ADDITIONAL NOTES ON SEED TESTING.[1]

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INTRODUCTION.

The interest in seed testing appears to be greater at the present time than ever before in the history of American agriculture. This is due, no doubt, largely to the special investigations along this line which have been made by the Department of Agriculture in the last four years. For some time previous to the inauguration of this work by the Department, various State experiment stations devoted more or less time to making vitality tests of vegetable seeds, paying little attention, however, to the scientific side of the subject. Early during the present year the committee appointed by the Association of American Agricultural Colleges and Experiment Stations devised rules and adopted a standard apparatus for testing agricultural seeds. Since that time a number of the stations have entered upon the work systematically in response to an increasing demand among their patrons for more definite knowledge concerning the purity and vitality of the seeds which they desired to plant.

The fundamental principles and methods of testing seeds have been given at some length in former papers, together with figures and descriptions of the apparatus in ordinary use. This paper will deal mainly with special apparatus, methods, and expedients which have been suggested in the course of regular work in this division. First, however, attention is called to the important feature of field tests, which is generally slighted by seed control stations.

FIELD TESTS.

Probably since the earliest development of the seed trade in America, and certainly for more than a hundred years, dealers in vegetable seeds have made preliminary tests of their stocks to ascertain the vitality. These tests have usually been accompanied by experiments in small fields or gardens, called "trial grounds," to determine the genuineness of the variety, it being well known that there is a great tendency in different strains of cultivated plants to depart from a desired type owing to the frequent variation in soil, climate, and

[1] The previous papers have been "Pure seed investigation," Gilbert H. Hicks, Yearbook Department of Agriculture for 1894, pp. 389–408, and "Testing seeds at home," by A. J. Pieters, Yearbook Department of Agriculture for 1895, pp. 175–184.

seasons. Usually the more highly bred the variety, the greater is this liability to vary. Hence, in these field tests careful selection is made, in order to maintain the characteristics of the type. Inferior plants, termed "rogues," are weeded out, while plants which show peculiar characters of a desirable nature, either with respect to earliness, vigor, or yield, are marked and their seed carefully saved to be used in the production of new types or "varieties," as they are loosely called. Unfortunately, there is but little uniformity among seedsmen and growers in their ideas of the limits of different types, so that a Golden Wax Bean, for example, offered by one seedsman, while possessing the general features of the variety sold under that name by other members of the trade, may depart widely from the original form in certain particulars, until we may have almost as many kinds of Golden Wax Bean as there are growers of this variety. On the other hand, it is too often the case that the only difference in the variety offered for sale consists in the name, and Smith's Golden Wax Bean upon being tested in the field proves to be identical with the "variety" catalogued as Jones's Golden Wax Bean.

Were it not for the careful selection practiced by seedsmen in their trial grounds and the close attention which many of them pay to the seed crops which are grown for them in different parts of the country, all semblance to uniformity in type would soon depart from our standard vegetables, and the result would be great deterioration in quality and productiveness. Owing to the special training and experience of the seedsman in this matter and the superior facilities which he usually has for obtaining stock which possesses certain desired characters, the ordinary farmers and gardeners will probably find it better, as a rule, to purchase their vegetable seed from a reliable dealer, one who grows his own seed and tests it from year to year in his trial grounds. For many reasons such a seedsman has a decided advantage over the ordinary planter in the ability to furnish reliable seed of any desired strain.

The inherent tendency of all plants to vary, added to the influence of different conditions of growth, especially when the soil and climate are widely different from those where the seed was grown, make it almost imperative for the gardener to test his seed in a trial ground of his own, where the conditions are the same as in the fields where his crops are likely to be grown for sale. Many "truckers" grow their own seed after having secured a strain which is peculiarly adapted to their own land and market. This custom, however, does not seem practicable for the great majority of seed buyers who grow vegetables for their own tables. Hence, the advisability, in such cases, of purchasing seed from dealers who either grow their own stock or test all of it under practical field conditions. Seedsmen whose wares are derived mainly from foreign sources or from American-grown plants which have not been inspected by themselves or

their agents, labor under a decided disadvantage in comparison with those who grow their own seeds principally.

In view of these facts we would strongly recommend to every farmer and gardener who desires to plant only the best varieties of seed that, in addition to obtaining what knowledge he can from his seedsman and experiment station concerning his seeds, he set apart a small corner in his garden or field for experimental purposes, and there carefully test each variety. Such a trial ground would furnish him and his family a great deal of information which could be obtained in no other way. In this small patch of ground some of the "novelties" advertised by seedsmen could be tested with special reference to one's own climate and soil. Owing to the natural conservatism of the farmer, there is a tendency in many communities to grow the same varieties and strains of vegetables that have been grown in that locality for years. Introductions of new and valuable things occur largely by chance, if at all; whereas, were each farmer to conduct a small trial ground as here recommended, there would soon be in many cases a marked improvement in the varieties and strains of cereals and vegetables planted in his locality. Careful observations, including measurements, should be frequently made on the plants growing in this trial ground, and these should be noted. This work might be done in many cases by the farmer's wife or older children. We venture to predict that a departure from the routine methods of farm work like this would often result in solving the problem how to keep the boys on the farm. At the same time it would increase the efficiency of the farmer's work, and frequently secure an addition to his income.

APPARATUS FOR SEED TESTING.

Since seed testing was inaugurated by the Department it has been found that in some cases special apparatus or methods are desirable to expedite the test while not sacrificing anything of its accuracy. A few suggestions along these lines may be of interest, especially to seedsmen and experiment station workers.

Germinating chamber.—The standard germinating chamber adopted by the Association of Agricultural Colleges and Experiment Stations cooperating with the Department of Agriculture has already been figured and described.[1] After a thorough trial this germinator has been found entirely satisfactory for seed testing. Brass shelves have been substituted for the original ones made of galvanized iron, since the latter are apt to rust sooner or later. This improvement brings the cost of the germinating chamber up to $79.50. A germinator costing $62.50, with fewer openings, but similar in every other respect, except that the door is of copper, lined with asbestus and mineral wool, and

[1] "Rules and apparatus for seed testing," Circular No. 34, Office of Experiment Stations, pp. 5-7.

without panels or glass, has been designed by us for seed testing alone. In this chamber the seeds are constantly in the dark, which is one of the normal conditions of germination. Some experimenters, indeed, claim that certain grass seeds germinate best in the light, but it is believed that equally good results can be obtained by alternating the temperature.

Blotting paper.—Damp blotting paper has proved the most efficient substratum for germination tests, as a general rule, but it does not answer very well for some very fine, slow-germinating seeds like tobacco and June grass, owing to the fact that the blotters adhere too closely in such cases to permit the proper circulation of air. This difficulty may be largely obviated by placing narrow strips of glass between the folds.

Plaster of paris germinating dishes.—Porous clay dishes of various design and depth have been recommended to secure proper moisture conditions in seed testing. In some of the European seed control stations the germinating dishes of this description, invented by Dr. F. Nobbe (see Yearbook Department of Agriculture, 1894, p. 404), are used. In our laboratory, however, Nobbe's dishes have given lower results than any other form of apparatus tried. The ordinary porous saucers sold by florists have been found inadequate on account of their variable porosity. Probably this difficulty would be lessened if they were dried in the sun instead of in kilns. Experiments are now being conducted by the division with small porous dishes made of plaster of paris (fig. 14), which appear to possess the right degree of porosity, and, what is of still greater importance, the variation in porosity between any two saucers made of this material is exceedingly slight, if any. To make these dishes, the plaster of paris should be thoroughly mixed with water until it is about the consistency of cream. It is then poured into a mold (fig. 15), which consists of a bottom of hard wood with grooves near the edges to admit the sides, which are detachable. When in place, these sides are held firmly by hooks and staples. The top consists of a pane of glass the same size as the bottom. Attached to its center by Nonpareil glue is a small, round, shallow, flat-bottom glass dish—for example, a Petri dish, which projects into the soft plaster of paris to the required depth. These molds can be made by anyone, and of any desired size. These plaster of paris saucers when in use are set in water in a pan in the germinating chamber to about one-third of their depth and the seeds sown in the bottom without any covering.

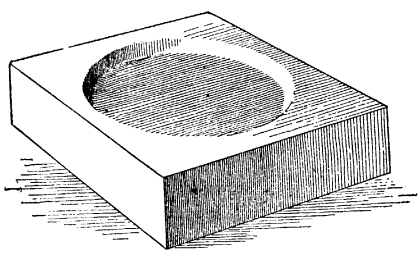

FIG. 14.—Plaster of paris germinating dish.

Mirror box for grass-seed tests.—In making purity tests of the seeds

of many grasses it is difficult to discriminate by ordinary methods between sound seed and empty glumes. This difficulty is obviated in some foreign seed control stations by means of the so-called "Spiegelkasten," or mirror box. A modified form of this box (fig. 16) has given better satisfaction than the original design, and can be easily made and with little expense. It consists of a box of hard wood, half an inch thick. It is 12 inches long, 8 inches wide, and 6½ inches high, the front being open, and the top consisting of a pane of ordinary glass. The inside of the box is painted a dead black. Attached by hinges to the upper margin of the box in front is a rectangular piece of black binders' board, 12 by 8 inches in size. A smaller piece of similar board, 8 inches square, is attached to each end of the box at its upper edge. These boards are for the purpose of excluding all extraneous light. In the center of the box is a mirror about 10 by 7½ inches in size, so pivoted that it can be turned at different angles and

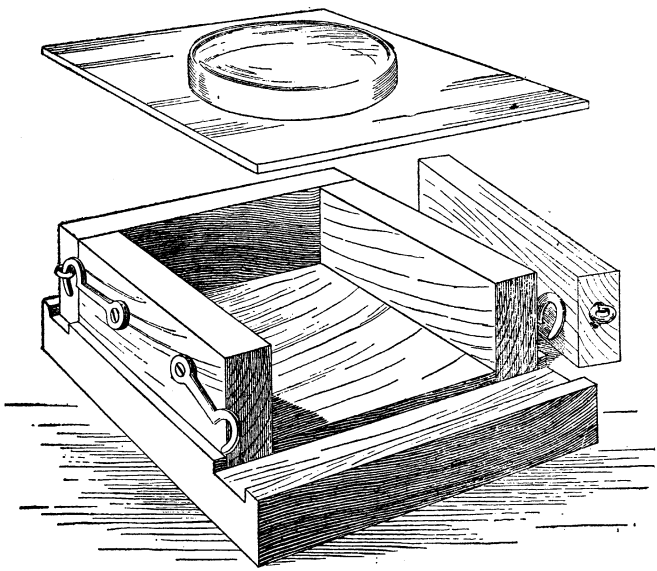

FIG. 15.—Mold for making plaster of paris germinating dishes.

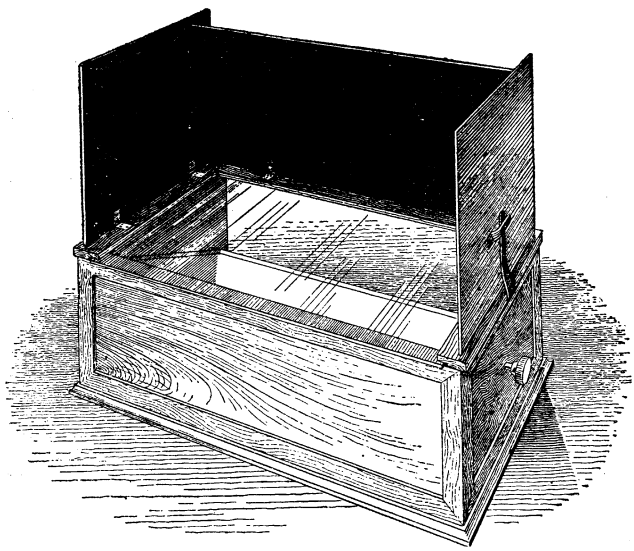

FIG. 16.—Mirror box for testing grass seeds.

reflect the light which enters the open side of the box up through the glass top.

Grass "seeds" are spread thinly over the surface of the glass top, and the mirror adjusted so as to throw the light up through the seed. The operator faces the apparatus with the open side opposite to him and toward the light. The mirror should be so arranged that it will not throw any light into the operator's face. With this apparatus the outlines of grass seeds within the glumes can be clearly seen, and the chaff can be removed with the other impurities of the sample.

A much simpler method of identifying the sound seeds in grasses consists in the use of a pane of glass, over the surface of which the seed, thoroughly wet, has been thinly spread. This glass is held up to the light, and with the forceps the good seed may be easily picked out. It would be well for the purchaser of grass seed, especially of meadow foxtail, awnless brome, and velvet grass, to make use of this simple test. For laboratory purposes the mirror box is to be greatly preferred, since the seed can be handled much better when dry.

High temperature.—To secure the temperature of 30° C., for six out of each twenty-four hours, as recommended for the seeds of many grasses, celery, parsley, parsnip, pepper, and some cucurbits, very good results may be obtained by the use of an ordinary drying oven provided with an asbestus bottom and shelves of galvanized iron or copper wire.

METHODS ADOPTED FOR DIFFERENT SEEDS.

Asparagus.—The endosperm, or food material, of the asparagus seed, is horny, and absorbs water with difficulty. Under ordinary methods this seed germinates irregularly, and in order to obtain the full germinative value, the test must be continued much longer than is desirable. In the meantime various molds develop upon some of the seeds, causing their decay. Soaking this seed in water kept at 30° C. for twenty-four hours materially hastens its germination, while a much larger percentage of seeds sprout. At the end of twenty-four hours seeds thus soaked are somewhat swollen and they begin to sprout in two days, while unsoaked asparagus seeds do not begin to germinate until the sixth or seventh day. Even with this treatment the germination of asparagus seed is somewhat irregular, though not nearly so much so as when soaking is not resorted to. Clipping this seed with a sharp knife sometimes hastens its germination, but care must be taken not to cut the germ. To avoid this, clip the concave side at the scar or hilum.

Beans.—As a rule, no difficulty is experienced in sprouting the seed of beans. In the case of Lazy Wife Pole, Improved Golden Wax, and Henderson's Bush Lima, we have sometimes found it necessary to clip the seed at one end, simply cutting through the outermost coat. In several instances, without such treatment, seeds of these varieties

remained in the germinating chamber for forty-eight days, a very small percentage only having germinated, most of the ungerminated being hard and sound. More than 90 per cent of the same varieties, when clipped, germinated in four days. Beans should not be soaked in water before the germination test.

Beet.—This seed germinates well under ordinary methods, but care must be taken in counting out the sprouts to remove the entire seed, germ and all, otherwise the sprout will start out again and may easily be mistaken for an original one.

Cabbage.—Narrow strips of blotting paper should be placed along the edges between the folds, to prevent the seeds from rolling out. Similar methods should be adopted in the case of all spherical seeds.

Celery.—Great difficulty is frequently experienced in getting good results with this seed in a germinating chamber, and upon the whole it is better to rely upon greenhouse tests. Seed has been kept in the chamber for a number of days without sprouting, and then transferred to sand in greenhouse flats with excellent results, over 70 per cent of the seed germinating after this transfer was made. In one case where the test had been continued in the chamber for forty-nine days without sprouting, 85.2 per cent germinated after having been planted in the soil. This result seems to be invariable. Thus far, our experiments indicate that the most successful germination of celery seed requires either an alternating temperature (30° C. first six and 20° C. the remainder of the twenty-four hours) or the presence of light and a free circulation of air under a constant temperature, as the following table will show:

Germination of celery seed.

Manner of test.	Number of tests.	Day of observation.												Per cent.	Average per cent.
		1	2	4	5	6	7	8	9	11	12	13	14		
Number of seeds sprouted in dark, between blotters, alternating temperature[1]	1	0	0	0	0	14	21	21	28	25	4	4	10	63.5	64.75
	2	0	0	0	0	20	25	25	21	26	7	3	5	66.0	
Number of seeds sprouted in dark, between blotters, constant temperature (20° C.)[1]	1	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0.0	
Number of seeds sprouted on sand, constant temperature (20° C.), in light[1]	1	0	0	0	0	46	39	20	12	11	2	3	3	68.0	67.75
	2	0	0	0	0	31	34	27	20	20	1	1	1	67.5	
Number of seeds sprouted on surface of blotters, constant temperature (20° C.), in light[1]	1	0	0	0	0	13	24	31	26	23	7	4	4	66.0	71.75
	2	0	0	0	0	24	43	34	20	22	3	1	8	77.5	
Number of seeds sprouted in sand, in flats in greenhouse	1	First sprouts on seventh day												70.0	71.5
	2	First sprouts on seventh day												73.0	

[1] In germinating chamber.

NOTE.—The third and tenth days being Sundays, no observations were made, the number of seeds sprouted on the tenth day being included in the count of the eleventh day. Two hundred seeds were used in each test. Glass strips were placed between the blotters.

It should be observed that between blotters at a normal temperature not a single seed had sprouted at the end of fourteen days.

Corn.—This seed does well in blotters, but usually germinates about a day earlier in canton-flannel folds. The same is true to a certain extent of other seeds of similar size, such as beans, peas, cowpeas, etc. Wrinkled kernels, as those of sugar corn, require a longer time and more moisture for sprouting than smooth kernels. The same holds good of wrinkled varieties of peas.

Lettuce.—Soak the seeds in water at about 23° C. for five hours, then transfer them to blotters, which should be kept very wet for the first forty-eight hours. With this method at least 80 per cent of the seed should germinate within two days. Soaking lettuce seed in hot water even for a short time, or in cold water for ten or twelve hours, seems to injure the seed. Some lettuce seeds germinate readily without this treatment; but it has been found that no reliance can be placed upon germinating tests of lettuce seed unless previously soaked as directed.

Okra.—This seed has a very hard coat, and with ordinary methods germinates very slowly. It may be soaked in water at 50° C. for five hours, but a better percentage of germination is secured by clipping the seed on the end opposite the scar. A method better adapted for the ordinary gardener consists in soaking okra seed in water at a temperature of about 22° C. for twenty-four hours before planting.

Onion.—Good onion seed should germinate well without special treatment; but molds seem to develop more quickly upon this than upon any other kind of vegetable seed. Hence, it is desirable to hasten germination, if possible. The latter may be accomplished without injuring the seed by soaking it for an hour in a solution consisting of one part bichloride of mercury to one thousand parts of water. Onion seed germinates best at a temperature of about 18° C. and with a moderate amount of moisture.

Parsley.—Like celery, parsley germinates better in sand than between blotters. In the chamber tests of this seed much time is required. The seed begins to germinate about the seventh day, and may continue to sprout up to the twenty-eighth day or even longer. Molds do not seem to hinder the germination of parsley seed. In counting these seeds, which are really fruits, care should be taken to avoid error, since the fruits are borne upon the plant in pairs and frequently remain attached after the seed is thrashed.

Parsnip.—Requires the same treatment as parsley.

Salsify.—Germinates better between folds of canton flannel or asbestus in the Geneva pan than between blotters.

Watermelon.—Much difficulty has been experienced in testing this seed, which usually does not germinate well in the chamber at the

ordinary temperature of 20° C. No method thus far tried has proved entirely successful, but alternation of temperature has given the most satisfactory results.

Tobacco.—Tobacco seed does not sprout well, as a general thing, between blotters. Very good results can be obtained by spreading it on the bottom of porous saucers made of plaster of paris or of sun-dried clay. These are set in water in the germinating chamber and kept at a constant temperature of 20° to 21° C. Care must be taken that the water is not deeper than the thickness of the bottom of the saucer in all tests of this kind.

Vicia villosa.—Requires no special treatment if the seed is fresh, in which case it usually begins to sprout in two days. Old seed, however, requires clipping.

TESTING FLOWER SEEDS.

More trouble is likely to be encountered in testing seeds of flowers than those of vegetable and forage plants. This may be due to several reasons: First, with the exception of sweet peas, nasturtiums, and other common flowers, for whose seeds there is a constant and large demand, there is always a possibility that the stock from which the tests are made is not perfectly fresh; old seeds, being less vigorous than fresh ones, germinate more slowly, hence are more apt to decay, even when especial care is taken. Second, owing to the great variety of orders represented in our ornamental plants it is impossible to apply the same uniformity of methods in testing such seeds which one would use in the case of common vegetable and field seeds. Third, most of our garden and field plants have been grown for seed purposes for many years, which has produced in them a tendency to bear vigorous seed; on the other hand, ornamental plants are frequently propagated by cuttings, and in comparatively few instances has the habit of forming vigorous seed been as well established. Fourth, owing to the relatively small importance of flower seeds but little attention has been given to scientific methods of testing them, although gardeners and florists are well informed on the proper ways to grow such seeds in the soil. During the past two years the Department has made several thousand tests of different varieties of flower seeds, and it seems advisable to give a summary of our experience in this matter at the present time and to invite suggestions and criticisms from any who have had similar experience.

We presume the majority of seedsmen test their flower seeds in soil, but it will be seen from the table which follows that the germinability of nearly all of the ordinary flower seeds of trade can be adequately ascertained by means of a germinator or "water" test. If soil is used it should be of a very light loamy nature, previously sifted and sterilized. Pure, sterilized sand may also be employed. The soil or sand is placed in common greenhouse flats, the proper drainage conditions having

been secured. Caution must be exercised in planting the seed and the most favorable depth for each variety employed. In general, it may be stated that the seeds should not be planted deeper than twice their diameter. The soil should be thoroughly and uniformly moistened at the start, and it is advisable to cover the flats with newspapers to reduce evaporation. No general directions can be given in regard to temperature. In most instances, however, the same temperature should be maintained that is used in making ordinary tests.

Methods for testing flower seeds.

Kind of seed.	Seed bed.	Duration of test.	Remarks.
		Days.	
Adonis autumnalis	G[1]	30	Seeds should be clipped; germinate very slowly.
Ageratum	C[2]	10	Owing to the impossibility of cleaning thoroughly by machinery this seed usually contains about 50 per cent of chaff. The good seeds remaining germinate promptly.
Agrostemma coronaria (Rose campion.)	C	10	
Althæa rosea (Hollyhock.)	G	16	Commercial seed germinates rather slowly and irregularly. If tested soon after maturity it sprouts without difficulty.
Alyssum maritimum (Sweet Alyssum.)	C	10	
Aquilegia (Columbine.)	G	16	Similar to Althæa in behavior.
Amarantus tricolor (Joseph's Coat.)	C	10	
Antirrhinum (Snapdragon.)	G	16	
Brachycome iberidifolia	C	10	
Calendula officinalis (Pot Marigold.)	C	10	
Callistephus (China Aster.)	C	10	
Canna	C	14	Seeds give a higher percentage of germination if clipped. Canton flannel preferable to blotters.
Celosia cristata (Cockscomb.)	C	10	
Centaurea cyanus (Cornflower.)	C	14	
Cobæa scandens	C	10	Germinates vigorously when fresh. If tested in soil, seeds should be planted on edge.
Collinsia	G	16	
Convolvulus tricolor (Dwarf Morning-Glory.)	C	14	

[1] G=sand or soil in greenhouse flats.
[2] C=blotters in germinating chamber, unless otherwise stated.

Methods for testing flower seeds—Continued.

Kind of seed.	Seed bed.	Duration of test.	Remarks.
		Days.	
Cosmos hybridus	C	10	
Datura cornucopia	G	23	Germinates slowly and irregularly. Should be placed in hot water at 95° C. and allowed to cool to about the temperature of the room.
Delphinium (Larkspur.)	G	16	Same treatment as Datura.
Dianthus (Pink and Carnation.)	C	10	
Digitalis (Foxglove.)	C	10	
Gaillardia	G	16	
Godetia	C	10	
Gomphrena globosa (Globe Amaranth.)	C	10	
Helichrysum (Everlasting.)	C	10	
Iberis (Candytuft.)	G	16	
Impatiens (Balsam.)	C	10	
Ipomœa quamoclit (Cypress Vine.)	C	14	
Ipomœa Bona-nox (Moonflower.)	C	10	Seeds should be clipped.
Lathyrus latifolius (Perennial Pea.)	C	21	
Lathyrus odoratus (Sweet Pea.)	C	10	
Linum grandiflorum (Ornamental Flax.)	C	14	
Lupinus (Lupine.)	C	10	Germinates better if clipped.
Matthiola (Ten Weeks Stock.)	C	10	
Maurandia	G	23	Germinates with difficulty. Seeds should be planted very shallow and kept constantly, but slightly, moist.
Mirabilis (Four o'Clock.)	C	10	
Nemophila	G	16	
Œnothera (Evening Primrose.)	G	16	
Papaver (Poppy.)	C	10	Avoid excessive moisture. Place glass strips between the blotters to admit sufficient air.
Pentstemon	G	16	
Petunia	C	14	
Phlox	G	16	
Platycodon	C	14	
Portulaca	C	10	
Reseda odorata (Mignonette.)	C	10	
Ricinus (Castor-oil plant.)	C	10	

Methods for testing flower seeds—Continued.

Kind of seed.	Seed bed.	Duration of test.	Remarks.
		Days.	
Scabiosa (Scabious.)	G	16	
Schizanthus	C	10	
Tagetes (Marigold.)	C	10	
Thunbergia	C	10	
Tropæolum (Nasturtium.)	C	10	Use canton flannel folds.
Verbena	C	14	
Viola tricolor (Pansy.)	C	10	
Zinnia	C	10	

GERMINATING EXPERIMENTS IN PROGRESS.

Experiments are now being conducted with seeds of different grasses, trees, and other plants which ordinarily sprout with difficulty. The results of such experiments will be published from time to time, with a view of rendering assistance not only to those engaged in seed testing, but to all who may have occasion to plant such seeds in the open ground.