of spring work begins.

The Germination of the Seed.—The seed contains the germ or young plant, often surrounded by stored food material. This stored material will be used to nourish the young plant until it secures a foothold in the ground and is able to absorb water and has sent out leaves which enable it to make its own food.

Certain conditions are necessary for the germination of all seeds. These are as follows: (1) Water, (2) moderately high temperature, and (3) air (oxygen). If any one of these is lacking, the seeds will not germinate.

Hard Seeds.—Most grains have seed coats which permit the ready intake of water. It very often happens that the seeds of alfalfa, sweet clover and other legumes have seed coats which are almost impermeable to water. Such seeds are called "hard seeds." They will not grow readily when placed under perfect conditions for germination. Hard seeds are not necessarily poor seeds. Some of them will germinate in several weeks; some will remain in the ground for an indefinite period without germinating. It has been determined experimentally that on the average about one-third of the hard seeds will germinate in a reasonable time. Unhulled sweet clover seed may often have as much as 85% hard seed. Hulled sweet clover has a lower percentage of hard seed than the unhulled. Alfalfa seed will often have 20% to 25% hard seed.

It is claimed that a larger percentage of hard seeds is produced in dry climates or when ripening takes place under dry seasonal conditions than in moist climates or moist seasons.

The permeability of leguminous seeds can be increased by "scarifying"; that is, passing them through a machine that scratches the surface. The ordinary alfalfa huller is effective for this purpose, as is shown by the experiments of Harrington, who found that alfalfa grown under a variety of soil and climatic conditions had about 90% of hard seeds if hulled by hand, and only about 20% if hulled by machine.

Scarifying machines are on the market. One machine, known as the Ames Hulling and Scarifying Machine, which may be operated with a one-horse power motor, or a two-horse power gasoline engine, has a capacity of from 18 to 25 bushels of alfalfa or sweet clover seed an hour. Scarifying, or abrasion of the seed surface, is accomplished by blowing the seed over garnet paper. The Ohio Agricultural Experiment Station gives the following results from using this machine, with sweet clover seed:

Seed not scarified	30% germination
Seed scarified	87.6% germination

It is unwise to plant leguminous seeds with a high percentage of hard seed.

Temperature and Germination.—The temperature which is the most favorable to germination is not the same for the different kinds of seeds. Moreover, the highest temperature and the lowest temperature at which seeds germinate vary. For example, it is quite well known that cucumbers and melons require a higher temperature to germinate properly than wheat and barley and some other small cereals.

Cool season crops, such as peas, lettuce, radish, small cereals, etc., will germinate readily at 50° to 60° F., while corn, pumpkin, cucumber, egg plant, and other warm season crops require a temperature of 70° to 80° F., to give fairly rapid germination.

Oxygen and Germination.—All seeds require air (oxygen) in order to germinate. Seeds will not germinate when the soil is deprived of air. If seeds are planted too deep in heavy clay soil, or in a soil that is too wet, they are quite likely to have a poor supply of air and to germinate slowly.

Light and Germination.—A number of seeds germinate better in the light than in the darkness. The best known example of such a seed is Kentucky bluegrass.

Conditions Affecting the Vitality of Seed.—It is a common observation that when a lot of seeds is placed under the most favorable conditions for germination a number of them fail to germinate. Some seeds are quick to germinate and form strong, vigorous seedlings. Others sprout but slowly and the young plants are weak and sickly. The farmer wants seeds which have a power to germinate readily and produce vigirous sprouts. In other words, he wants seeds of high vitality.

There are many conditions which affect the vitality of seeds:

1. *Maturity.* Although seeds will often germinate when they are not fully ripe, the plants from such are usually weak and cannot withstand unfavorable conditions. Moreover, the yield from immature seeds is always lower than from properly matured seeds. Lack of maturity or low vitality in corn is usually indicated by soft ears, by any discoloration of the grain, especially at the tips, and by blisters on the skin. Immature corn quickly loses its germinating power.

2. *Age.* All seeds gradually lose their viability with the lapse of time. The rate at which they lose their viability depends upon the kind of seeds and upon the condition of storage. As a rule, seeds retain their viability longest under low and equable temperature and moisture conditions. Ordinary crop seeds lose their vitality rather quickly when stored under high temperatures and where the atmosphere is moist.

Seeds containing oil, such as corn and flax, lose their vitality much earlier than starch-bearing seeds. The seeds of legumes are noted for their great longevity. Some have been known to retain their viability for 150 to 250 years.

The seeds of many plants have a rest period. That is, they will germinate better after a period of rest than they will when first mature. This dormancy is more common among wild plants than among domesticated ones. For example, wild oat experiences a delay in its germination, seldom germinating the same year that it is formed; on the other hand, the seeds of cultivated oats will germinate the same year in which they are formed. The seeds of a number of weeds will lie in the ground for years in a dormant state. It has been shown that some seeds are still viable after thirty years burial in the soil. Among such are the seeds of pigweed, black mustard, shepherd's purse, common dock, green foxtail and evening primrose.

There is an old saying that one year of seeds means seven years of weeds. A crop of seeds is borne; some of them may germinate immediately if the conditions are favorable; others may remain dormant for a year or two, and still others may remain dormant for five or six or seven years. In cultivation the seeds may be buried to such a depth that they do not get enough oxygen to germinate. Consequently, they lie dormant in the soil. Later, perchance, they may be turned to the surface in plowing and brought under conditions favorable to their germination.

3. *Freezing.* Corn often suffers from freezing before the grain is thoroughly dry. The tissue of the grain is broken down by the freezing of the water in it. If the grain becomes thoroughly dried, it will withstand very low temperatures. Corn containing 13% moisture may be stored with safety in bins exposed to very low temperature.

Corn raised along its upper altitudinal limits in Colorado may quite frequently suffer from an early frost; and although the grain may have the appearance of being healthy in every respect, many of the germs may be killed or their vitality considerably reduced as a result of the freeze, although slight. Consequently, it is very essential that Colorado-grown corn be given a careful test for germination before planting. Where frost was known to have injured part of a crop, or there is any doubt about the viability of the seed, it is the safest plan to have germination tests made. If the test is low, and better seed is not obtainable, the deficiency can be made up by increasing the rate of planting. All seed corn, no matter what its source, should be carefully tested this year for germination.

Corn grown in Colorado in 1917, that has been tested to date at the Colorado Seed Laboratory, shows extremely wide variations in the percentage of germination, from almost zero to 95%.

4. *The low vitality of seed may be due to the unfavorable conditions which prevail at the time the seeds are maturing. Most seeds mature best under dry atmospheric conditions.*

5. *The vitality of seeds depends largely upon the manner of curing.*

6. *Storage conditions affect in a very marked degree the vitality of seeds.*

The following table gives the length of time seeds may be expected to retain their vitality under average storage conditions:

TABLE I.—AGE AND VITALITY OF SEED

Seed	Years
Alfalfa	6–8
Alsike clover	2
Asparagus	5
Beans	3
Beets	6
Brome grass	5
Cabbage	5
Carrots	4
Cauliflower	5
Celery	8
Corn, field	2
Corn, sweet	2
Cress	5
Crimson clover	1–2
Cucumbers	10
Egg plant	6
Endive	10
Kale	5
Kentucky bluegrass	1–2
Kohlrabi	5
Leeks	3
Lettuce	5
Millet	6
Muskmelon	5
Mustard	4
Okra	5
Onions	2–5
Orchard grass	2-3
Parsley	3
Parsnip	2
Peas	3
Pumpkin	5
Pepper	4
Radish	5
Red clover	6–8
Red top	6
Rhubarb	3
Salsify	2
Spinach	5
Squash	5
Timothy	6
Tomato	4
Turnip	5
Vetches	3
Watermelon	5
Wheat, oats, barley, rye, and other small grains	1-2
White clover	2

Under the dry climatic conditions of Colorado and other western states, many seeds may retain their vitality much longer than given in the above table.

From the above discussion it will be seen that there are many factors which affect the vitality of seed. In the first place, the vigor and longevity of seeds are specific, varietal characters, determined by heredity; and in the second place, the vigor and longevity of seeds are influenced markedly by the environmental conditions prevailing during the growth of the plant, particularly during the period of maturing, and to conditions which obtain while they are in storage.

These facts simply emphasize the urgent necessity of testing seeds before placing them in the soil.

Standards of Purity and Germination.—The following table shows the standards of purity and germination of a number of common garden and field seeds; it is taken from the Yearbook of the U. S. Department of Agriculture, 1896. These standards have no legal status; the Colorado Pure Seed Law sets no standard. The table is included to give one some idea of what is considered good seed, so that he may have a basis of comparison by which to judge of the quality of any lot of seed:

TABLE II.—STANDARDS OF PURITY AND GERMINATION

Seed	Purity %	Germination %
Alfalfa	98	85–90
Asparagus	99	80–85
Barley	99	90–95
Beans	99	90–95
Beet	99	150 sprouts from 100 balls
Bluegrass, Canada	90	45–50
Bluegrass, Kentucky	90	45–50
Brome grass	90	75–80
Buckwheat	99	90–95
Cabbage	99	90–95
Carrot	95	80–85
Cauliflower	99	80–85
Celery	98	60–65
Clover, alsike	95	75–80
Clover, crimson	98	85–90
Clover, red	98	85–90
Clover, white	95	75–80
Collard	99	90–95
Corn, field	99	90–95
Corn, sweet	99	85–90
Cotton	99	85–90
Cowpea	99	85–90
Cress	99	85–90
Cucumber	99	85–90
Egg plant	99	75–80
Fescue, meadow	95	85–90
Lettuce	99	85–90
Kafir corn	98	85–90
Melon, musk	99	85–90
Melon, water	99	85–90
Millet, common	99	85–90
Millet, hog (*Setaria italica*)	99	85–90
Millet, pearl (*Panicum miliaceum*)	99	85–90
Mustard	99	90–95
Oats	99	90–95
Okra	99	80–85
Onion	99	80–85
Parsley	99	70–75
Parsnip	95	70–75
Peas	99	93–98
Pumpkin	99	85–90
Radish	99	90–95
Rape	99	90–95
Rye	99	90–95
Salsify	98	75–80
Sorghum	98	85–90
Spinach	99	80–85
Spurry	99	85–90
Squash	99	85–90
Timothy	98	85–90
Tomato	98	85–90
Turnip	99	90–95
Tobacco	98	75–80
Wheat	99	90–95

II. HOME METHODS OF SEED TESTING.

The Purity Test.—Purity tests are beneficial and advisable from the standpoint of better yields made possible by definite knowledge of the quality and constituents of the lot of seed to be sown. Casual inspection of a lot of seed will reveal very few of the weed seeds present, especially when the lot under examination has been milled and the chaff, sticks, and smaller weed seeds removed. A carefully conducted purity test will, because of its thoroughness, result in the detection of all adulterants as well as unmilled weed seeds and inert matter. Take, for example, alfalfa containing a small amount of large-seeded alfalfa dodder. Not one buyer in ten will detect this undesirable seed because of its close resemblance in size and color to the alfalfa seed.

Each farmer before planting should know just what his lot of seed contains of weed seeds and inert matter such as broken seed, chaff and dirt.

When seed is home-grown there is no particular hurry about having a purity test made, and there is ample time to have tests of such seeds made at the Colorado Seed Laboratory, which is specially equipped to make very accurate analyses. When it is necessary to purchase seed from a seed company it may be advisable to make a purity test at home, for a home test means immediate returns and the farmer is able to take advantage of a choice lot of seed when it appears on the market, whereas a delay of several days in securing results from the state laboratory would mean loss of opportunity in securing the best seed before the stock has been entirely exhausted. The prospective buyer should ask for a representative sample of the seed offered for sale and satisfy himself as to the quality before purchasing. The large and reputable seed companies conduct a "buy on sample" business, and a purity test is therefore entirely possible.

FIG. 1.—Seed trier which may be used in taking samples of the smaller seeds from sacks without opening the sacks.

Samples from home-threshed seed should be taken in such a way as to secure a representative sample. The ordinary metal seed sampler (Fig. 1) is very commonly used for sampling small seeds such as alfalfa, red clover and timothy in bags. The use of this sampler does away with opening each bag. When only one bag is to be sampled, small amounts should be taken from the top, middle and bottom of the sack. If more than five bags, samples should be taken from every fifth bag. The composite sample of one lot in any case should be thoroughly mixed in a receptacle so that there may be even distribution of weeds and dirt throughout the sample. The sample so mixed is known

as the test or trial sample. Of course, samples may be taken by hand from open bags, bins, etc.

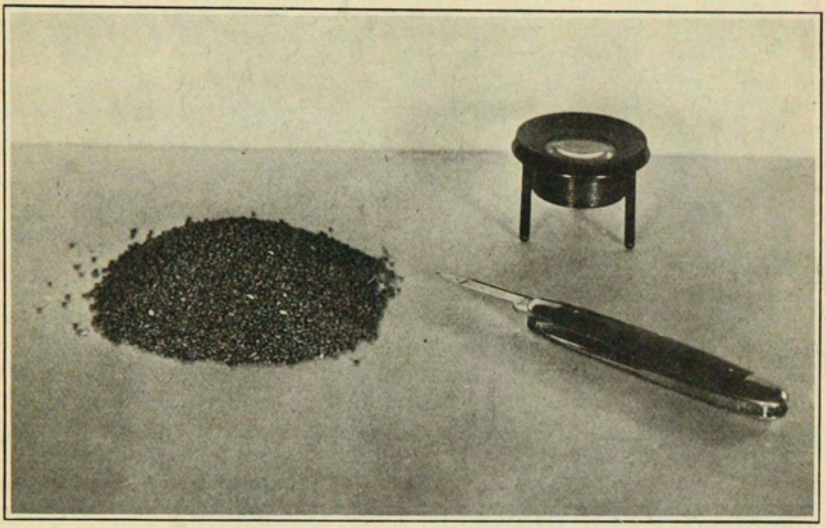

FIG. 2.—The seed to be tested as to purity is spread out on a sheet of paper. A knife and simple tripod lens are all the apparatus necessary to separate the seed into pure seed, weed seed and other crop seeds, and inert matter.

The first step in making a purity test is to spread the trial sample on a flat white surface, preferably cardboard over wood (Fig. 2). The necessary apparatus consists of tripod lens* and a knife or forceps for separating weeds, broken seed and inert matter from the seed. If the trial sample is too large, it may be divided and re-divided (Fig. 3) until the desired amount is obtained.

TABLE III.—THE APPROXIMATE AMOUNTS OF SEEDS TO TAKE FOR PURITY TESTS

Alfalfa, red clover, sweet clover	1-6 oz. (5 grams)
Timothy, alsike clover, white clover	1-16 oz. (2 grams)
Wheat, oats, barley, rye, buckwheat	1 oz. (28 grams)
Brome grass	1-10 oz. (3 grams)
Bluegrass, red top, Bermuda grass	1-28 oz. (1 gram)

Accurate scales or balances are seldom accessible to the farmer and for the majority it will be necessary to roughly estimate the percentage of foreign material. (In U. S. D. A. Farmer's Bulletin No. 428, T. H. Hillman has described a simple weighing device which should give fairly accurate results.)

In making a home purity test some knowledge of weed seeds is necessary. For the purpose of determining the unknown weed seeds,

*Tripod, lens and forceps are obtainable at any drug store.

the Colorado Seed Laboratory has prepared a collection of the most common weed seeds* (Fig. 4). By means of this collection the farmer can easily distinguish seeds of the common weeds.

After the separation or purity test is complete the resulting divisions will consist of pure seed in one pile, dirt, chaff and broken seed or other inert matter in the second pile, and weed seeds or other seeds in the third. The percentage of purity can be accurately determined when scales are available or roughly estimated if there are no scales to be had. Unknown seeds which do not occur in the authentic collection may be sent to the Colorado Seed Laboratory for identification.

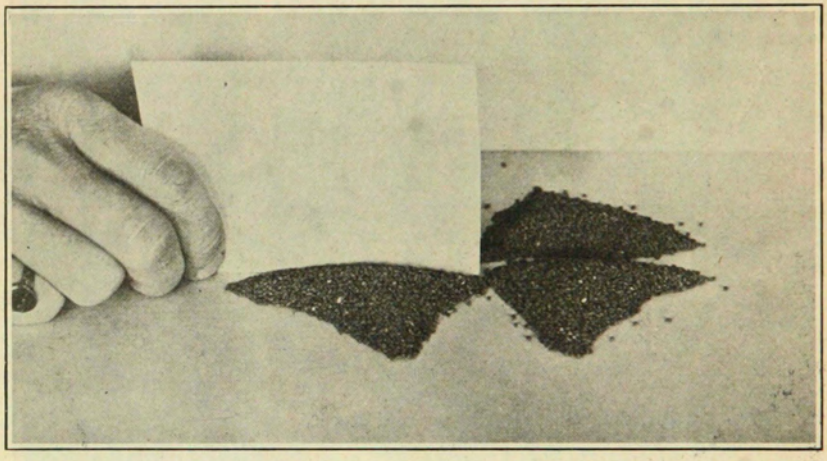

FIG. 3.—Showing method of dividing original purity sample in order to obtain the proper amount for purity analysis. This method of dividing eliminates any tendency of the individual to select either good or bad seed for analysis.

Much has been written regarding home purity tests, but there is still much doubt as to the accuracy of such tests even when good scales are obtainable. There is oftentimes marked variation in purity tests made by experts using highly specialized apparatus, so it is obvious that a *rough* estimate or the use of even an ordinary scale would mean wide variation—far greater than the usual 2% allowed in the seed laws of the several states. Emphasis should be placed upon the ability of the Seed Laboratory to give the farmer that which he cannot afford to obtain for himself—the knowledge of highly trained experts and the use of specialized apparatus, which make for accuracy.

Germination Tests.—Germination tests can be made by anyone, if the correct method is followed and care is exercised. For germination, all seeds require heat, air and moisture.

It has been found after many years of experiment that different crop seeds require different seed bed conditions for the most accurate

*Each collection case contains 24 different weed seeds and may be purchased from the Seed Laboratory at the cost of preparing—75c.

results in germination. The seed beds most commonly used are blotters, strips of Canton flannel, sand, soil and sawdust. The last three named are used in either flats or pots. The kind of seed bed to use depends upon the size of seed and variety. The large seeds require more moisture than the smaller seeds, and blotting paper would not supply a sufficient amount, whereas Canton flannel would hold too

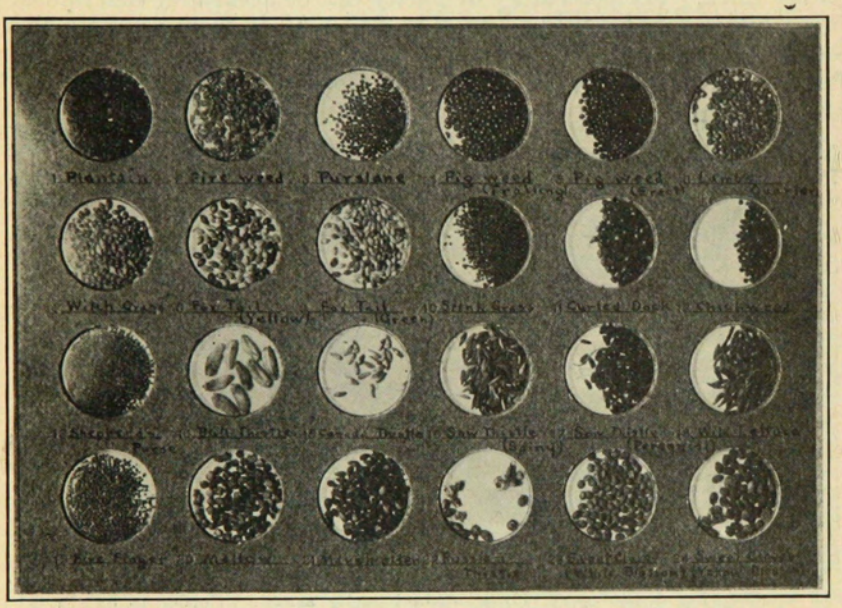

FIG. 4.—Weed seed set: This collection of 24 different common weed seeds may be purchased from The Colorado Seed Laboratory at cost price of 75 cents.

great a supply for the smaller seeds. In making germination tests care should be taken to keep the blotters and cloths moist, but not *saturated* or *dripping*.

The following table will serve as a guide in reference to seed beds, temperature, and duration of test:

TABLE IV.—SEED BED, TEMPERATURE AND DURATION OF TESTS.—(See Note)

Kind of Seed	Seed Bed	Temperature Fahrenheit	Day for Making Germination Report	
			Preliminary	Final
Field Crops:				
Barley	B	68	3	5
Beans	C	68–75	3	6
Beets b–c	B	68–75	5	10
Buckwheat	B	68–75	3	5
Corn*	C	68–75	3	5
Flax	TB	68–75	2	5
Hemp	B	68–75	3	5
Oats	B	68	3	5
Peas*	C	68–75	4	8
Rye	B	68	3	5
Turnips	B	68	3	5
Wheat	B	68	3	5
Grasses, Clovers Forage Plants:				
Alfalfa	B	68	3	5
Bermuda grass	BJ	68–75	10	21
Blue grass	BJ	68–75	14	28
Brome grass	B	68–75	5	10
Clover, alsike	BT	68	3	5
Clover, crimson	B	68	2	4
Clover, mammoth red	B	68	3	5
Clover, common red	B	68	3	5
Clover, white	TB	68	3	5
Cow peas*	C	68–75	4	10
Johnson grass	B	68–75	6	10
Meadow fescue	B	68–75	5	10
Millet	B	68–75	3	5
Orchard grass	B	68–75	6	14
Rape	B	68	3	5
Red top	TB	68–75	5	10
Sorghum	B	68–75	3	5
Sudan grass	B	68–75	3	5
Timothy	TB	68–75	5	8
Turnips	B	68	3	5
Vetch	C	68–75	4	14
Vegetables:				
Asparagus	C	68–75	6	14
Beans*	C	68–75	3	6
Beets b–c	B	68–75	4	10
Cabbages	B	68	3	5
Cauliflower	B	68	3	5
Carrots	B	68–75	6	14
Celery	TB	68–75	10	21
Cucumbers x	B	68–75	3	5
Egg plant	B	68–75	8	14
Lettuce b	B	68	2	4
Muskmelons x	B	68–75	3	5
Onions	B	68–75	4	7
Parsley	B	68–75	14	28
Parsnips	B	68–75	6	21
Peas	C	68–75	3	6

Kind of Seed	Seed Bed	Temperature Fahrenheit	Day for Making Germination Report	
			Preliminary	Final
Peppers	B	68–75	4	10
Pumpkins x	C	68–75	3	6
Radishes	B	68	3	5
Salsify	C	68–75	5	10
Spinach	B	68	5	10
Squashes x	C	68–75	3	6
Sweet corn	C	68–75	3	5
Tomatoes	B	68–75	4	10
Turnips	B	68	3	5
Watermelon x	B	68–75	4	6

NOTE:

B—Between blotting paper.

TB—On top of blotting paper.

BJ—Bell jar (these seeds may also be germinated in daylight germinator).

C—Between folds of cloth.

b—Soak six hours in water at room temperature before testing for garmination.

c—It is recommended that the germinaton of beet seed be confined to determining the percentage of balls which give sprouts.

*—Germinate in soil when possible.

x—Germinate in sand when possible.

To make the germination test, first prepare the seed bed. If blotters are to be used, select blue or white blotting paper in strips about 6 inches by 12 inches and fold lengthwise once. When Canton flannel is used, for large seeds, the strips should be about 8 inches by 32 inches and folded lengthwise twice.

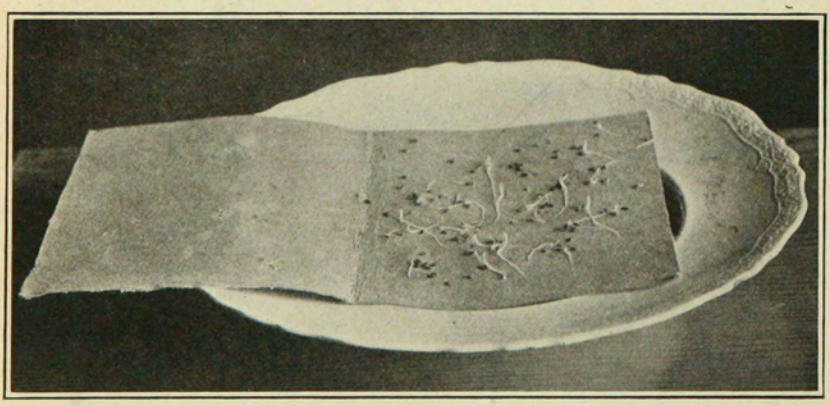

FIG. 5.—Use of dinner plate in making germination test. The blotter is dipped into water, laid on the plate, the seeds spread evenly over surface of blotter, and another dinner plate inverted over them, thus making a moist chamber.

Next, immerse the blotters or cloths in water and after draining, place on an ordinary dinner plate (Figs. 5 and 6). It is advisable to run two tests of each lot. Count two lots of 100 seeds each, taking the

seeds as they come without discrimination and including shriveled as well as plump seeds. Selection of plump seeds only would fail to give a representative test. Scatter 100 seeds on each blotter or cloth

FIG. 6.—Germinating corn between the folds of Canton flannel. Use two dinner plates, one inverted over the other.

so that no two seeds touch each other. If the seeds are to be germinated between blotters or cloths, the end of the strip should be folded over the seeds before the top plate is adjusted. Then cover with a plate of glass or another dinner plate, thus making a moist chamber.

Do not place the plates on a window sill or over the stove. Keep the tests in that part of the house where the temperature is most uniform. The seed bed should be kept moist during the test. Count the sprouts according to the length of time designated in Table IV.

Attention is called to seeds of legumes (alfalfa, red clover, alsike clover, etc.) which remain hard at the end of the given period for test. These are known as hard seeds, which usually grow quickly when the seed coats are scratched or broken. One-third of the number of hard seeds may be considered as sprouts and added to the percentage of germination.

A few varieties of garden seed germinate best in sand. (Table IV.) These seeds can be sown in pots or small wooden flats (Fig. 7) with a light covering of sand. The pots or flats should be shaded, as direct sunlight causes rapid evaporation. The sand should be moistened lightly every day.

Corn should be germinated in soil when possible (Fig. 7). Germination tests may be made in flats or pots, whichever is convenient. Sprouts in soil can be counted as they appear. It is advisable to allow three or four days additional when tests are made in soil, because it requires more time for the sprout to break through the soil than to make the same growth between folds of Canton flannel.

Canton flannel over sawdust is the most popular method of making individual ear tests of corn. The ordinary soil flat (Fig. 7) is filled with well moistened sawdust to about three-fourths its depth.

After marking off the Canton flannel in 2-inch squares with ink or indelible pencil it should be well moistened and placed over the wet sawdust. The squares may be numbered to correspond with the numbers on the ears being tested. Kernels from different parts of the ear, usually six to ten in number, are placed in each square, and the whole is then covered with a second layer of Canton flannel. The final count in this case will come after six days.

In making a germination test there are, in brief, several items of importance: (1) Count out the seeds accurately; (2) keep blotters

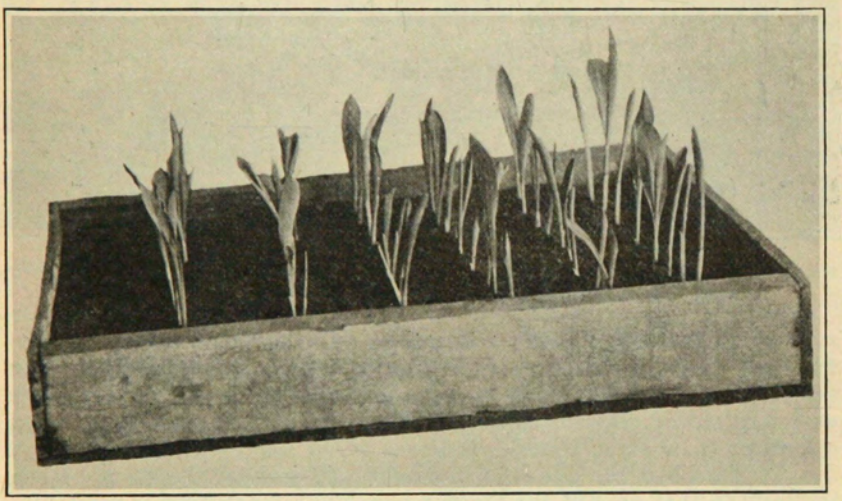

FIG. 7.—The soil flat, especially recommended for testing germination of corn, beans, peas, and other large seeds.

and cloths moist, but not *saturated;* (3) keep at a uniform temperature, and (4) count the sprouts at periods stated in the table.

The ease with which germination tests can be made, from the standpoint of apparatus and labor, means that home germination tests will rapidly become popular among farmers. To them it represents a guarantee not only of their own seed but all seed that is being offered on the market, and the consequent lessening of risk of great losses.

III. METHODS OF SEED TREATMENT FOR THE PREVENTION OF DISEASES IN CERTAIN FARM CROPS.

One of the chief reasons why so little attention is given to the sowing of healthy seed is that the damage resulting from various plant diseases is invariably underestimated by the crop grower. In a goodly number of instances the purity and germinative power of seed have been carefully determined, but the failure to go one step farther and make sure that it is wholly free from disease has brought quite un-

necessary losses in the crop and caused no end of worry to the farmer himself. We should not forget to add to the slogan "Pure seed, and viable seed," the third important essential, "clean seed," because it is only through healthy seed that we may ever expect to harvest healthy crops and to insure maximum profits. Passing notice might well be given to the value of seed disinfection as it affects only such diseases as the smuts. Below is a table showing in dollars and cents the possibilities in confronting smut in wheat, barley and oats alone:

TABLE V.—LOSS FROM WHEAT, BARLEY AND OATS SMUT IN COLORADO

Kind of Grain	Year	Total yield based on average	Average % of smut in crop	Average losses bushels	Average loss for 1 year, dollars
Wheat	1909	7,224,057	6	433,443.42	910,230.30
Barley	1909	1,889,342	5	94,446.10	113,363.00
Oats	1909	7,642,855	5	382,142.75	247,142.00
				Total,	$1,270,735.00

Seeds As Carriers of Disease.—Some of the diseases most dreaded in farm crops are among those carried over on agricultural seeds. Together with the handling of clean seed comes the problem of clean soil. The latter is greatly influenced by the quality of seed sown. It has been shown that, at least for some sections of the United States, the use of bad seed and infested soil associated with constant cropping brings about soil-sickness for such crops as wheat, rye and barley, and perhaps many others. There is no doubt that poor yields in many cases are entirely the result of noxious diseases introduced to the soil and crop by means of infested seed. Bolley of the North Dakota Experiment Station, contends that many disease organisms attack the roots, leaves and stems of wheat and cause material damage to the crop. He believes they are the chief cause of failure of wheat to properly stool. Parasitic diseases introduced into a soil are apt to persist year after year and do considerable damage, the amount of which depends upon the kinds of soil and atmospheric conditions. In contact with the seed, these diseases are readily distributed from crop to crop and from season to season. In fact, they may be so well protected within the shallow parts of the seed or within the seed coats themselves as to effect distribution over long distances as from Europe to America, or *vice versa*. Disease germs thus concealed upon the seed may escape the most careful observer, so that the proof of bad seed appears first in the crop. Poor yields should arouse suspicion regarding the health of the seed; missing plants, shriveled grain, unusual yellowing of leaves, and dwarfing, all may easily be the result of fungi which gained foothold by the route of uncleaned seed.

Clean seed, however, cannot insure a normal healthy crop when put into infected soils. We should not forget the soil problem in looking after that of the seed, and it is essential, therefore, that the condition of the soil in regard to the presence of disease should have consideration in determining the scheme of crop rotation.

On the other hand, while one is using every effort to keep the

soil clean by crop rotation, he should be just as *careful that diseased seed does not undo all his work of preparing the soil.*

Advisability of Disinfecting Diseased Seed.—There is hardly a group of plant diseases known which can be more readily and completely controlled than those carried on the outside of seeds. Considering the cost of treatment, which seldom exceeds two cents per bushel, the farmer can ill-afford to use anything but clean seed. Whenever any noticeable number of diseased plants is seen in a field, there always occurs a material loss of the crop, hence prompt means of eradication should always be taken, depending upon the disease present. Not all diseases can be controlled by treatment of the seed as, for instance, wheat rust, mildews or blights, or even corn smut, but on the other hand, such diseases as the cereal smuts, certain anthracnoses and various vegetable diseases are best controlled by seed disinfection.

It is not always an easy matter to determine whether or not fungi are attached to seeds wanted for seeding purposes, but it is very unwise to use seed known to have come from diseased fields, even in small amounts.

Seed treatment is very simple and can be performed with a very small outlay of materials and a minimum of trouble. The principle of seed treatment is to kill fungous spores lodged on the surface of the seed by the application of a disinfectant solution. The solution must be strong enough to destroy the spores, but effect no injury to the grain. For this purpose formalin and corrosive sublimate are most in use. Formalin is a solution of formaldehyde gas in water. When purchased for seed treatment, it should possess 40% concentration. All druggists have this strength in stock (and it is sold at 50 to 70 cents per pound). Corrosive sublimate is a severe poison and when employed for seed disinfection, the seed should not be fed to livestock. It is diluted in the proportion of 1 part to 1,000 parts of water. Corrosive sublimate is sold in the form of a powder and readily dissolves in lukewarm water.

Diseases for Which Seed Treatment Should Be Used.

Bean.

Bean Anthracnose. This disease affects all above ground parts of the plant. The greatest injury occurs on the pods usually, where the appearance of the disease is marked. It is manifested by spots that are round to oval in shape, discolored, dark and sometimes pinkish and surrounded by a reddish zone or margin. On the leaves the spots are similar in appearance to those on the pods; they occur on the large veins, generally on the under surface. In advance stages, the leaves may be eaten through by the fungus. Frequently the seeds themselves show marked discoloration as a result of serious attacks on the pods, and as a general rule the seeds carry the disease over the winter to next season's crop.

Control:

1. Wherever possible, destroy all diseased vines by burning.

2. Do not plant beans on land a second year after it has produced the disease; wait about three years.

3. Avoid cultivation of diseased plants while rain or dew is on them.

4. Seed selection is the best and safest means of control. Hand-picked seed pods should be used; the picking should always be done when seed is to be taken from diseased fields.

5. In cases of seriously affected seed, if such must be used, it is important to sterilize the seed, although sterilization may not render it absolutely healthy, due to the presence of the disease-producing organism within the seed. Disinfect the seed by soaking 18 minutes in a solution of 1 part of water to 1,000 parts of corrosive sublimate. It is advisable to plant the seed soon after drying.

Bacterial Blight. This occurs as spots upon the pod, leaf, stem and seed of field, garden and lima beans. The leaves are usually the first to be attacked. The spots are irregular in outline and water-soaked when young. Later these spots dry up and become papery and brittle. Sometimes whole leaves are affected and sometimes all leaves on a plant are killed. Spots on the pods later become reddish in color, although not sunken. As a rule, they may be separated from anthracnose spots by the absence of black color and definite smooth margins which are frequently rose red in color. The disease is carried over on infected seed. It is spread in the field by insects.

Control: The measures of control recommended for anthracnose apply equally well to blight.

Cabbage.

Black Rot of Cabbage. This is a bacterial disease characterized by the occurrence of black streaks on the woody portions of the stem and leaf stalks. Diseased leaves pulled from the stem show blackened spots in the leaf stalk. Badly diseased plants are dwarfed, often one-sided, and are devoid of the lower leaves at maturity. Sometimes the entire head fails to develop, or the plant dies in mid-season. The disease germ may enter at the leaf margins, through the roots or at the base of he leaf close to the stem. A very disagreeable odor nearly always accompanies the disease.

Control:

1. Soak the seeds before planting for 15 minutes in either: (1) corrosive sublimate solution of 1 ounce to 1,000 ounces of water, or (2) in formalin solution of 1 part formalin to 240 parts of water.

2. Change the crop for two or three years, although do not plant vegetables related to cabbage.

3. Burn refuse from diseased plants.

4. Do not allow animals to roam over infested fields, for they carry the organisms to non-infested fields.

Celery.

Blight. There are two distinct blights of celery, the early blight and the late blight. Remedial measures for the two are similar.

Early Blight. This blight makes its appearance in the early stages of the plant's growth. The outer leaves are attacked first, the disease is manifested by grayish-green spots, almost circular in outline and with slightly raised borders. Later the spots may coalesce and exhibit an ashen gray color. Finally the entire leaf withers and dies. Spores produced from these spots are readily blown to other plants and set up the disease anew.

Late Blight. In general, this blight resembles the early blight of celery. It may follow early blight in the same field. As compared with the early blight, the spots are less regular in outline and with yellow interiors instead of ashen gray. As in the early blight, the disease begins on the older, outer leaves, passes to the inner leaves, until no salable part is free from the injury. Severe attacks mean worthless celery, since the bunches will not keep in the market or storage. Even slight attacks on the leaves are undesirable and the price is usually cut by market buyers. The disease organism lives over winter on trash of diseased plants. The seeds from diseased fields practically always carry the fungus. Wet weather makes the late blight severe by facilitating spore dissemination.

Control:

1. Disinfect the seed before planting, by first soaking it for ½ hour in warm water, but not in hot water. Then soak for ½ hour in a solution of corrosive sublimate, 1 part to 1,000 parts of water. This solution can usually be purchased from druggists already prepared. Corrosive sublimate is very poisonous.

2. Seed that is two or three years old, if of good germinative power, may best be used for seeding purposes, since the disease organisms on the seed are usually dead after that length of time.

3. Do not set plants from the seed bed that are the least spotted. Burn diseased plants and rubbish from the field in the fall.

CEREALS.

Wheat.

Stinking Smut. This is the most common and most destructive smut of wheat. It is exclusively a disease of the grain. At harvest the contents of the grain are completely replaced by black powdery masses of spores having a disagreeable odor. The affected grains are enclosed by the chaff and appear darker than healthy kernels. On

threshing, the smutted berries are broken open and the powdery spores scattered. They lodge on healthy grains where they remain. The spores are sown with the grain and the young wheat plant becomes infected in a very early stage. The smut does much damage, not only in reducing the yield, but badly smutted wheat loses grade on the market and is docked because it cannot be used for milling purposes. Stinking smut affects both fall and spring wheats, but fortunately cannot affect any other cereal.

Control: The smut can best be exterminated by disinfecting the seed, the principle being to kill the spores adhering to the grain without injuring the seed itself. If the seed is badly smutted, it is advisable to run it first through a fanning mill and then treat it.

Solution required: One pound of formalin of guaranteed 40% strength. Mix this with 40 to 45 gallons of water.

Application to grain: Two methods may be used—*steeping method* or *sprinkling method.*

Steeping Method:

1. Secure a wooden barrel or tank of convenient size and put in enough of the above-mentioned solution to allow the immersion of a sack of grain.

2. The solution must completely cover the sack of grain.

3. Lift the sack several times up and down in the solution until the bubbles of air stop coming to the surface.

4. Allow the grain to remain in the solution for exactly 10 minutes, but not for a longer or shorter period.

5. Remove the sack and allow to drain back into the barrel.

6. Set away in wet sacks for 2 hours, or empty in a heap and cover with canvas or wet sacks.

7. At the end of two hours, dry the seed by spreading it out on a clean floor.

8. The solution should be replenished as often as needed. The dipping may be facilitated by using block and tackle to hoist the sacks.

Sprinkle Method: (Fig. 8)

1. Use a clean floor or wagon bed or canvas in the open. A few bushels of grain should be spread a few inches deep upon the floor and sprinkled with the above mentioned formalin solution.

2. Sprinkle the solution over the grain with ordinary garden sprinkling can. Use about one gallon of solution to each bushel of grain. By all means use enough to thoroughly wet the kernels.

3. Then the grain should be well shoveled. A thorough mixing while the solution is being applied will insure contact of the solution with the grain which is necessary to make the treatment

entirely successful. One person can handle the mixer while another thoroughly mixes the grain.

4. Shovel treated grain into pile and cover with canvas or gunny sack that has previously been dipped into formalin solution. Leave covered about six hours, but not more than twelve hours.

5. Spread grain out not more than 2 inches deep and allow to dry.

6. The grain should be put into clean sacks or stored in a clean bin so as to prevent spores from coming in contact with it. In no case should it be returned to the bin from which it was taken unless the bin has been cleaned with formalin solution. Sweeping in the granary before the treated grain has been removed should never be done, since large quantities of smut spores which settle on the floor and walls may find their way back again to the grain.

FIG. 8.—The sprinkle method of treating grain for smut: One man sprinkles the grain with the formalin solution, while the other thoroughly mixes the grain and solution by shovelling over and over.

By the use of this sprinkle method, two men can treat large quantities of seed in a short time, and it is preferred for treatment of any considerable amount of grain. Either method is entirely satisfactory and efficient.

Recommendations:

1. All utensils, such as sacks, seeders, etc., if likely to be contaminated, should be cleaned with formalin before being used.

2. Grain must not be left covered for more than 12 hours, while 6 hours is desirable; the grain must be dried thoroughly if it is to be stored any length of time.

3. The formalin solution does not lose strength with age, but rather increases in strength; the water evaporates before the gas.

4. Wetted grain should not be exposed to frost, because it injures seriously the germination.

5. The formalin purchased must be of guaranteed 40 per cent. strength. Make the solution according to directions. Thoroughly mix the grain and solution.

6. Grain treated with formalin solution may be fed to stock; the formalin leaves no poisonous substance upon evaporation.

7. Treated grain may be kept indefinitely so long as protected from further contamination.

8. It is urgently recommended that farmers treat enough grain to furnish clean seed for the following year, if they are not in a position to treat seed for the whole of their acreage. When this is done, treated seed should always be sown by itself to give the best results, and no other grain should be mixed with it in harvesting.

Loose Smut. This smut is caused by a fungus distinct from the one just described. It is not present in large amounts in Colorado wheat. It is earlier than stinking smut and differs in the total disappearance of the smutted berries and chaff. At harvest time only barren stalks of smutted plants remain, the spores having been disseminated before maturity. The spores come in contact with other heads of grain while they are flowering and infection of the seed is the result. From such an infected seed a smutted plant will develop the following year, although from all external evidence of the seed no one could tell that it bears the smut fungus embedded in the seed. Loose smut is therefore carried over within the seed, not on the outside as in the case of stinking smut.

Control: The object of seed treatment is to kill the smut fungus within the grain, but produce no injury to the grain itself. The formalin treatment is of no account here as it does not reach the interior of the grain. A method of cold and hot water treatment may be used to destroy the smut fungus within the seed However, it is advisable, in view of the relatively small amounts of loose smut in Colorado wheats, to purchase seed known to be free from the disease. If this cannot be done, then the use of the hot water method is imperative. This method is as follows:

Hot Water Treatment for Loose Smut of Wheat:

1. Secure a reliable thermometer and large wooden barrel or any kind of metal tank or vat.

2. Use good strong gunny sacks that allow water to pass through to the grain.

3. It is well to have some kind of stove or fireplace to heat the water, as it must be kept at nearly constant temperature.

4. The seed is to be soaked 4 or 5 hours in water at a temperature of 68° F., to 86° F., and then followed by hot water treatment with the temperature at 124° to 125° F., for ten minutes. The temperature should never be below 122° F., or above 129° F.

5. It is well to have two barrels for water of the two temperatures, together with hot and cold water close at hand.

6. Fill grain sack one-half to three-quarters full with grain to be treated and allow plenty of room in each sack for grain to move back and forth. Immerse in barrel with water at 86° F., for four hours; add hot water as needed to maintain this temperature.

7. Into a second barrel pour hot water and bring it to a temperature of 112° F., then remove the grain to this barrel, leaving there 15 or 20 minutes.

8. Meanwhile, prepare a third barrel with water at 129° F Place the grain in this barrel and carefully watch the temperature, as it will become lower a few degrees, but should not be permitted to go below 122° F. It is best if kept at 125° F., but should never be lower than 122° nor higher than 129° F. The former fails to destroy the fungus, while the latter very seriously injures the germination of the grain. Keep in this barrel for 10 minutes.

9. Especial care must be taken to thoroughly dry the grain after treatment; this is one of the greatest drawbacks of the whole treatment. If possible, use sunshine, air currents and shoveling to get it well dried.

Oats.

Loose and Closed Smut. The common smut of oats is loose and is very similar to stinking smut of wheat. It appears at heading time and is conspicuous by the darkened smutted grains and chaff. Smut spores are easily blown away, leaving the oat plant bare. The spores lodge on healthy grains and are carried over winter clinging to the outside of the seed.

Control:

The formalin method described for stinking smut of wheat is to be used for the prevention of oat smuts. Either the steeping or sprinkle method may be used.

Barley.

Closed Smut. At maturity the smut masses are enclosed by a thin covering which gives a dark color to affected heads. Spore masses are broken up in threshing and healthy seed becomes contaminated. As a result, the crop grown from such seed will contain smut unless the seed is sterilized.

Control: Use the formalin sprinkle or steeping methods given under stinking smut of wheat.

Loose Smut. In this the smut masses are not enclosed for any length of time by the scales or chaff. Soon after heading the smutted stalks become bare, owing to the disappearance of all smutted parts. It appears earlier than the closed smut and differs further in that the grain becomes diseased in the field, the smut fungus entering the germ of the grain exactly as in the case of loose smut of wheat.

Control: Follow the same method given for the control of loose smut of wheat.

Corn.

Corn Smut. The appearance of corn smut is so well known that the description here is unnecessary. Seed treatment cannot control this disease in corn, because the seed does not carry the fungus. Corn smut is mentioned here because of a somewhat prevailing opinion that smut can be exterminated from this crop by means of seed disinfection. Infection of the corn plant comes originally from the soil, from smut boils that live over winter.

Control: Instead of seed disinfection, the most profitable and practical control is to change the crop for two or three years. On a small scale the smutted parts may be removed from the field and burned, although this is not practical in fields badly smutted.

Millet.

Millet Smuts. The foxtail and grain millets are attacked by two smuts which recently have become important in different sections of the United States. Smut in the foxtail varieties is recognized in the field by early yellowing of the heads which at harvest appear darker than healthy heads. In the grain millets, such as red hog or proso varieties, the smutted head is enclosed by a whitish membrane forming a smut boil. Spores of the disease are spread to healthy grain in threshing and these produce infection of the millet seedling in a very early state of its growth.

Control: Use formalin solution made of one pound of formalin, 40 per cent. strength to 40 gallons of water. The sprinkle method may be used as recommended for wheat or the grain may be immersed in this solution for one hour. The grain should be thoroughly dried.

Flax.

Wilt. The cause of flax wilt is a fungus which grows on the inside of the plant. It is found that the roots of diseased plants are chiefly affected. Flax wilt may live over in the soil from year to year. Plants of all ages may be attacked, wilting and dying in

response to deficient water supply. The disease organism is carried by the seed and it is therefore important to disinfect the seed, particularly as is known to be unhealthy.

Control:

1. Use formalin solution made at the rate of 1 pound of formalin 40 per cent. strength to 40 gallons of water.
2. Use the sprinkle method described under stinking smut of wheat.
3. The solution should be thoroughly mixed with the seed, using about ½ gallon of solution to 1 bushel of seed.
4. Allow the seed to stand 5 or 6 hours covered by a canvas or wet sacks and then dry by stirring it around.
5. Fanning before treatment will remove many light weight affected seeds.
6. Rotate crops on infected soil. It is well to remove or burn diseased flax straw or stubble.
7. Do not use fresh or undecayed manure made from infected flax straw. Well-decayed manure will contain no spores capable of germination.

Rye.

Smut. This disease is known as stalk smut, stem smut and stripe smut. All above ground parts are attacked. The first appearance of the smut is marked by elongated narrow stripes grayish in color. Later the affected tissue appears brownish or black, due to the exposure of the black smut spores from beneath the epidermal layer. The disease is first noticed usually at heading time. At this time the leaves may show rifts or splits lengthwise, and the stems are often misshapened and stunted. The heads are almost always destroyed and often do not develop.

The smut spores are spread in threshing or are blown by wind to healthy grain. Infection may come either from infected seed or from diseased soil.

Control:

1. Two things are essential in controlling this disease—crop rotation and seed treatment. Stakeman and Levine recommend the following method (Bul. 160, Minn. Agr. Exp. Sta.):
2. Use formalin 1 pint to 40 gallons of water for seed treatment.
3. Dip the sack of grain into the solution in such a way as to wet all the grain, lift it out, drain for a moment, dip again and repeat until it is certain all the grain is wet.
4. Then either keep the grain in the sacks or pile it and cover with wet sacks for 4 to 12 hours.

5. It may then be dried and sown.

6. The sprinkle method may also be used if preferred. Use one pint of formalin to 40 gallons of water and follow directions given for stinking smut of wheat.

Timothy.

Leaf Smut. This disease affects mainly the leaves and stems, although the heads are also attacked. Stunting or dwarfing is characteristic of affected plants. The disease appears first in the form of elongated narrow stripes on the leaves and later on the stems. The general appearance of affected plants is quite similar to that of rye smut. The stripes or spots at first are grayish in color, but later are black, owing to the exposure of the black spore masses. Affected leaves become very much torn and shredded, especially those at the top of the plant. No marked discoloration is visable from a distance except in extreme attacks.

Affected plants do not usually produce heads. However, when they do appear they are found to be diseased. In severe attacks all parts of the head are destroyed, even including the bristles. Osner has shown that the timothy smut fungus may pass the winter in three different ways:

1. In the green tissues of the plants.
2. In the embryo of the seed.
3. In bulbs and rootstocks of perennial plants.

The greater percentage of infection, no doubt, occurs at the time the plants are flowing, hence the seed when mature contains the smut fungus in the embryo. In respect to infection, therefore, timothy smut is quite similar to loose smut of wheat and barley.

Control:

1. Hot water treatment of the seed offers the best known control measures.

2. The method recommended under loose smut of wheat may be used for timothy, except for modifications as follows:

3. Soak the seed in cold water 6 to 8 hours. Then transfer it to water at about 118° to 120° F., and leave for one minute. From this transfer the grain to water at 125° F., and keep it there for 10 minutes. The temperature should not be allowed to exceed 126° F., or serious injury may result to the germination power of the seed.

4. Keep down all wild grasses adjacent to the field which became smutted. Timothy smut occurs on red top, orchard grass, Kentucky blue grass and many others.

Tomato.

Tomato Wilt, Blight. Affected plants show a gradual wilting beginning with the lower leaves. Wilting is usually accompanied by a yellowing and a dying of the lower leaves. The water-conducting vessels become blackened, as can be seen by cutting through the stem or leaf stalks. The disease may progress slowly or within a week the whole plant may die, depending upon weather conditions and severity of the attack. Frequently the fruit of affected plants remains attached, but ripens earlier than normal. The disease organism once introduced into the field will remain in the soil for several years. The most common way of spreading the disease is probably by means of plants taken from diseased seed beds. Young plants are usually attacked, but the effects are not noticeable until maturity.

Control:

1. Plant clean seed in new soil if at all possible.

2. Rotate the crops so that tomatoes will not be planted in the same field more often than once in 3 years.

3. Remove and burn affected plants as soon as they appear in the field.

4. Disinfect the seed by soaking in corrosive sublimate 1 part to 1,000 parts of water for 3 minutes.

5. As soon as seed is treated, it should be washed in water and then dried.

6. Seed treatment may not be necessary if conditions of sanitation are carefully regarded and uninfected seed is used.

IV. THE COLORADO PURE SEED LAW.

The Twenty-first General Assembly of Colorado passed an act "to regulate the sale, the offering or exposing for sale, and the importing of field and garden seed; to provide for the testing of such seeds; to make an appropriation for carrying out the provisions of this act; to provide a penalty for its violation, and to repeal all acts or parts of acts in conflict with this act."

In passing this measure, Colorado has taken a step forward looking toward the improvement of its agriculture. The Colorado Seed Act aims to prevent the introduction and spread of noxious weeds; to protect the farmer from unknowingly purchasing seed which runs high in noxious weed seeds and adulterants, or low in percentage of germination; and to protect the careful and conscientious seedsman against the carelessness or wilful designs of the unscrupulous seedsman. The act does not require a farmer to purchase seed of any particular quality. He is at liberty to buy low-priced, inferior seed,

if he wants to. But now, that all agricultural seed must be labeled, the farmer may know what he is buying. The effect of the Seed Act will be the more general use, in Colorado, of seed of high purity and high germination. Nothing but the best of seed will be shipped into the State. No reliable retail or wholesale merchant or other seller of seed will offer for sale seed that is not up to standard. Farmers generally will become more and more particular about the seed they purchase. As a result, our fields will be freer of noxious weeds, our crop stands more uniform, and yields increased.

QUESTIONS AND ANSWERS RELATING TO SEED LAW.

1. **When did the Act become effective?** The Act was approved April 10, 1917, and the labeling requirements under it took effect October 1, 1917.

2. **What are "field seeds" as used in the Act?** Field seeds are defined as the seeds used by farmers, and which include the seeds of red clover, sweet clover, white clover, alsike clover, alfalfa, Kentucky blue grass, Canada blue rass, timothy, brome grass, orchard grass, red top, meadow fescue, oat grass, rye grass and other grasses and forage plants, corn, flax, rape, wheat, oats, barley, rye, buckwheat and other cereals, field peas, grain sorghums and forage sorghums.

3. **What is the main feature of the Law?** It requires the labeling of all field seeds sold or offered or exposed for sale within this State for seeding purposes in this State, either in bulk, packages or other containers of five pounds or more. The Law is primarily a labeling law.

4. **Where shall the labels be placed?** The main intent of the Act is to place the label in such a position that the purchaser of the seed may readily see that label. If it is a sack of seed, on the outside of the sack; if a bin, small or large, on the outside of the bin.

5. **Is any particular form of label or tag required?** No.

6. **In what language shall the label be?** English language.

7. **Must the statements on labels be written or printed?** Either written or printed.

8. **What shall the label contain?** The label shall contain (1) the commonly accepted name of the field seeds; (2) the name and full address of the person selling or offering for sale such seeds; (3) the approximate percentage of purity, which shall be within 2%; (4) the name and approximate number per pound of each kind of seed designated as noxious weed seed which is present in excess of 90 seeds to a pound; (5) the percentage of germination, which shall be within 10%; (6) the date when such germination test was made; (7) the state or foreign country where the seed was grown and, if in Colorado, the locality, or plainly marked "unknown."

9. **Must the label give both the name of the kind of seed and the variety of seed? For example, can wheat be sold under the label "Wheat" without giving the variety name, such as Marquis, Defiance, etc.?** Seeds may be labelled as to kind only; that is, wheat may be sold under the name

"Wheat" without designating the particular variety, if the purchaser is willing to buy wheat under such label. However, it will usually be the case that a purchaser of seed will want to know the variety as well as the kind. If seed is labeled as to variety, that variety name must be the correct one. If the variety is requested and is unknown, the label should have the statement, "variety unknown."

We are suggesting the following as a suitable form of label to use:

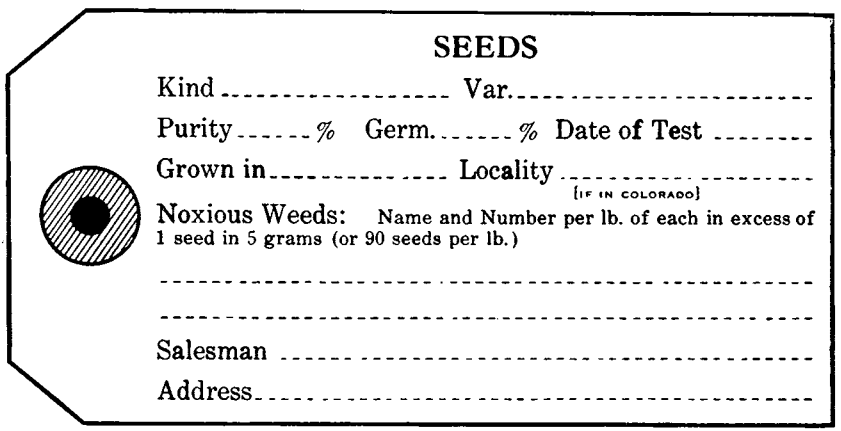

FIG. 9.—A form of label recommended. The label may be of any shape, but the material on this label is that prescribed by The Colorado Seed Act. Tags or labels may be made at home or purchased.

10. **Can a seedsman sell mixed seed?** He can, if he labels it "seed mixture."

11. **Can an elevator sell seed wheat from a bin containing two or more varieties from a number of different farmers?** It can, providing it labels such bin of seed wheat, "seed mixture," or "variety mixture," and also gives the other requirements of the label. Of course, if a bin of seed, even though from a number of farmers, is of the same variety, the variety name may be given.

12. **What is meant by "percentage of purity?"** The freedom of seed from foreign matter or from other seeds distinguishable by their appearance, expressed in percentage.

13. **Must the percentage of purity of seeds be exactly that indicated on the labels?** The percentage of purity as indicated on the label must be within 2% by weight.

14. **What weeds are designated an noxious in the Law?** Any variety of wild mustards, any variety of clover and alfalfa dodder, wild oats, any variety of the plantain, bindweed, or wild morning glory, any variety of the poverty weed, crab grass, cheat, Canada thistle, cockle, sow thistle, wild barley or squirrel tail grass, and hop clover.

15. **Does the Seed Act require that a seedsman must sell seed of any particular quality?** No. A seedsman may sell seed of any quality, good or

bad, providing he labels that seed correctly. The label must be accessible to every purchaser of seed and the purchaser of seed, knowing what the seed is from the label, buys on his own responsibility.

16. **Is one required to buy seed of any particular quality?** No. One may buy seed of any quality desired. He may buy poor seed or good seed. He may pay a low price or a high price.

17. **May a sample containing noxious weed seed in any quantity, no matter how large, be offered for sale?** Yes, providing the label states the fact.

18. **May a sample with a low germination test be offered for sale?** Yes, providing the label states the fact.

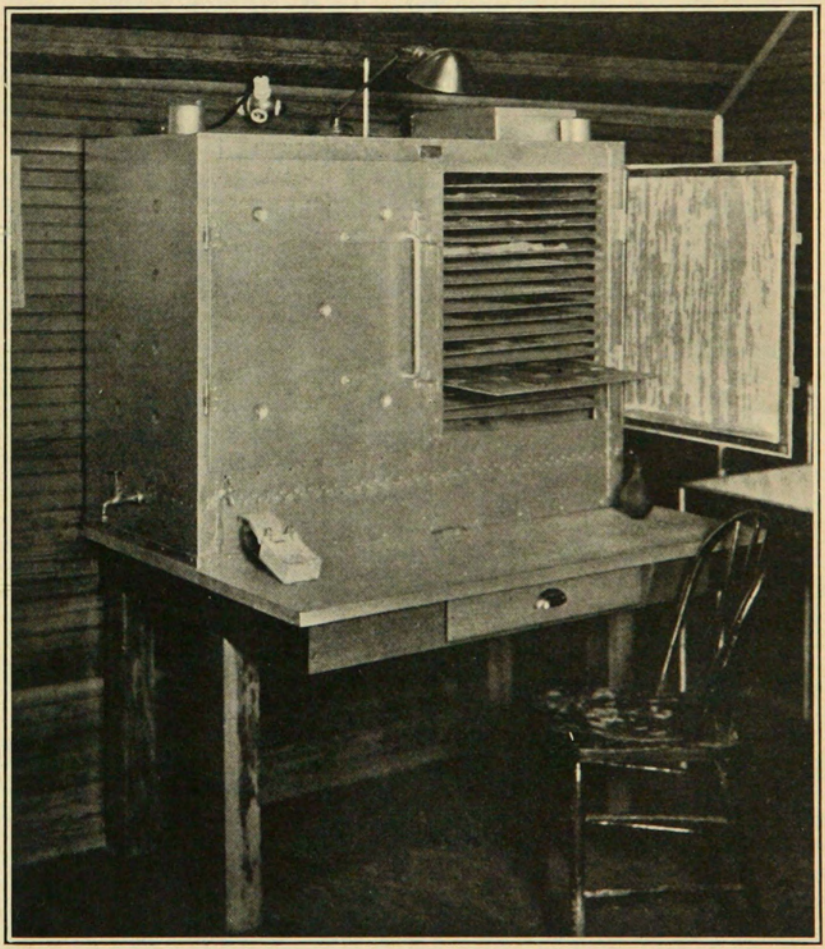

FIG. 10.—A corner of The Colorado Seed Laboratory showing the electrically heated and controlled seed germinator, with a capacity of about 500 samples.

19. **Does the Colorado Pure Seed Law set any standard of purity or of germination?** No.

20. **If a shipment of seeds from the wholesale dealer or farmer is divided by the retailer into separate packages or lots of five pounds or more and offered or exposed for sale, is it necessary to label each separate package or lot?** It is. In such case the information on the wholesaler's label or farmer's label may be used or a sample of seed may be sent to the Seed Laboratory where a test will be made and reported upon free of charge. If the wholesaler's label or the farmer's label is used on these smaller lots, the retailer assumes the responsibility for the correctness of the same.

22. **Can an elevator sell so-called "commercial wheat" for seeding purposes?** Yes. Such seed, of course, must be labeled according to the provisions of the Act.

23. **Where may seed be sent for test?** Any citizen of this State or person shipping seed into Colorado for seeding purposes in the State has the privilege of submitting to the Colorado Seed Laboratory samples of field or garden seeds for tests and analyses, subject to such rules and regulations as may be adopted by said Laboratory.

24. **May a seedsman or any other seller of seed test his own seed and use such data on the label?** Yes, but he must stand back of his tests and, if they are not correct within the limits prescribed by law, he is subject to prosecution. His tests are subject to retests by the Colorado Seed Laboratory.

25. **What charges are made for tests and analyses of seeds by the Seed Laboratory?** The Seed Laboratory has ruled that tests and analyses will be made free of charge until further notice. However, it probably cannot make more than 25 purity tests and 50 germination tests a month for any one person or firm.

26. **What are the directions for sending samples to the Laboratory for tests?** Place name and address of sender on each package, give commonly accepted name of seed, variety if known; if seed is home-grown, so state, indicating the season harvested; if the seed was purchased, give the name of person or firm from whom purchased; state whether a purity or germination test is wanted, or both; if both are requested, indicate whether or not a purity report is desired before the germination report. Unless otherwise directed, both purity and germination tests will be made and both reported at the same time. All transportation charges on seeds sent to the Laboratory must be prepaid. Address all samples and correspondence to The Colorado Seed Laboratory, Fort Collins, Colorado.

27. **What sized sample should be sent for test and analysis?** The minimum weight of seed forwarded for test should be: (a) one ounce of grass seed of any kind, or of white and alsike clovers; (b) two ounces of red and crimson clover, alfalfa, millet, flax, or seed of like size; (c) one-half pound of wheat, oats and other cereals, or seed of like size.

28. **What information will the Seed Laboratory give on the reports issued?** Two reports will be issued for each sample, a purity report and a

germination report. The purity report will give the percentage of pure seed, the percentage of noxious weed seeds, the percentage of other seeds distinguishable by their appearance and the percentage of inert matter. It will also give the number per pound of each kind of noxious weed seeds, indicate the presence of other seeds and give the character of the inert matter. The germination report represents the average of duplicate tests. It gives the germination of the seed at the end of a short period of time and also the final germination, and, in the case of leguminous seeds, the percentage of hard seeds.

29. **How shall dealers and others use the information on these reports?** This information must not be used for advertising purposes. The reports are upon the samples submitted and are no guarantee that the information in them is representative of the whole lot of seed from which the sample is taken, unless such sample has been taken in regular form by the seed inspector. The one who receives a report may copy the data from the reports issued from the Laboratory on to a label. If he does this he is guaranteeing that his sample is representative of the lot from which it was taken.

30. **How shall seeds mixed for special purposes, such as lawn mixture and pasture mixture, be labeled?** Mixtures of field seeds prepared for special purposes must be so labeled. They must be labeled "seed mixture" or "lawn grass mixture" or "pasture mixture," etc. In addition, the label of each seed lot must contain the name and address of the person selling or offering for sale such seed; also the percentage of purity, the percentage of germination and the name and approximate number per pound of the noxious weed seeds and the foreign country in which the seed was grown and, if in Colorado, the locality, or plainly marked "unknown."

31. **Does the law provide for seed inspection?** Yes, the Colorado Agricultural Experiment Station at Fort Collins, through its regularly appointed agent, The Colorado Seed Laboratory, will inspect, "examine and make analyses of and test seeds sold, offered or exposed for sale in the State at such time and places and at such expense as it may deem necessary. The inspector will have free access at all reasonable hours upon any premises to make examination of any seed, whether such seeds are upon the premises of the owner of such seeds or on other premises or in the possession of any warehouse, elevator or railway company, and upon entering payment therefor at the current price may take any sample or samples of such seed." Samples will be taken according to rules recommended by the Association of Official Seed Analysts of North America. These methods insure a fair and representative sample. Duplicate samples are taken. One is left with the owner of the seed, the other taken by the inspector for analysis. Both samples are sealed. The owner of the seed is at liberty to accompany the inspector when the sampling is done and the samples are sealed. Samples are drawn so that they will represent as accurately as possible the bulk lot from which they were taken. Failure to secure representative samples is one of the most common causes of variation in tests of seed.

32. **What methods of sampling are advised?** Samples from sacks or bags should be made up of portions taken from near the top, middle and bottom, approximately one-third from each level. If there are a number of

sacks of the same lot of seed, samples from different sacks should be taken. Samples should be drawn from each bag when there are not more than five bags; but never from less than five bags. These samples may be kept separate and given a designation mark, such as a, b, c, or may be combined into one sample.

Seed "triers" or "samplers" (Fig. 1) may be purchased, enabling one to sample seed without opening the sack. Loose seeds in boxes, barrels, bins, or other receptacles may be sampled by taking approximately equal parts from three different places, and mixing.

33. **Suppose the seedsman finds it necessary to replenish his stock during the seeding season and has not the time to wait for a germination test, must he use the regular label?** Seed sold or exposed for sale during the then seeding season from such an emergency shipment will be exempt from the requirements to label as to germination when labeled "emergency." Moreover, The Colorado Seed Laboratory must be notified of the date when such shipment was received and furnished with a copy of the bill of lading.

34. **How shall seed be labeled that passes directly from farmer or grower to seed merchant?** The regular label does not need to be used in this case, but it must be labeled, giving the commonly accepted name and the state or foreign country where the seed was grown and, if in Colorado, the locality, or plainly marked "unknown."

35. **Is it necessary to label field seed being shipped or hauled to a general market to be cleaned or graded before being offered for sale?** No.

36. **Must field seed being held in storage be labeled?** No.

37. **Can the regular label be dispensed with if it is labeled "not clean seed?"** Yes, if held for sale outside of the State only.

38. **Can the regular label be dispensed with if seed is labeled "not tested seed?"** Yes, if held for sale outside of the State only.

39. **Does the Law control the importation of uulabeled seed?** It does. "No seed in quantities of five pounds or more shall be shipped or brought into Colorado from outside the State by any person to be used by himself for seeding purposes unless such seed shall have been tested and the containers of such seed shall have affixed thereto in a conspicuous place on the exterior of the container of such field seeds a plainly written tag or label giving the information and tests required by the regular label and bear an official certificate of inspection for purity and viability issued by the state from which shipment is made or by the Colorado Agricultural Experiment Station or by U. S. officers or board. In case such importer shall receive such seed and it has not been tested or tagged or labeled as required by this Act, the importer of such seed shall immediately notify The Colorado Seed Laboratory and send the Director of this Laboratory a fair and proper sample of the imported seed for inspection and shall hold such seed until the test required by this Act shall have been made."

40. **Is it unlawful for any transportation company to import field seed that is not tested and labeled?** Yes, "it shall be unlawful for any transportation company to bring into the State of Colorado, except as hereinafter

provided, any field seed as defined in this Act for seeding purposes, unless such seed has been tested as to purity, which test shall be established by the official certificate issued by the state from which such shipment is made or by the Colorado Agricultural Experiment Station or by United States officers or board, and a duplicate of such certificate shall be attached to the bill of lading, and unless the containers of such seed are labeled or tagged, giving the information as required on the regular label. Where such certificate has not been obtained or where the containers of such shipments have not been labeled or tagged, the transportation company may bring the seed into the State, but shall notify The Colorado Seed Laboratory and shall hold such seed for inspection, such inspection to be made at the expense of the owner of the seed."

41. **What constitutes a misdemeanor under the Act?** "Whoever sells, offers or exposes for sale within the State any field seed as defined above without complying with the requirements of labeling, or whoever shall prevent the representatives of the Colorado Agricultural Experiment Station from inspecting said seed and collecing samples, or any transportation company or person who shall ship or bring field seed into this State without complying with the requirements above shall be guilty of a misdemeanor."

FIG. 11.—Making purity analyses in The Colorado Seed Laboratory. Samples submitted by you for analysis are given the most pains taking attention, and care is taken to give you accurate information as to the percentage of pure seed, the percentage of noxious weed seeds, the percentage of other seeds, the percentage of inert matter, and to identify and designate on the report to you each kind of weed seed found in your sample.

42. **What is the penalty for one guilty of a misdemeanor?** Upon conviction, one found guilty of a misdemeanor shall be fined not more than $100.

43. **How are prosecutions instituted?** When the Colorado Agricultural Experiment Station, through its regularly appointed agent, The Colorado Seed Laboratory, "believes or has reason to believe that any person has violated any of the provisions of this Act, it shall cause notice of such fact, together with full specifications of the Act or omission constituting the violation, to be given to such person, who, either in person or by agent or attorney, shall have the right under reasonable rules and regulations as may be prescribed by The Colorado Seed Laboratory to appear before the Laboratory and introduce evidence. If, after such said hearing or without hearing, in case said person fails or refuses to appear, said Colorado Seed Laboratory shall decide or decree that any or all of said specifications have been proven to its satisfaction it may, in its discretion, so certify to the proper prosecuting attorney and request him to prosecute said person according to law for the violation of this Act, transmitting with said certificate a copy of the specifications and such other evidence as it shall deem necessary and proper. Whereupon said prosecuting attorney shall prosecute such person according to law."

44. **Who may submit samples for tests and analyses?** The Act provides that any citizens of Colorado or any persons shipping seed into Colorado for seeding purposes in the State may send samples to the Seed Laboratory of the Agricultural Experiment Station for test and analysis, subject to such rules and regulations as may be adopted by the Seed Laboratory.

45. **What publications will be issued by The Colorado Seed Laboratory?** It "shall make an annual report to the State Board of Agriculture, a copy of which shall be transmitted to the Governor of the State of Colorado, upon the work done under this Act, which report shall show the results of inspection, examination, analyses or tests of field seeds, together with dates of said inspection, examination, analyses or tests, and may include names of persons, firms or corporations having had seed under such inspection, examination, analysis or test."

46. **What other publications may be issued at the discretion of the Seed Laboratory?** It may "publish bulletins or press reports setting forth results of inspections, examinations, analyses and tests, which bulletins or reports may include the names of the persons, firms or corporations having had seeds under inspection, examination, analyses or tests. It may also at its discretion publish bulletins or press reports setting forth information on field seeds, which bulletins may be distributed free to the citizens of this State."

47. **What appropriations have been provided for equipment?** The General Assembly appropriated from the State Treasury $1,500 for the equipment of a seed testing laboratory at the Colorado Agricultural Experiment Station.

48. **What appropriations are made for carrying out the provisions of this Act?** There is an annual appropriation of $4,000, beginning with the fiscal year 1917, for carrying out the provisions of this Act.