THE SPROUTING OF SEEDS.

IT is well known that the germination of seeds is more or less influenced by many comparatively trivial circumstances and conditions; yet there have been no general inquiries in this country into the exact effects of these conditions, or their importance to the cultivator. Their relations to seed-testing have always seemed to Professor L. H. Bailey of the Cornell Agricultural Station to be of special importance, and it is in this direction that the investigation here referred to has been undertaken. Most of the published records of seed tests are obviously nearly valueless, because they take no account of the conditions of test. This is particularly true of those cases in which germinative vitality is recorded as low, for no assurance is given that other or more careful management might not have increased the percentages. It has been found repeatedly that a sample which gives very poor results under one treatment may give good results under another. The notes of experiments which follow may serve as suggestions to those who test: at all events, it is not too much to expect that the importance of care and uniformity in seed-testing will be emphasized. It is not to be expected that laws can be announced as the results of these somewhat discursive tests, but indications may be safely drawn in some instances.

Seed-tests are of two sorts, — the determination of the purity of the sample as regards foreign material, as weed-seeds, chaff, dirt, and the like; and the determination of the germinative vitality. The former series of tests require a simple mechanical separation of the ingredients of the sample.

Germinative vitality is commonly estimated by per cent and rapidity of sprouting.[1] Rapidity of sprouting is held to indicate vigor or strength of seed, yet the results of many tests show that it is even more influenced by conditions than is the ultimate percentage of sprouting. Causes which determine the viability and vigor of seeds are either congenital, or due to the conditions of harvesting or storing. The expression or measure of this viability and vigor is again determined by the conditions of germination. In the present investigation, with the exception of studies of the relations of weight and color to sprouting, only the conditions of germination have received attention. Seeds can be so readily selected in reference to weight and color, that it was thought advisable to study these phases of the subject in connection with conditions which may be fully controlled by the operator.

The importance of seed-testing is obvious, yet its value is ap-

[1] The verb "sprout" is used in preference to "germinate," as germination is complete only when the plantlet has assumed its true leaves, and has begun to assimilate. In seed-testing, the process is rarely carried to full germination.

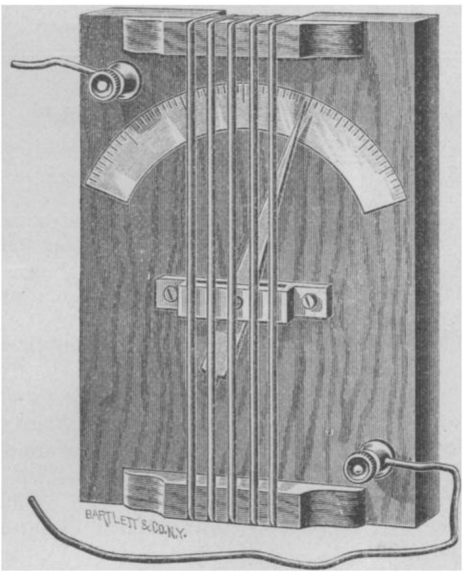


FIG. .

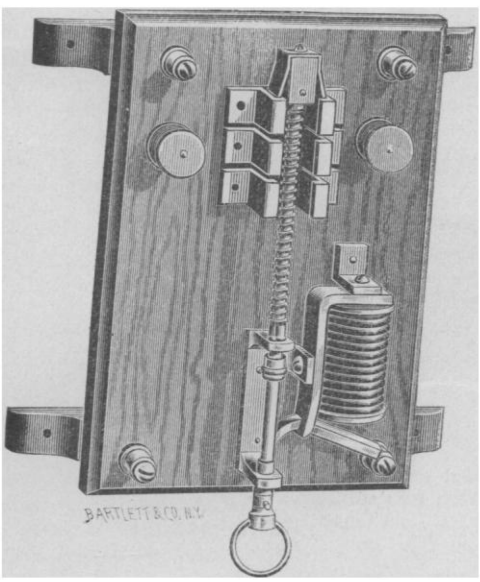


FIG. 4

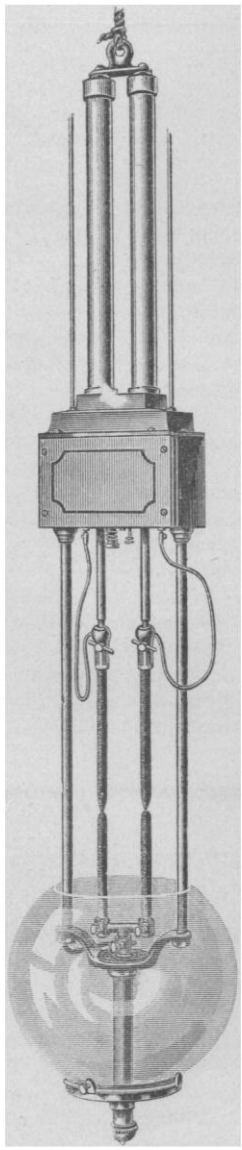


FIG. 5.

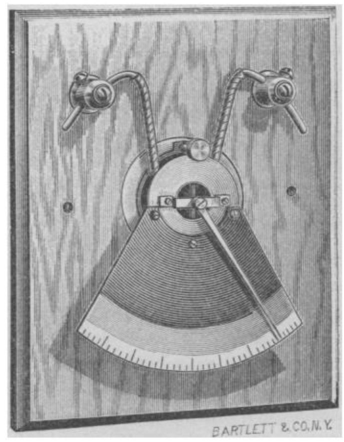


FIG. 6.

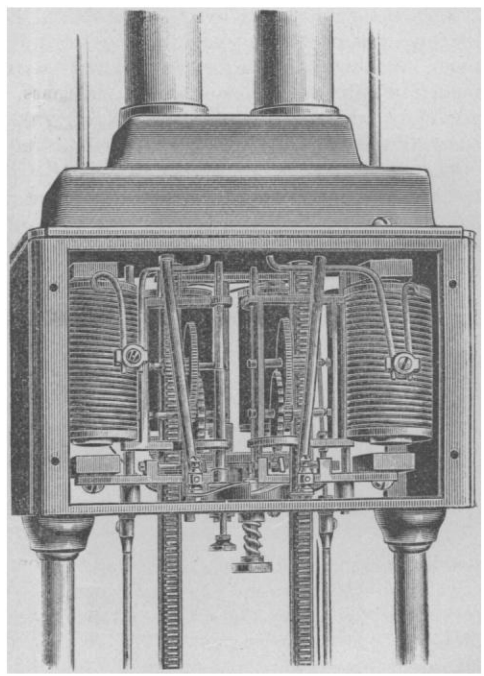


FIG. 7.

KNOWLES SYSTEM OF ELECTRICAL DISTRIBUTION.

parently commonly misapprehended. Its primary value is the determination of the vitality of a given sample. This testing, except in rare instances, should be conducted by the grower himself. The proper work for the experiment station is that of determining the best methods and conditions of testing each species and variety: in other words, it seems that the sphere of the stations is to discover and announce laws and rules, rather than to perform the petty tests for the multitude. Merely testing seeds for the purpose of determining how many will grow, is surely not experiment, and the publication of disconnected tests seems to be entirely unprofitable. The endeavor to determine the relative merits and honesty of seedsmen, by means of testing their seeds, is the merest folly.

There appears to be no necessity for seed-control stations in this country, certainly not for such seeds as fall to the hands of the horticulturist. The control stations of the Old World have suffi-

FIG. 1.

ciently exposed the tricks of seedsmen, and have rendered open dishonesty unprofitable. There is now such sharp competition in the seed-business, that seedsmen themselves must exercise every caution in order to demand trade. Improved methods and apparatus for harvesting and cleaning are giving us clean samples. The greatest risk in the purchase of seeds is the possibility that inferior strains or varieties may be procured; but this is a risk which the control station could not assume to govern, inasmuch as the substitution becomes apparent only when the crop is grown The experiment stations may be expected to influence sufficient control in the seed-business, as occasion shall require.

The tests enumerated in this article have been conducted with the greatest care. Unless otherwise recorded, they have been made in a steam-heated forcing-house. As a rule, they have been made in earth, in shallow earthen seed-pans. These pans are exceedingly convenient, and they afford good drainage. In some cases, lily-pans have been used, but they differ from the seed-pans only in their circular outline and somewhat greater depth. Illustrations of seed-pans may be seen in Figs. 3 to 7. For sowing seeds at uniform depths, two devices have been used. The simpler of these (Fig. 1) is nothing more than a block of half-inch stuff, two inches wide, of the required length, upon which is nailed a cleat equal in thickness to the depth of sowing. The cleat is pressed into the soil evenly, and the seeds are dropped into the furrow it makes. The other device (Fig. 2) may be called the Tracy planter. It consists of two strips of heavy tin plate nearly three inches wide, hung upon two wire pivots or hinges some two inches long. At their upper edges, and equidistant from either end, the plates are joined by a firm spiral spring, which serves to throw the upper edges apart, and to cause the lower edges to join. This trough is filled with the required number of seeds, and is then inserted into the earth to a given depth, when the fingers push inward on the spring, and the trough opens and delivers the seeds.

[illegible]ences of Constant and Variable Temperatures.

The tests here enumerated were made in an incubator of which the temperature was controlled by a galvanic current communicating with clock-work, and in a steam-heated forcing-house. In the incubator the temperature rarely varied three degrees, while the position of the seed-table in the forcing-house was such that variation sometimes amounted to sixty-five degrees. In some cases, duplicate tests were made in an out-door cellar which was used for the storing of nursery stock.

The conclusions from the tests — seven with beans (Green Flageolet), one with peas (White Garden Marrowfat), one with radishes (Half-Long Early Scarlet), two with turnips (Red-Top Strap Leaf), and four with onions (Giant Yellow Globe Rocca) — were as follows: —

1. Different results are obtained from the same sample of seeds under different variations of temperature, of which the daily mean is essentially the same.

2. Sprouting takes place more quickly under essentially constant temperature of about 74° than under a temperature ordinarily variable, which gives about the same mean.

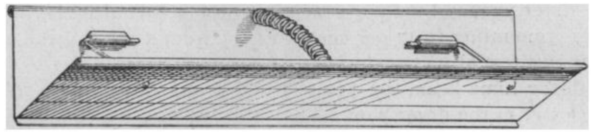


FIG. 2.

3. Rapidity of sprouting is particularly marked in beans and peas.

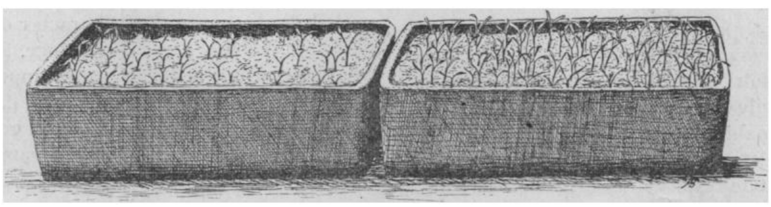
4. As the mean temperature becomes lower, rapidity of sprouting becomes slower.

5. Greater rapidity of sprouting does not appear to be correlated with greater per cent of total sprouting.

6. Constant temperature, of the degree here mentioned, does not appear to give greater percentages of sprouting: at least, the variation in this respect between the constant and variable temperatures is no greater than that which is usually obtained from tests conducted under identical conditions. In the seven tests with beans, however, there is an average gain of 5 per cent in favor of those under constant temperature.

II. Influences of Different Quantities of Water.

Mr. W. W. Tracy of Detroit, well known as an expert in the handling and testing of seeds, once said that he rarely obtained the same results from different tests of the same sample, if made in houses under the care of different men. He attributed this variation mostly to the various amounts of water habitually used by the different men. Acting upon this suggestion, a number of very careful tests have been made in weighing the amounts of water used. The results have been the most marked of any which have ever come under Professor Bailey's notice in the testing of seeds.



Wet Pan. FIG. 3. *Dry Pan.*

The tests were all made side by side in a forcing-house, unless otherwise recorded, in earthen pans. The soil, with one exception, was a good quality of light potting earth, containing a good admixture of field-sand. Although the pans were very shallow, extra drainage was given by the use of broken pots. The samples which received the most water were rarely wet enough to drip: in fact, they had no more water than is given in many houses. The pans sparingly watered were dryer than they would be kept in most houses. The 8-inch round lily-pans are 4½ inches deep. The 10-inch seed-pans are 2½ inches deep, and the 12-inch pans 3 inches deep.

The conclusions drawn from the tests — two with tomatoes (Green Gage), two with cucumbers (Nichol's Medium Green), one with lettuce (Boston Market), two with carrots (Vermont Butter and Early Forcing), one with celery (White Plume), one with turnips (Early Six Weeks), one with pepper (Golden Dawn), two with Lima beans (Large White), and two with *Cobœa scandens*

(Vaughan) — were, that (1) the quantity of water applied to seeds under test may make a remarkable difference in the results; (2) that sprouting is decidedly more rapid in tests which receive less than the usual amounts of water given in greenhouses (this is markedly the case in all the tests, with the exception of three indifferent and comparatively unimportant instances); (3) that the per cent of sprouting is much greater, as a rule, in the dryer tests; (4) that the addition of water above the amount to keep the earth simply moist is injurious; and (5) that the wide differences between the results of the wet and moist tests are not necessarily due to the rotting of the seeds in the wet tests (this is shown in the two tests with cucumber-seeds in which the dryer tests gave similar or even smaller totals than the wet tests).

In the tests with carrot, sprouting was remarkably more rapid in the dryer pan, and the per cent of sprouting was also very much greater, amounting to 47 per cent. Fig. 3, from a photograph, represents this test at its conclusion.

With the Lima bean, the per cent of sprouting was over 70 per cent greater in the dryer pan. This was due to the fact that more of the beans rotted in the wet pan. On May 22, twenty-six of the beans sown May 4 were rotten in the wet pan. Only six were rotten in the dryer pan, and ten were sprouting. It is known that seeds with a slight surface abrasion often germinate better than those which are uninjured; but this test indicates that great care must be exercised to water such seeds sparingly, as they are more likely to rot. Fig. 4, from a photograph, represents this test on May 20.

III. Influences of the Soaking of Seeds before Sowing.

It is a common practice in both field operations and seed-testing to soak seeds in water before sowing. Several tests made indicate very clearly the leading results of this custom. In this connection it is interesting to study results with the Geneva seed-tester, which tests seeds by soaking them. A number of tests were made with the Geneva tester in comparison with sowing in potting soil in forcing-house. The results, which are too extended to be detailed here, indicate that higher sprouting tests are given by the Geneva tester than by planting under known conditions. Ten tests in each case with Marblehead Mammoth cabbage-seeds gave an average germination of 88 per cent in the tester, against 77.6 per cent in the soil. The earliness at which the sprouting is visible in the tester renders testing expeditious; but it must be remembered that full germination cannot often be secured in the apparatus. (Cf. § IX.)

The conclusions drawn from the tests — two with carrots (Early Forcing and Vermont Butter), four with tomatoes (one Green Gage, three Belle), one with turnips (Early Six Weeks), two with radishes (Early Scarlet Globe), and one with onions (Giant Yellow Globe Rocca) — were as follows: —

1. Great gain in rapidity of sprouting, counting from the time of planting, may be expected as a rule, if seeds are previously soaked in water; and the longer the seeds are soaked, within reasonable limits, the greater is usually the gain in rapidity of sprouting, This fact is interesting, in face of the experience that very profuse watering after sowing gives an opposite result. (Cf. § II.)

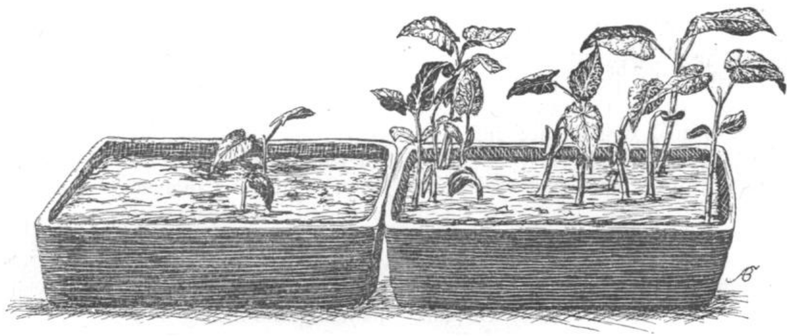
2. This gain in rapidity of sprouting in soaked samples is really fictitious, however, inasmuch as germination actually begins in the soaked seeds before the dry samples are sown. In truth, the soaked seeds are sown earlier than the dry ones. If this advance in period of sowing is added to the date of sowing of the dry seeds it will be found that dry seeds as a rule sprout fully as early as soaked seeds, and many times much earlier.

3. The total amount of sprouting does not appear to be influenced by soaking.

4. Similar results are not to be expected from all species of plants.

IV. Influences of Character of Soil.

It is well known that texture of soil often has much to do with the germination of seeds in the field. Soils which bake, which become very dry, or which hold too much moisture, always tend to give a poor "stand" of crop. But the soils used in houses are such as to occasion no thought of their influence upon germination; yet there are cases in which such soils cause variation in seed-tests. This was particularly marked in a lot of beans tested this spring. Samples happened to be sown at the same time in potting soil on a bench, and under a cloth on the surface sand. Those in soil gave much poorer germinations than the others. Other sowings were therefore made from the same lot at given depths in sand for purposes of comparison. The figures cannot be presented in the limited space of this article, but it was found that sproutings were in some cases nearly twice as many in sand as in potting soil. More beans rotted in the soil than in the sand. The soil had not been sifted, and it contained some manure; yet it was only four inches deep on the bench, and it would seem that the drainage was good. Tests in this direction warrant the following conclusions: 1. Variations in results of testing may sometimes be expected in consequence of character of soil in which the tests are made; 2. In the present instance, low results in potting soil, as compared with tests in sand, appear to be due to the greater amount of water held in the earth, causing the seeds to rot. The results may therefore be studied in connection with those upon the influence of varying amounts of watering. (Cf. § II.)



Wet Pan. FIG. 4. *Dry Pan.*

V. Influences of Light.

Darwin, in his "Cross and Self Fertilization" (American edition), p. 13, says, "On other occasions, from the want of time, the seeds, instead of being allowed to germinate on damp sand, were sown on the opposite sides of pots, and the fully grown plants measured. But this plan is less accurate, as the seeds sometimes germinate more quickly on one side than on the other. It was, however, necessary to act in this manner with some few species, as certain kinds of seeds will not germinate well when exposed to the light. . . . This occurred in the plainest manner with the seeds of *Papaver vagum* and *Delphinium consolida*, and less plainly with those of *Adonis æstivalis* and *Ononis minutissima*. Rarely more than one or two of the seeds of these four species germinated on the bare sand, though left there for some weeks; but when these same seeds were placed on earth in pots, and covered with a thin layer of sand, they germinated immediately in large numbers."

Of late years there has been more or less said concerning the sowing of seeds for test upon the surface of soil, and covering with glass in order that every seed may be watched; and certain seed-testing apparatus have been devised upon this principle. It appears from Darwin's experience that with some seeds grave errors may occur from this practice, and further evidence of the same nature is furnished from the tests here recorded. Several tests were made in which the seeds were sown upon the surface of soil in pots or pans; the pots, unless otherwise mentioned, being plunged in sphagnum moss to keep the soil moist. Over the top of the pot or pan was placed a pane of glass, or a close-fitting iron saucer or a board.

The conclusions from these tests — one with *Papaver rhœas* (English poppy), one with larkspur (Dwarf Rocket), one with *Adonis æstivalis*, and one with radishes (Early Scarlet Globe) — were as follows : —

1. Very great differences in results may sometimes be expected between samples exposed to light during the process of sprouting and those kept in darkness.

2. When such differences occur, they indicate that light retards or even wholly prevents germination.

3. In some species this influence of light is greatly marked, while in others it is not apparent.

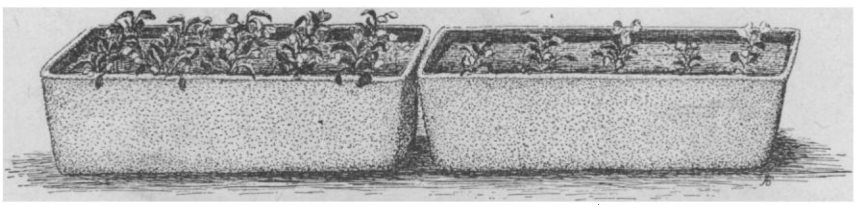
4. It is apparent that those apparatus which test seeds by holding them on a porous plate above water are to be looked upon with distrust, unless provided with an opaque covering; and even then they may prove unsatisfactory, as the experience with the larkspur-seeds indicates that best sproutings follow planting in the soil.

VI. Weight of Seed in Relation to Sprouting.

Many experiments have been conducted this year upon the relation of weight of seed to germination, but the figures are too numerous to be recorded here. The general results of the tests may be indicated, however. Most of the work recorded in Sections VI. and VII. was performed under the direction of Professor Bailey, by Mr. B. R. Wakeman, of the class of 1889, in preparation of a thesis for graduation.

Of itself, *per se*, weight appears to exercise no influence upon germination, but it is often a tolerably accurate measure of viability as determined by various causes. Broadly stated, it may be said that comparative lightness in a seed indicates arrested growth, and consequent lowness of germinative vitality.

Fig. 5, from a photograph, illustrates a test with radish-seeds, in which the differences were marked.



Heavy Seeds. FIG. 5. *Light Seeds.*

It is often true that over-ripe seeds germinate more slowly, and give lower total results, than others, and this over-ripeness is sometimes indicated by additional weight. It is to be expected, therefore, that in some instances best results in germination come from the seeds of lighter weight.

The conclusions from a number of tests — two with cabbages (one Red Dutch and one Flat Dutch), one with radishes (Early Scarlet Globe), one with beans (Improved Green Flageolet), and one with *Lathyrus sativus* (gesse), and others — were as follows : —

1. Variations in results of testing, both as regards rapidity of sprouting and the total amount, may be expected between seeds of different weights in the sample.

2. This variation is much greater in some species than in others. In these tests the variation was particularly marked in cabbage, radish, sweet pea, bean, gesse (*Lathyrus sativus*), burnet (*Poterium sanguisorba*), martynia, orach.

3. As a rule, the heaviest seeds in any sample give earliest and highest results.

4. In some cases the lightest seeds in the sample give earliest and highest results, apparently because the heaviest seeds, with which they are compared, are over-ripe; or in some instances under-maturity may result in earlier germinations, and such seeds are sometimes light in weight.

VII. Color of Seed in Relation to Sprouting.

Color may be assumed to indicate, in most cases, some vital character of the seed, as determined by various causes. In one species, or even in one individual sample, it may indicate a different character from what the same color does in another species or sample. It may indicate degree of maturity, method of curing, age of seed, or other peculiarity. It is to be expected, therefore, that color may sometimes designate more or less accurately the germinative vitality of the seed. It follows, however, that no general law of relation of color to germination can be announced: every species, and sometimes every sample, must be investigated for the law which governs itself. Many tests in this direction have been made, but one example will show something of the extent of variation in seeds of different colors.

With the bean (Green Flageolet), sproutings were most rapid, and higher in total per cent in the green-colored samples. This test was twice repeated with similarly marked results. The same variety from the Department of Agriculture gave opposite results, however.

Fig. 6 shows tests of white and green colored Lima beans, sown at the same time. The green-colored seeds are ahead.

Four tests with morning-glories (both *Convolvulus major* and *C. minor*) gave results uniformly in favor of white seeds as contrasted with black ones in the same sample.

From a considerable study of the importance of color in relation to germination, the following conclusions have been drawn: 1. Seeds which differ widely in color in any sample frequently give different results under test; 2. This variation in results may lie in greater rapidity of sprouting, or in higher total amounts, or in both; 3. The relative values of seeds of different colors vary with each species, or sometimes with each sample.

VIII. Influences of Latitude.

Plants of high latitudes are more sensitive to heat and cold than those of the same species growing nearer the equator; i.e., they start or vegetate relatively earlier in spring. This subject has been investigated in several directions; but, so far as the writer is aware, it has not been pursued in this couutry in relation to germination of seeds. The following tests are incidental to this investigation, being a part of a general series of researches upon the influence of latitude upon plants, but they are suggestive in this connection.

A sample of white dent corn was secured from the Alabama Experiment Station, and samples of white and yellow dents were obtained from the South Carolina Station. The germination of these samples was compared with that of corn grown on the farm of Cornell University.

With corn from different latitudes, fifty kernels in each sample, sown one inch deep in 12-inch seed-pans, sprouting was much the most rapid in the New York corn, but differences in totals were evidently not due to influence of latitude. The plants from New York seed were by far the largest and most vigorous of any in the test during the month which they remained in the house. The Alabama seed gave the least vigorous plants, while South Carolina seeds gave intermediate results. Fig. 7, from a photograph, illustrates the New York and Alabama samples ten days after sowing.

Three other tests were made, with the same result. In one test the sample from New York was represented by seed taken from a crib of soft corn, yet this sample gave earliest results, though less marked than in the other instances. A similar lesson appears to be taught by the behavior of the seeds of species of *Carex*, which were planted this spring. Of some eighty pots of seeds, collected by Professor Bailey in Europe last year, thirteen show germination at the present time; and of these, all the most forward, with two exceptions, are northern species, collected in Scotland.

The conclusion is, that northern-grown corn appears to germinate more quickly than southern-grown corn.

IX. Variations in Duplicate Tests under Like Conditions.

It may be well to briefly call attention to the fact that scarcely any two tests made with seeds from the same sample, under conditions apparently identical, are exactly alike in results. It frequently happens that these results are so dissimilar as to give no warrant for expressing an opinion of the value of a sample from two or three tests.

The conclusions are that (1) one test cannot be accepted as a true measure of any sample of seeds; and (2) variation in duplicate tests is likely to be greater when seeds are planted in soil than when tested in some sprouting apparatus like the Geneva tester (cf. introduction to § III).

X. Comparisons of Results of Seed-Tests with Results of Actual Sowing in the Field.

It has been said recently that the ideal test of seeds is actual sowing in the field, inasmuch as the ultimate value of the seed is its capability to produce crop. This notion of seed-tests is obviously fallacious, although the statement upon which it is based is true: in other words, actual planting rarely gives a true measure of the capabilities of all the seeds of any sample, because of the impossibility to control conditions and methods in the field. The object of seed-tests is to determine how many seeds are viable, and what is their relative vigor. If planting shows poorer results, because of covering too deeply or too shallow, by exposing to great extremes of temperature or moisture, or a score of other untoward conditions, the sample cannot be held to account for the shortcoming.

Various samples were tested indoors, and actually planted in the field. The seeds were sown in the field June 5, and the last notes were taken from them July 5. They were sown on a gravelly knoll. Rain fell about every alternate day, and the soil was in good condition for germination throughout the month. The indoor tests were made in loose potting earth, or in sand in seed-pans.

The conclusions were, that (1) actual planting in the field gives fewer germinations than careful tests in conditions under control (this difference in total of germination, even under favorable conditions of planting, may amount to over 50 per cent); and (2) in planting, due allowance should be made for the comparatively bungling methods of field-practice by the use of greater quantities of seeds than would seem, from the results of tests, to be sufficient.

XI. Impurities in Samples of Garden-Seeds.

Over one hundred packages of seeds have been carefully examined for impurities, and in ninety separate instances the results have been tabulated and compared. This examination consisted in counting every seed in the sample, counting the impurities, weighing the seeds and the impurities, and determining, so far as possible, the character of the impurities. The percentages of impurities, both by number and weight, have been calculated. From these analyses it is easy to draw conclusions as to the probable extent of adulteration or impurity in garden-seeds. No evidence of adulteration was found, and weed-seeds were few and unimportant. In some cases the sample had not been properly cleaned, but in general the more important seeds were very free from impurities. The impurities were very largely immature and imperfect seeds. The average of impurities, by number, was found to be 2.76 per cent, and by weight, 1.38 per cent. The investigation appears to indicate that there is no necessity for seed-control stations in this country, for the purpose of preventing dishonesty and carelessness in the sale of garden-seeds. The detailed results will soon appear in *Agricultural Science*.

As a general summary of his results, Professor Bailey gives the following: —

I. The results of a seed-test depend very largely upon the known conditions under which the test is made.

1. Variations in temperature may cause variations in rapidity of sprouting.

2. An essentially constant temperature of about 74° gives quicker results than an ordinarily variable temperature of a similar mean.

3. It is probable that any constant temperature gives quicker results than a variable temperature of which the mean is the same as the constant temperature.

4. As the mean temperature lowers, sprouting, as a rule, becomes slower.

5. In some instances, greater rapidity of sprouting, due to a constant temperature of 74°, does not appear to be correlated with greater per cent of total sprouting. In beans, however, greater per cent of sprouting appears to follow greater rapidity of sprouting.

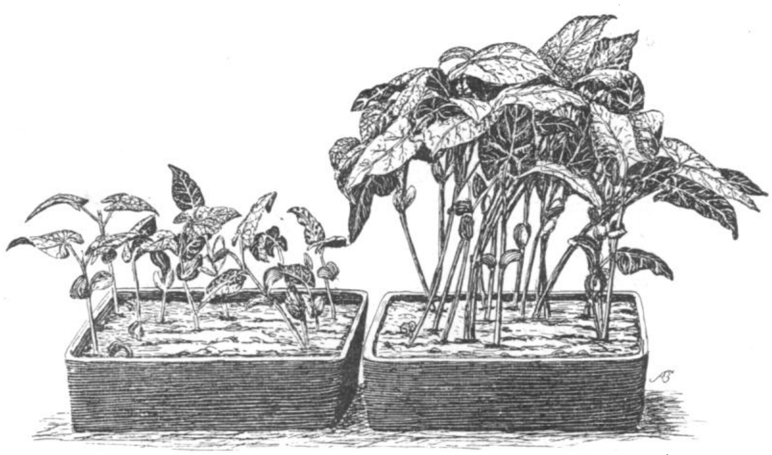
6. There is probably a tolerably well defined optimum temperature for each species of plant, in which best results from seed-tests can be obtained. This limit is not closely determined for most garden-seeds.

7. The quantity of water applied to seeds may determine both the rapidity and per cent of sprouting.

8. A comparatively small amount of water gives quickest and largest results.

9. Greater quantities of water than are required for best results lessen rapidity and per cent of sprouting either by causing the seeds to rot or by retarding germination, or by both.

10. The soaking of seeds in water before planting does not appear to hasten sprouting if the planting-time is reckoned from the time at which the seeds are put to soak; but, if planting-time is counted from the time of placing the seeds in soil, quicker sproutings are the result. This method of reckoning is incorrect, however.



White Seeds. FIG. 6. *Green-Colored Seeds.*

11. The soaking of seeds does not appear to influence the total amount of sprouting.

12. The results of soaking appear to vary in different species.

13. The character of soil in which the test is made may influence the results, both in rapidity and per cent of sprouting.

14. Light has great influence upon the sprouting of the seeds of some species.

15. When light has any influence, it retards or wholly prevents sprouting.

16. The effects of light upon sprouting are different in different species.

17. The weight of the seed is often a tolerably accurate measure of its viability, as determined both by rapidity and per cent of sprouting.

18. As a rule, heavy seeds germinate better than light ones of the same sample.

19. Seeds of different species may vary in sprouting in reference to weight.

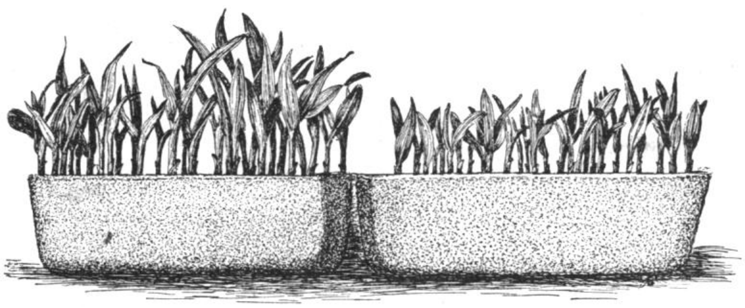
20. The color of the seed in some cases is a tolerably accurate measure of rapidity and per cent of sprouting.

21. When there is any variation in viability in reference to color, it is usually found that the stronger sproutings occur in the darker-colored seeds.

22. The relative values of seeds of different colors vary with each species, or sometimes with each sample.

23. The latitude in which seeds are grown may determine their behavior in germination.

24. Northern-grown corn appears to germinate quicker than southern-grown corn. It is to be expected, from our knowledge of the variation of plants in reference to latitude, that seeds of most species will give similar results.



Ithaca. FIG. 7. *Alabama.*

25. Variation in results of seed-tests may be due to the apparatus in which test is made.

26. Those apparatus in which the seeds are exposed to light are to be distrusted.

27. Those apparatus which afford no protection to the seeds other than a simple layer of cloth, paper, board, or similar cover, are usually unsafe, from the fact that they allow of too great extremes in amounts of moisture.

28. The so-called Geneva tester appears to give better results of sprouting than tests made in soil, probably from the fact that moisture and temperature are less variable than in the soil-tests.

29. In order to study germination to its completion, tests must be made in soil.

30. Tests made indoors are more reliable than those made in the field.

II. Results commonly vary between tests made under apparently identical conditions, even with selected seeds: therefore one test cannot be accepted as a true measure of any sample of seeds.

III. The results of actual ordinary planting in the field cannot be considered a true measure of the viability or value of any sample.

IV. Rapidity of sproutings, unless under identical conditions, is not a true measure of vitality or vigor of seeds.

V. There appears to be no pernicious adulteration of garden-seeds in this country, and, as a rule, there are no hurtful impurities.

In the ordinary farmer's garden, seed-testing is perhaps of little or no value; but to the market-gardener, who plants considerable areas to special crops, and to the seedsman, it is highly profitable. It is possible that in some cases the character of the crop can be prognosticated with some degree of certainty from behavior of plants in germination, wholly aside from percentages of sprouting. The studies of experts in this country and Germany indicate, that, when accurate information is desired as to the value of seeds, the seed-test should present at least the following data: name of variety, where grown, when grown, how kept, per cent by weight of foreign matter, per cent by weight of apparently good seeds, nature of foreign material, weight of seeds, manner of testing, number tested, average and extreme temperatures during trial, first germinations in hours, last germinations in hours, per cent by number germinated, per cent unsprouted but sound at end of trial, date of test, estimate of agricultural value.

INHERITANCE OF INJURIES.

PROFESSOR A. WEISMANN of Freiburg, Germany, has made some experiments on mutilation. On Oct. 17, 1887, he had the tails removed from seven female and five male white mice. On Nov. 16 the first brood appeared. These and all subsequent broods were removed from the cage. Up to Dec. 17, 1888, 333 young were born, and in none of them was there any sign of the mutilation being inherited. In cage 2, fifteen young, of Dec. 2 1887, were placed, their tails having been removed. These, up to Dec. 17, 1888, produced 233 young, all with normal tails. In cage 3 fourteen young of the second generation, with tails removed, were placed; and up to Dec. 17, 1888, they produced 141 young, all quite normal. The experiment was carried, with a negative result, down through five generations of mutilated animals. The length of tail of new-born mice varies from 10.5 millimetres to 12 millimetres. In the series of experiments, 849 young were produced by mutilated progenitors, and in no case was a mouse produced with its tail less than 10.5 millimetres. The author points out, that, while it might be said that experiments through a far greater number of generations were needed, the so-called cases of inheritance of mutilation all imply that the mutilation is impressed on the immediately following generations. A mother breaks her finger, and her daughter has the joint of the corresponding finger imperfect. A cow has her horn torn off, and in due course gives birth to a one-horned calf. Moreover, there are many cases of mutilations which have been made for hundreds of years without result. For instance, Settegast shows that all the crows but the rook have bristly feathers on their beaks. Rooks, too, have these feathers while nestlings; but later on they lose them by perpetually pushing the beak into the ground in search of food. There are a great many cases which at first sight appear to prove the inheritance of injuries. As an example of how easy it is to be deceived, Weismann relates that a friend had a vertical scar (with comb-like striæ) on the left ear, the result of a sword-wound. On the left ear of this gentleman's daughter was a curiously similar marking. But it was ultimately noticed that on the right ear of the father was an appearance precisely similar to that on the left ear of the daughter. On closer examination of the father's left ear, there was seen under the scar a linear streak, from which the striæ ran, forming a comb-like structure. It was this, doubtless a