STUDY OF DORMANCY IN SEEDS OF SOME IMPORTANT WEEDS

by

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A Thesis

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A B S T R A C T

Dormancy in seeds of eight weeds, collected in the Province of Quebec, was studied in 1949 and 1950. The work reported herein was aimed at determining the presence of dormancy in freshly harvested seed; the effect of dry storage; the effect of stratification at low temperatures both in the laboratory and under simulated field conditions; the germinating capacity of unstratified seed in the soil; and the share of the seed coats in delaying germination.

Germinating capacity of freshly harvested seed varied, depending on species, from zero to almost 100%. Dry storage was beneficial in increasing the germination percentages.

Stratification at low temperature was effective with some species and, ineffective with others.

Germination of small-seeded species declined with deeper sowing.

Seed coats proved more or less important in delaying germination.

Embryo dormancy was found to vary with the different species ranging from complete absence to more than one year.

INTRODUCTION

Many records can be found in the literature of seeds that are supposed to have lain in the soil for decades and which are still capable of germination. Most of those observations are based on the appearance of plants on recently plowed meadows or pastures of long standing.

That seeds of some plants have quite a long life span is demonstrated by Beal's experiment (Crocker, 1948). In 1879 he buried seeds of 20 kinds of plants in sandy soil 20 inches deep. The tests showed that nine of the 20 species of seeds buried were still germinating at the 40-year period, five at the 50-year period, and three at the 60-year period.

Enough evidence can be found in the literature that the seeds, at least for some plants, retain their vitality in soil better than in dry storage. For the purposes of practical agriculture it means that the seeds of many wild plants will lie in moist soil for years without germinating or the germination may spread out over a period of years, with now and then a few seeds germinating. This delayed germination in seeds of wild plants is very common.

Delayed germination or dormancy is advantageous to many wild plants in nature. The plant can survive in the seed stage over the winter and sprout and grow in the spring. This is no doubt helpful in the persistence of the species.

It would be a great misfortune for man if all at once seeds of cultivated plants ceased to have at least a short dormant period, for instead of producing grain, the embryos would continue to grow in the green ear and form seedlings. Thus man and domestic animals would be without any food in the form of dry seeds and propagation by seed would be made impossible.

On the other hand dormancy in seeds causes man a great deal of inconvenience. Those which are dormant do not produce seedlings promptly when sown unless they are subjected to special treatment to throw them out of dormancy. Seeds of wild plants, many of them being classed as weeds, which persist in soil for many years alive, produce unwanted plants in crops which require strenuous efforts from the farmer to fight these plants.

One of the greatest difficulties in maintaining successful farming, and particularly in producing a more abundant supply of clean forage and grain seed, is the prevalence of weeds. It is important to consider not only the large number of weed seeds sown with improperly cleaned grain but also those already in farm soils. As it was already pointed out the seeds of most annual weeds, when imbedded in the soil, retain their vitality in a dormant stage for several years. There is but one possibility of controlling weed seeds in soil, viz., by forcing them to germinate, i.e., by overcoming their dormancy and by destroying the seedlings. It was the object of this study to determine for eight selected weeds the factors of dormancy as well as the methods of overcoming it.

The following were the main problems in the course of the experiments in this study:

(1) The presence or absence of dormancy in the seeds soon after ripening and changes in dry storage of 12 to 18 months;

(2) The response of the seeds to low temperature stratification both in the laboratory and under field conditions;

(3) The germination of dry-stored seed in different types of soil at different depths;

(4) The part of the seed coat in delaying germination.

Results of the experiments along these lines were aimed at pro-

viding at least some information on the behaviour of two main categories of weed seeds - those already present in the soil in a dormant stage and those sown with seeds of cultivated plants. As the direct approach to the first group of seeds requires long time projects and because the scope of this study was limited by time and means, the problems put forward are more on the side of dry stored seed.

REVIEW OF LITERATURE

1. Categories of Dormancy

In his recent work Akamine (1944) summarized the causes of dormancy in seeds as being the result of one or more of the following conditions:

(1) presence of enclosing structures that hinder maximum expansion of the seed;

(2) inability of seed to absorb water;

(3) presence of structures that interfere with exchange of gases;

(4) need within the seed for stimulators of respiratory and nutritive activities;

(5) dormancy of the embryo itself;

(6) immaturity of embryos;

(7) secondary dormancy;

(8) presence of inhibitors produced by seed hulls.

This has but little improved Crocker's (1916) classification: Akamine only added groups (4) and (8).

a. Mechanical resistance of seed coats

Some seeds are held in a dormant state because the force of the expanding contents is not sufficient to rupture the coats. Crocker and Davis (1914) found that dormancy in seeds of Alisma Plantago was due to mechanical restraint of the seed coat thus preventing the complete swelling of the embryo which exerted a pressure of about 100 atmospheres against the seed coat. Akamine (1944) claims that dormancy of Paspalum notatum is of a similar nature, germination being delayed by the tough lemma and palea and not by the seed coat. He found that the lemma and palea were so tough that any part of them remaining on the caryopsis materially reduces the maximum imbibitional swelling of the embryo and of the cary-

opsis in general, thereby preventing germination.

b. Impermeable seed coats

Hard-coatedness in seeds is of extreme importance in increasing their life span in storage as well as in the soil. Hard coats maintain a low moisture content in the embryos by hermetically sealing them individually and thus providing condition so that the seed will not absorb water and therefore germination under seemingly optimal conditions cannot take place. Harrington (1916) and a number of other authors showed that most species of the family Papilionaceae produce seeds with hard coats, likewise the Convolvulaceae, Chenopodiaceae, Geraniaceae, Malvaceae, Rosaceae and other families have species that bear hard seeds.

Stevenson (1937) in his studies with Melilotus alba demonstrated that strains with both hard and soft seed coat can be developed by selection and inbreeding. The same was true with other leguminous plants as reported by several authors. The conclusion being that hard-coatedness is primarily determined genetically, but the appearance or degree of hardness is also modified by environmental factors. Crocker (1948) observed that more than 98% of handhulled Melilotus alba seed are hard when they ripen during hot, dry weather and 100% are soft when they ripen during rainy weather. Middleton (1933) showed that well matured seeds of Lespedeza stipulacea decrease in their hard seed content and correspondingly increase in germination in dry storage through the winter. Jones (1928) found that the percentage of hard seed in Vicia villosa can be distinctly influenced by the storage temperature and humidity, high humidity usually decreasing the proportion of hard seed.

Many investigators agree that the outside layer of cells of the coats prevent the entrance of water. Coe and Martin (1920) assert that the absorption of water in Melilotus alba seed was not prevented by either

the cuticularized layer or the cone-shaped structures of the Malpighian layer but by the "light line" in that layer. In the coats of the impermeable seeds the light line was usually broader, the Malpighian cells thickened more below the light line, and the main cavities of the Malpighian cells were more reduced and farther below the light line than in the coats of permeable seeds. No canals except occasionally a few very small ones were seen crossing the light line in impermeable seeds.

c. Gaseous exchange

Embryos of seeds being, in the main, completely sealed within the seed coats and often additionally covered with fruit coats and other structures are far from satisfactorily equipped to get the needed oxygen supply from the air. Harrington (1923) found that increased oxygen pressure in the atmosphere greatly increased the germination at room temperature of partially after-ripened Triticum sp. Vlamis and Davis (1943) report that Hordeum sp. seeds undergoing germination are extremely sensitive to oxygen deficiency. Brown (1940) showed that the imbibed seed coat of Cucurbita pepo permits carbon dioxide to diffuse through it several times as fast as oxygen. Many researches might be cited which show that some imbibed seeds are limited in their use of oxygen from the air because of the low permeability of the coats to oxygen.

It is generally agreed by now that the embryo has a certain oxygen pressure demand in order to grow. Crocker and Davis (1914) demonstrated that embryos of seeds of Alisma Plantago, with coats broken, will germinate in the absence of oxygen. Taylor (1942) determined the effect of various oxygen pressures on the germination of Oryza sativa and cultivated Triticum sp. In the absence of oxygen the germination of Oryza seeds was reduced less than 10% below that in air. No germination of Triticum occurred under similar conditions. Considerably less than half of a

normal germination of Triticum resulted in oxygen concentrations below 1%.

Another important fact is that the low permeability of the coats limits the oxygen pressure to the embryo below the minimum necessary for growth. This has been proved on Xanthium by Crocker (1906), Thornton (1935), Shull (1911). These findings although very interesting may not explain the dormancy of any considerable number of different kinds of seeds.

d. Light

Crocker (1936) divides plant species as to the requirements of their seeds for light for germination into the following three groups:
(1) light requiring and light-favoured - many species of Gramineae family, Oenothera sp., Epilobium sp., and very many others are favoured by light, while much smaller numbers will not germinate without light like Viscum album;
(2) light completely or partially inhibits germination - Phacelia, Nigella, Allium;
(3) seeds germinate equally well in light and in dark - Avena, Hordeum, Triticum, Zea mays, many species of Papilionaceae family.
Light-favoured seeds may remain dormant when covered by soil to such a depth as to exclude the necessary light, while light-inhibited seeds may fail to germinate if they are sown with little or no cover.

So far no satisfactory explanation of the action of light upon the germination of seeds has been found although several theories have been offered, postulating that the action of the light is upon the living endosperm or embryo, or that the action is upon the non-living coats. It has been proved that certain changes of chemical nature occur in the germinating seed and there is no doubt that light at least in some instances

plays its share in these biochemical processes.

Different portions of the visible spectrum exhibit varying effects upon the germination, as was proved by Flint and McAlister (1935) on Lactuca sativa seed. They found that the spectrum region 5,200 to 7,000 A (red, orange, and yellow) was stimulative, the region 4,200 to 5,200 A (green, blue, and violet) was inhibitive, and the band 7,000 to 8,600 A (mainly infrared) was even more inhibitive.

Leggatt (1946) studying germination in Agrostis sp. confirmed a fact, long before observed, that potassium nitrate in 0.2% solution proved more effective than light in promoting germination in seeds not fully germinating-ripe. His opinion being that nitrate, while serving in the practical germination test as a partial substitute for light, appears to have an entirely different physiological effect. Akamine (1944) suggests that nitrate may act as a stimulant to hasten the respiratory and perhaps nutritive activity within the seed.

e. Dormant embryos

There are many species of plants with completely developed embryos when the seed is ripe where the seeds nevertheless fail to germinate even when environmental conditions are favourable. There is no doubt that dormancy of such seeds is due to certain physiological condition of the embryo. The embryo of such seeds will not grow when the seeds first ripen even if the seed coats are removed. Examples of this type are seeds of Sorbus aucuparia described by Flemion (1931), Setaria macrostachya - Toole (1940), Arctostaphylos - Giersbach (1937), and many others. On the other hand, there are many kinds of seed with non dormant embryos: Triticum sp. (Deming and Robertson, 1933), Bromus inermis (Coukos, 1944), and others.

Among the plant species with dormant embryos the most common type of dormancy is inability to produce roots. A more complicated type of dormancy is sometime present when the seeds have not only dormant roots but dormant epicotyls as well. This type of dormancy Barton (1936) found in six species of Lilium, Barton and Schroeder (1942) in Convalaria majalis and Smilacina racemosa; and a similar condition might be cited for several more plants.

f. Immature embryos

Several species of plants are known which do not develop embryos with the same rapidity as the surrounding tissues so that at the time of seed shedding the embryos are still imperfectly developed; in some species they have grown little beyond the fertilized egg stage, e.g., Cypripedium parviflorum (Eames and McDaniels, 1947). Similar situation arises when the seeds are removed from the plant before the normal seed shedding. These immature embryos will not produce sprouts under ordinary conditions unless they undergo after-ripening under a suitable environment. On the other hand, Gregory and Purvis (cit. Whyte, 1949) have demonstrated that immature embryos of Secale cereale, removed from the plant as early as five days after fertilization, are capable of producing normal plants in sucrose solution without being subjected to any special treatment.

g. Secondary dormancy

Some seeds which are capable of germination lose this capacity after being kept under unfavourable germination conditions. This induced dormant state in seeds is known as secondary dormancy.

Magnus (1920) found that seeds of Phacelia tanacetifolia when exposed to light in a germinator for a certain period of time fail to germinate even when they are moved back into the dark - they become "lighthard". The reverse is also observed. Some light-favoured seeds when placed in

a dark germinator become "dark-hard" and they will not germinate later in light.

The naked embryos of Xanthium show no dormant tendencies at maturity but Davis (1930) was able to induce dormancy in the embryos of intact seeds at temperatures at which germination ordinarily takes place (about 30°C.), provided that the restriction of gaseous exchange by the seed coats is supplemented by means of clay or agar to a point where germination may not take place. He was able to throw seeds into and out of dormancy repeatedly and at will.

Kidd (1914) showed that high partial pressures of carbon dioxide will inhibit germination of certain seeds and in time throw them into dormancy. Reduced pressures of oxygen make the carbon dioxide effective in lower concentrations. Thornton (1935) induced dormancy in the embryos of Xanthium seeds by placing intact seeds in atmospheres lacking oxygen.

Thornton (1945) states that secondary dormancy, and even primary dormancy, has its inception, it is believed, in the accumulation of intermediate products, formed by partial anaerobic respiration, which act as inhibitors because the oxidation system has been temporarily impaired through an insufficient supply of oxygen.

h. Germination inhibitors

Germination inhibitors are substances produced by plants or substances of related structure not found in plants which inhibit or delay the germination of seeds of the same or other species. The presence of germination-inhibiting substances in plants seems to be a widespread phenomenon. They occur in all parts of plants: in seeds of Brassica nigra (Evenari, 1949), in seeds of Silene coeli-rosa (Borris, 1936), in seeds of Lactuca sativa (Shuck, 1935), in seed coat of Brassica oleracea (cabbage) seeds (Cox et al, 1945), in endosperm of Iris (Randolph and Cox, 1943),

and some others. It has been found that these inhibitors are non-specific in their effects.

Evenari (1949) points out that besides inhibitors, high osmotic pressure and acid pH are often partly responsible for the germination inhibition caused by sap, juices, and extracts, and that germination inhibition is nearly always accompanied by stimulation of germination. Sometimes inhibition and stimulation appear in different concentrations, sometimes one after the other in the same concentration of the same substance. The main known inhibitors are the following substances or belong to the following chemical groups: hydrogen cyanide, ammonia, ethylene, mustard oils, organic acids, unsaturated lactones, aldehydes, essential oils, and alcaloids.

The problem of seeds whose germination is influenced by light or darkness is closely related to the problem of inhibitors. There are many indications that in light germinators an inhibitor is formed during germination which is destroyed by light or by application of certain chemicals (Gassner, 1915, cit. Evenari, 1949). With darkness germinators the inhibitor could be a photodynamic substance which inhibits only in the presence of light (Magnus, 1920).

2. Methods of Overcoming Dormancy

By applying suitable methods dormancy in many kinds of seeds can be broken, in other kinds of plants the dormant period can be shortened. The methods for breaking of dormancy vary, depending upon its cause.

a. Rupturing or weakening the seed coats.

When the cause of dormancy is in the seed coat, it can be interrupted by scarification. Several types of scarification can be applied.

It was long ago observed in agricultural practice that machine-threshed legume seeds usually show a higher percentage of germination than those that have been harvested by hand: the mechanical treatment scratched or cracked many of the seed coats to permit water uptake. This has been proved experimentally with Lathyrus hirsutus (Justice and Harks, 1944), with Vicia villosa (Jones, 1928), and many others.

Strong mineral acids, mostly concentrated sulphuric acid, have been used successfully to interrupt seed dormancy caused by resistant and impermeable seed coats. Length of immersion in conc. sulphuric acid depends upon the strength of seed coat. Lemmon et al (1943) showed the optimal period of time for Lathyrus maritimus as being 20 minutes, Brown and Porter (1941) for Convolvulus arvensis, 45 to 60 minutes.

Pfeifer (1934) showed on Symphoricarpos racemosus that when seeds were kept for a longer period of time in a moist substratum at higher temperatures, the seed coat became subject to decomposition by fungi with the ultimate result of seed coat softening, which permits the penetration of water into the seed. Giersbach (1934) showed with seeds of Cotoneaster sp. that the coat factor is overcome by a period of 3 to 4 months in moist soil at 15° to 25°C.

b. Temperature

The dormant embryos can be thrown out of dormancy or after-ripened when they are kept for certain period of time in moist substratum at low temperature (above freezing point), i.e. stratified at low temperature.

Barton (1930) showed that seeds of most coniferous plants after-ripen when they are stratified at 5°C. for a period of two months. Some species after-ripened during one month of stratification, while in a few cases the stratification period had to be extended up to three months. A few species responded best to temperatures other than 5°C., viz., 0°C., 10°C.

Flemion (1934) worked with seeds having hard coats and dormant embryos. She was able to induce germination by placing the seeds of Symphoricarpos racemosus for a period of three to four months in moist acid peat moss at 25°C., or by soaking the seeds in conc. sulphuric acid for 75 minutes, thus destroying the seed coat, which was followed by stratification of six months at 5°C. to after-ripen embryos.

For Lilium sp. Barton (1936) applied the following method.- Roots were produced at room temperature once they are not dormant and then they had to be exposed from six weeks to three months at low temperature (1°to 10°C.) to overcome the epicotyl dormancy.

Trillium grandiflorum and some other plants produce seedlings after two separate low temperature treatments. Barton (1944) obtained satisfactory results by stratifying the seeds at low temperature to overcome root dormancy followed by a period at high temperature for root production and finally a period at low temperature to overcome epicotyl dormancy.

Freshly harvested seeds of Avena, Hordeum, Triticum, etc. which do not exhibit very deep seated dormancy in the embryo can successfully germinate after pre-chilling of several days at low temperature or giving lower germination temperatures (12° to 16°C.) as shown by Harrington (1923a).

Harrington (1923) and the practice of seed testing laboratories show that many kinds of seeds germinate better when they are subjected to daily alternating temperatures, e.g., 18 hours at 20°C. and 6 hours at 30°C. Many Gramineae, Compositae, etc., species belong to this group. This action of the alternating temperatures upon the seed is not understood.

c. Dry storage

Duchartre (before 1885, cit. Harrington, 1923), working with Secale,

Triticum, and Hordeum, was one of the first to call attention to the beneficial effect of artificial drying on the germination of seeds. He found that after artificial drying the seeds of small grain were capable of germination when they were still far from mature and their endosperms were just leaving the milk stage. Similar results were obtained by Harrington (1923). He found that artificial dry heating was effective in varying degree in inducing the germination at room temperature of seeds not after-ripened or partially after-ripened Triticum, Avena, and Hordeum.

Dormancy can be overcome by dry storage of seed as well. Herman and Herman (1939) showed on Agropyrum cristatum, which did not germinate well immediately after harvest, that storage of the seed resulted in increased and accelerated germination. The storage period necessary for good germination was shorter in more mature seed.

Beneficial effect of artificial drying and dry storage in overcoming dormancy has been demonstrated on seeds of many species.

3. Inheritance of Dormancy

It seems very likely that dormancy in seeds is controlled by genes. Kiessling, 1911 (cit. Harrington, 1923) found striking differences, constant from year to year, in the individual dormancy and rate of after-ripening of different varieties and pure strains of Triticum, Avena, and Hordeum. It appeared evident to Harrington and Knowles (1940) that the inheritance of sprouting resistance in Triticum is not governed by a single gene. Toole and Coffman (1940) have reported that a marked difference was found in the proportion of dormant seeds of Avena fatua from different localities, and a wide variation in dormancy occurred among plants from any given locality. Lute (1938) showed that different collections of Avena

fatua may differ in dormancy even after having been grown and harvested under uniform conditions. Johnson (1935), from a study of delayed germination of Avena fatua X A. sativa, observed that germinability is dominant over dormancy.

MATERIALS and METHODS

a. Materials

The following weeds were selected for the purposes of this study:

(1) Setaria glauca P.B. (yellow foxtail),

(2) Rumex acetosella L. (sheep sorrel),

(3) Silene noctiflora L. (night-flowering catchfly),

(4) Portulaca oleracea L. (purslane),

(5) Brassica arvensis (L.) Ktze (wild mustard),

(6) Plantago lanceolata L. (ribgrass),

(7) Ambrosia artemisiifolia L. (common ragweed),

(8) Chrysanthemum leucanthemum L. (ox-eye daisy).

According to the Canada Seeds Act, 1937, these weeds fall into the following three groups: (1) primary noxious - Brassica arvensis, Chrysanthemum leucanthemum; (2) secondary noxious - Silene noctiflora, Plantago lanceolata, Ambrosia artemisiifolia; (3) other weeds - Setaria glauca, Rumex acetosella, Portulaca oleracea.

A total of 41 samples was collected at different places in the Province of Quebec during the summers of 1949 and 1950. Harvesting date of each sample as well as county where the sample was collected and 1,000-seed weight are given in the Appendix Table No. 1. The intention was to collect fully mature seeds, but the author was not in all cases sure that he was successful. Six samples were collected before the seeds were fully ripe: (1) samples No 118 and 122 of Silene noctiflora were harvested from closed pods with seeds not yet having reached the colour of mature seed; (2) Setaria glauca samples No 122-G, 113-G, 127-G, and 128-G were collected in the milk stage of ripeness or somewhat later, with lemmas and paleas still green in colour. The sample 113-G was riper than the other immature samples, with hulls green in colour but with almost fully developed caryopses. - Seeds of Plantago lanceolata sample No 102a were

extremely small but well mature; this condition was probably caused by premature ripeness because of heavy attack of grasshoppers.

Germination in the laboratory was carried out in glass test tubes one inch in diameter and five inches long. The tubes with the seeds placed on blotting paper were kept closed with a cork stopper. A special kind of blotting paper was used as a substratum in tubes. It was devised for use in the seed testing laboratories of Canada and was obtained through the kind cooperation of the Department of Agriculture at Ottawa.

Ordinary petri dishes - 1.5 cm high and 10.0 cm in diameter - were used as containers in the laboratory stratification (') experiments. The low temperature necessary for stratification was obtained in a commercial refrigerator.

(') The term stratification in this study mainly indicates the effects of temperature applied to moist seeds with the aim of inducing changes in the embryo or in the seed coat such that germination becomes possible when they are afterwards subjected to conditions favourable for germination. Dormant embryos after-ripen when they are given stratification treatment at low temperature. Hard coats usually soften and become permeable to water as a result of the action of microorganisms when the seeds are given stratification treatment at higher temperature. Any method where the seeds undergo the temperature treatment in the above mentioned meaning can be referred to as stratification, e.g., seeds which are present in the ground undergo natural stratification at low temperature in fall and in early spring, and stratification at higher temperature during late spring, summer, and early fall.

All the experiments in which the soil was involved were carried out in ordinary clay pots 4-inch in diameter. In experiments for the purpose of testing the germinating capacity in the laboratory after stratification in the field, each lot of 100 seeds was wrapped in a 4 x 4 inch piece of white nylon cloth.

The soil for filling the pots was sterilized to kill any weed seed that might be present in unsterilized soil. The sterilization was performed in the corn drier of Agronomy Department at 105°C. for 5 hours by means of hot air blast.

b. Methods

Technique of germination tests in the laboratory.

Seeds in lots of 100 were placed on a moist 2 x 4 inch blotting paper and rolled in a form to fit the inside of the test tubes. The test tube with planted seeds inside was sealed with a cork stopper to prevent undue drying out of the substratum. Every test comprises two test tubes with 100 seeds in each, unless stated otherwise.

As the slips of blotting paper were two inches wide they covered a little less than two thirds of the test tube surface while a little more than one third was free for access of light. The light source was the diffuse day-light coming into the laboratory through very large windows. The test tubes in trays were kept on the table approximately two and a half yards from the window. Germination tests in darkness were carried through by keeping the test tubes in tightly closed aluminium boxes.

In most cases the seeds were given germination tests at the temperatures of 20°C., 30°C., and alternating temperature from 20° to 30°C. One incubator was kept all the time at 30°C. It was equipped with an automatic thermoregulator which kept the temperature constant within the

range of 1°C. As there was no equipment to keep the temperature constant at 20°C. and the installation of new germinators comprising an air conditioning system was not feasible, the 20°C. temperature was simulated by the room temperature. For purposes of this paper "20°C." will be used in further chapters having in mind that it was actually room temperature. Fortunately, the fluctuation of temperature in the germinating room was not very large, and in the majority of tests the actual temperatures were very close to 20°C. Larger discrepancies were observed in short hot periods during the summer - temperature rose in the room to 26°C. - and for a few days in October before the heating system of the building started to function - the temperature fell as low as 16°C. Only a few tests were in progress during the periods of those extreme temperatures. The daily alternating temperature of 20°-30°C. was obtained by keeping the seeds for 6 hours (from 4 p.m. until 10 p.m.) in the incubator at 30°C. and the remaining part of the day at 20°C.

Germination of unstratified seed in the soil.

Seed samples collected in the summer 1949, and kept in dry storage through the winter were given a germination test in May, 1950, in sterilized soil. Three types of soil were used: heavy soil, pure sand, and mixture of heavy soil and sand in equal parts. Seeds in lots of 100 were sown in each 4-inch pot. Three depths of sowing were applied for each of the soil types: one quarter, one half, and one inch. The layout of the experiment was according to a split plot design with two replications. Samples and replications were in the first subdivision, the types of soil were in the second subdivision, and depths of sowing made the third subdivision. The properly randomized pots for each weed separately were kept in the greenhouse. The experiment was begun on May 18-22nd, 1950, and discontinued on September 14th, 1950.

Stratification in the laboratory.

Seeds in lots of 100 were placed on three layers of blotting paper in Petri dishes. Care was taken to supply an adequate amount of moisture. Thus prepared seeds were kept in a commercial refrigerator in which the temperature ranged from 1° to 7°C. at regular intervals, every one and one quarter of an hour.

Stratification in the field.

For the stratification experiment under field conditions throughout the winter the seeds were prepared in two ways: (1) seeds, in lots of 100, were wrapped in a piece of nylon cloth; four such lots were put in a 4-inch pot filled with soil and were covered with a half inch soil layer so that the pot was full to the top; (2) the pot was filled with sterilized soil up to half an inch from the top; 100 seeds were planted on the surface of soil in each pot, then covered with one quarter of an inch of the same soil and pressed; one sheet of a chemically pure filter paper was put on this surface and the remaining space of the pot filled with sterilized soil up to the top. A mixture of heavy soil and sand in equal parts was used. All the pots were buried in the ground and covered with one and a half inches of soil, so that from the seed to the surface of the cover there was a soil layer of two inches thick. Equal numbers of pots were buried in the ground (1) behind the greenhouse (= Loc. Gr.) of Horticulture Department (soil almost gravel, comparatively dry, fully exposed to sun) and (2) behind the barn (= Loc. Ba.) of Agronomy Department (heavy soil, lower placement thus containing more moisture, partly protected from sun by a small tree, snow thawed five days later than at Loc. Gr., and the soil temperature at seed level was from 2° to 10°C. lower than at Loc. Gr. through May). The pots with seeds were buried in the ground on November 19th, 1949, and kept there until May 1-6th, 1950, but

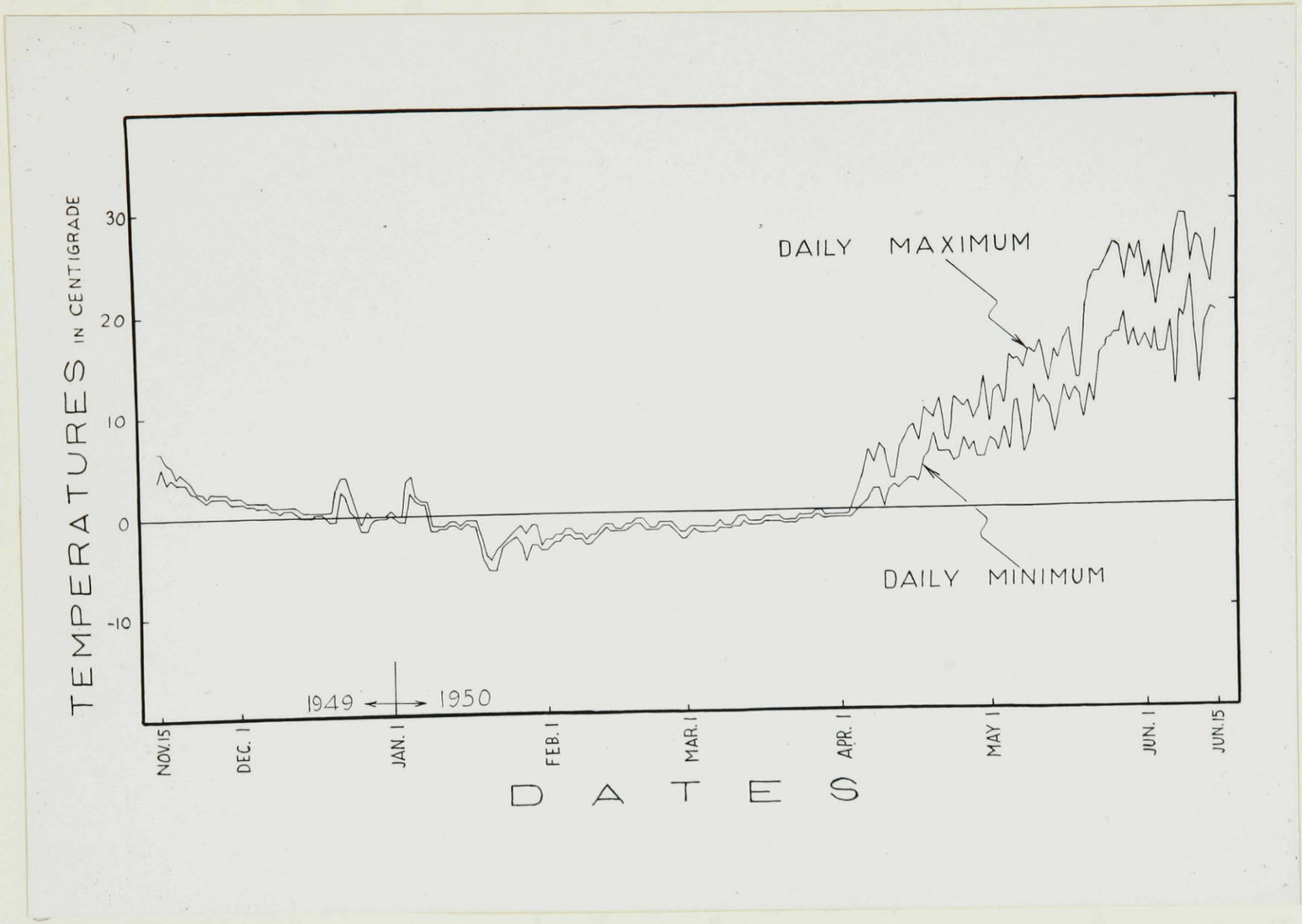

Fig. 1.- Daily maximum and minimum temperatures four inches deep in the soil at Macdonald College.

one third of pots with seed in nylon were left in the ground until June 14-16th, 1950. Daily maxima and minima of soil temperatures at four inches depth are given in Fig. 1. These data were recorded by the Meteorological Station at Macdonald College.- Seeds from nylon were given a germination test in the laboratory, while those sown in soil were tested in the original pots in the greenhouse under controlled temperature conditions.

Scarification.

Concentrated sulphuric acid was applied as a scarifying agent. Seeds were scarified in 100-seed lots. The seeds were placed in a 250 cc beaker and one half to one cc of acid was poured over them stirring with a glass rod. After the scarification time had passed excess of tap water (200-220 cc) was poured into the beaker and decanted. This operation was repeated and the seeds were left in the water for several minutes. Then the seeds were collected on filter paper and washed again for 15-20 minutes. The washed seeds were dried at room temperature for about 15 hours and given a germination test.

Other methods applied on seed coats.

(1) Caryopses of Setaria glauca were freed from hard and tightly closed lemmas and paleas with the help of a dissecting needle. (2) Ambrosia artemisiifolia seeds were released from the flower and very hard fruit enclosures also by the use of a dissecting needle. Because of the hardness of these enclosures and the fact that the seeds are comparatively small, the proper seed coat consisting of living cells was often slightly injured. The proper seed coat was removed after the seeds had lain on germination substratum for 3-6 days. (3) Plantago lanceolata embryos were freed from the seed coat and endosperm by cutting the end of a boat-shaped seed with a sharp scalpel or with the help of two dissecting

needles the seed was torn longitudinally thus releasing the embryo from coat and endosperm. No nutrient-substratum was used for embryos thus excised. (4) In the case of Silene noctiflora the hilum part of the seed coat was torn apart with a certain amount of endosperm with a dissecting needle.

Statistical analysis.

The data were analysed after the obtained values in percentages were transformed into angular units, $\sin.^2 \theta$ (Hayes and Immer, 1942). Observed data, transformed values, and statistical analysis can be found in the Appendix. The means and the necessary differences for significance in Appendix tables were obtained from transformed values. Means of observed data only are given in the Text-tables or produced in form of graphs.

Three types of statistical analysis were used. One experiment of each type is given in the Appendix with details of analysis showing how it was carried out. (1) In the majority of experiments the data were obtained from germination tests in the laboratory. Two lots of 100 seeds of every test were considered as being duplicates; the variance for duplicates only giving an idea of the precision of the laboratory technique. The aggregate of all the interactions containing "samples" was used as a valid error. The reason for doing so was the fact that in germination tests in the laboratory it is practically impossible to have replicates, and the next best source of random variation is provided by "samples" (Appendix Table No 41). (2) Experiments on winter-stratification of seeds sown in soil were analysed as an ordinary randomized block with three replications, where each treatment was represented by three pots (Appendix Table No 54). (3) Experiment on germination of non-stratified seed in three types of soil at three depths was arranged on the system of a split

plot. In the first subdivision "samples" and "replications" were taken, in the second - "soils", and in the third - "depths". (Appendix Table No 62).

GERMINATION OF FRESHLY HARVESTED SEED AND THE EFFECT OF DRY STORAGE

The seeds for this experiment were stored under ordinary conditions in the laboratory. As the building was heated during the winter, the seed samples were seldom if ever exposed to temperatures lower than 20°C. The relative moisture of the air in the laboratory was not measured.

This experiment was carried through with intact seed. The purpose of this experiment was to determine the germinating capacity soon after harvest and the changes that occur during dry storage.

Not all the samples were given germination tests immediately after harvest in 1949. The laboratory equipment was completed on August 20th, 1949, and the germination tests were begun that very day. Some samples were collected early in July, 1949, thus they were stored in the laboratory for 40-50 days until they got the first germination test. The seeds harvested in 1950 were given the first tests 3-5 days after collection.

This experiment was partly aimed at obtaining information on the effects of temperature and light on seed germination. Considering the facilities available in the laboratory, it was thought that the following temperature and light treatments would provide the information sought:

(1) in dark at the constant temperature of 20°C.,
(2) " " " " " " " 30°C.,
(3) in light " " " " 20°C., and
(4) " " at the daily alternating temperature from 20°C. to 30°C.

The seeds used in the germination tests were not sterilized. The advisibility of seed sterilization with chlorine solution was considered. Preliminary trials showed that chlorine oxidises the mucilaginous layer on Plantago lanceolata and Brassica arvensis seed thus possibly being capable of affecting the germinability of the seed. This observation led to the decision to carry through all the experiments with unsterilized

Table I.- Summary of significance of comparisons for the germination tests of intact seed

	Year of harvest	Treatments					Germination dates
		Temperature		Light			
Setaria glauca	1949	**	Lo.	**	Li.		**
Rumex acetosella	"	**	Hi.	**	Li.		**
Silene noctiflora	"	*	Lo.	**	Li.	at Hi.	
" "	1950	**	Lo.	**	Li.	at Hi.	**
Portulaca oleracea	1949	**	Hi.	*	Li.	at Lo.	**
Brassica arvensis	"			**	Li.		**
" "	1950	**	Hi.	**	Li.		**
Plantago lanceolata	1949	*	Lo.				*
Chrysanthemum leucanthemum	"	**	Lo.	**	Li.		
" "	1950	**	Lo.	**	Li.		**

* Significant at .05 level,

** " " .01 "

Letters after the asterisks indicate significance - meaning a significant positive treatment:

Lo. - lower temperature (20°C.),

Hi. - higher " (30°C. and 20°-30°C.),

Li. - light.

seed. During the course of the experiments it appeared that the attack of fungi was somewhat higher on freshly harvested seed but only on seed of Setaria glauca, Rumex acetosella, and Ambrosia artemisiifolia was this clearly evident. The structures of the three mentioned species, called

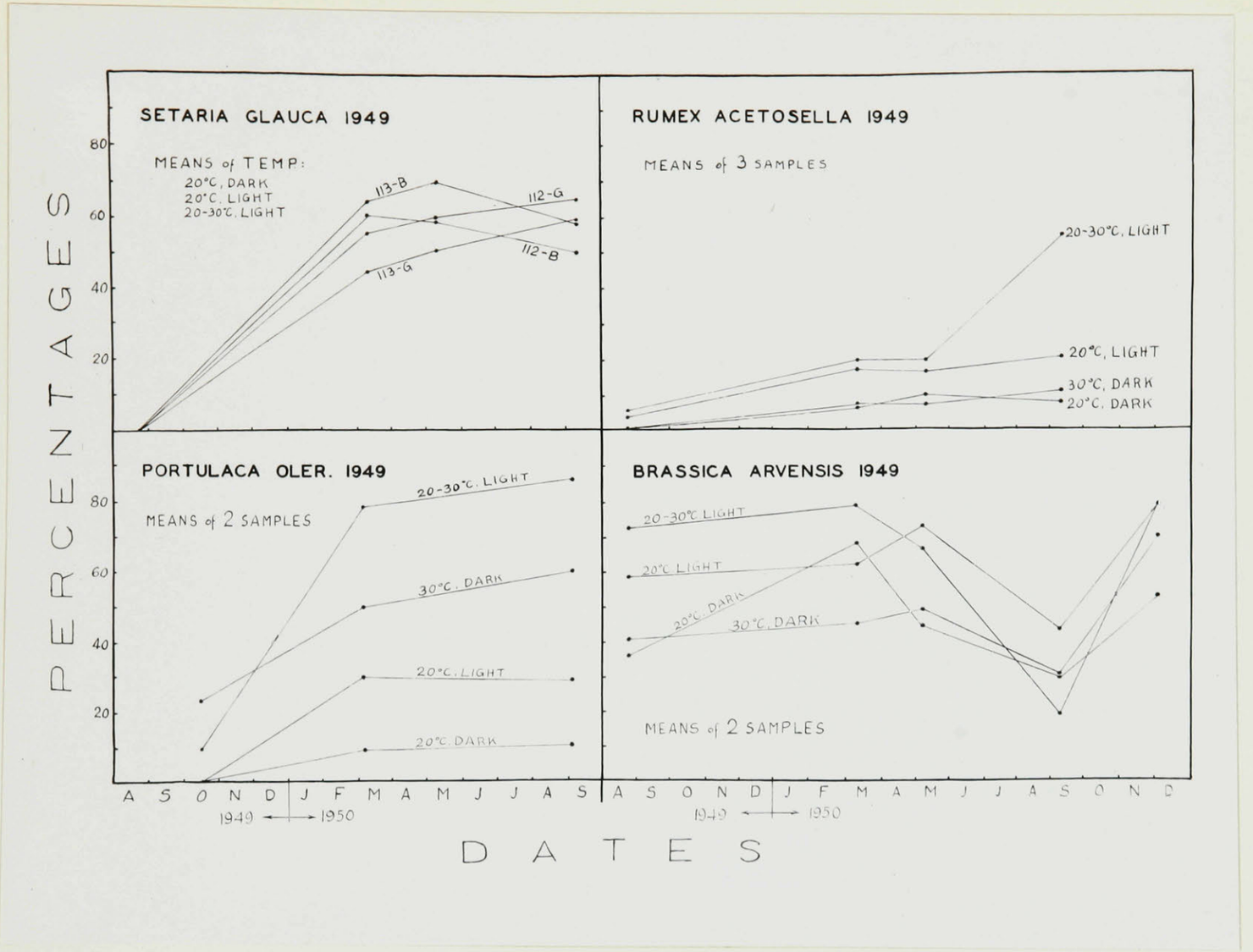

Fig. 2.- The effect of dry storage upon the germination of intact seed of Setaria glauca, Rumex acetosella, Portulaca oleracea, and Brassica arvensis.

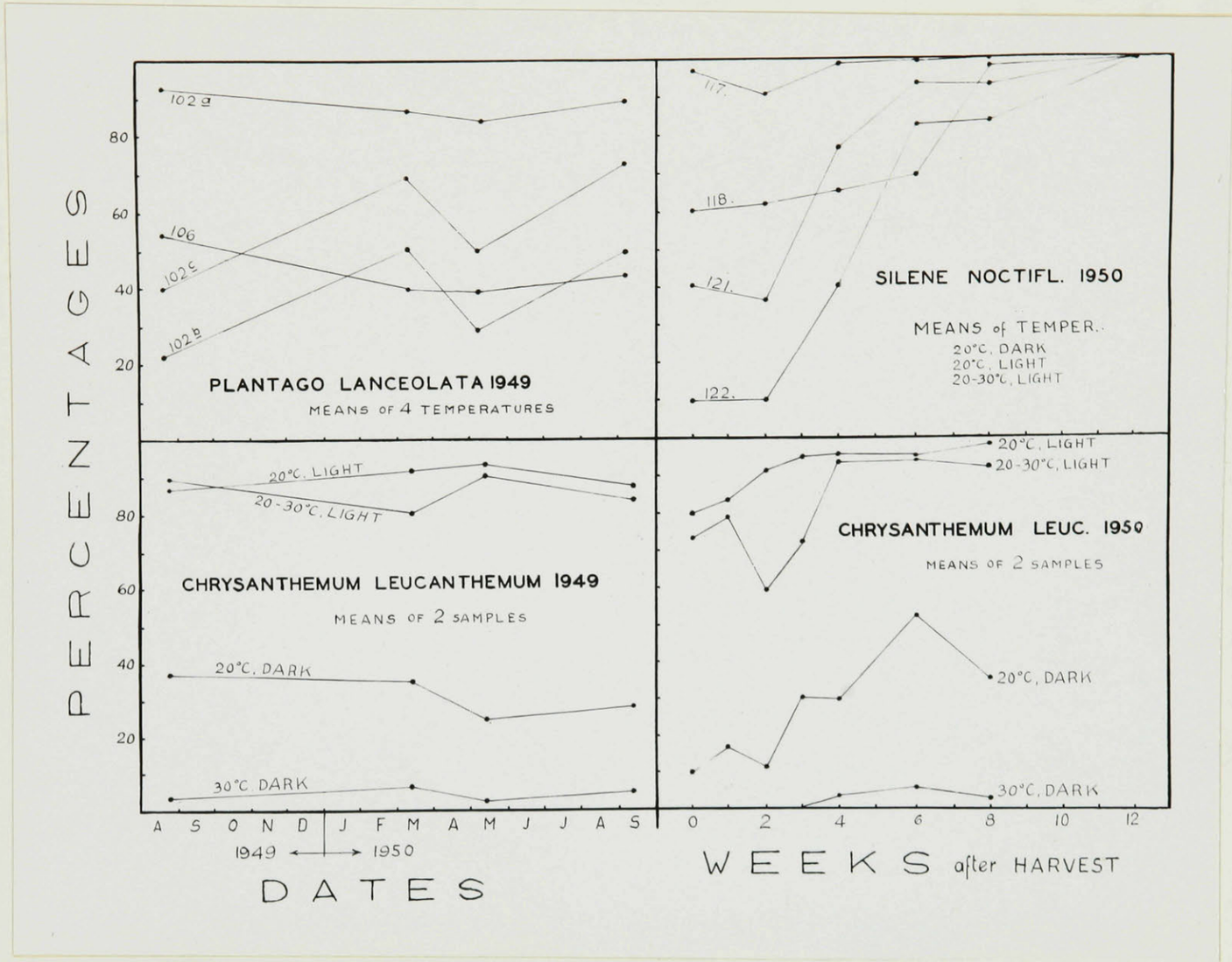

Fig. 3.- The effect of dry storage upon the germination of intact seed of Plantago lanceolata, Silene noctiflora, and Chrysanthemum leucanthemum.

"seeds", are actually more than seed in a strict morphological sense: they are fruits covered with fruit coats and other floral structures. Therefore they are exposed to free air and infection by fungi during growth and ripening, while in other species, which produce seeds enclosed in pods (except Chrysanthemum leucanthemum), the spores of fungi do not have any possibility of entering the interior of the pod.

Fast germinating species (Brassica arvensis and Silene noctiflora) were kept in the germinator for 14 days, while all other species so treated for 28 days. It was felt that for some species the germination period of 28 days may be too short, but the technical considerations did not permit extending the length of germination period, except on special occasions.

Some data of the experiments are produced in Figs. 3 and 4, and the summary on significance of comparisons in Text Table I. The complete set of data and statistical analyses are given in the Appendix Tables No 2-16.

Setaria glauca.

Freshly harvested intact seeds did not germinate at any of the temperatures and light treatments either in 1949 and 1950.

The germination rate increased markedly following dry storage, but seeds of the 1949 harvest failed to reach full germination in 14 months. From Fig. 2 we can see that the germination of mature samples (112-B and 113-B) began to decrease with the summer of 1950, while the germination of immature ones (112-G and 113-G) increased slowly but continuously until the last germination test in September, 1950. The mature samples gave higher germination over the immature ones seven months after harvest with highly significant differences. The differences were still significant nine months after harvest. Thirteen months after harvest the immature

samples gave a higher germination than the mature lots but the differences were not significant.

The 1950 seeds were given three germination tests in four months. The germination was very poor two months after harvest as shown in Text Table II. At the end of fourth month of dry storage the sample 128-B reached almost full germination, Text Table III. This shows that dry

Table II.- Germination of Setaria glauca harvested in 1950 (means for temperature and light treatments and germination dates)

Germin. dates	20°C., dark	30°C., dark	20°C., light	20°-30°C. light
Aug. 16, 1950	0	0	0	0
Oct. 16, "	4.0	0	7.2	2.4
Dec. 15, "	47.5	3.4	63.2	50.1

storage has not in every case a similar effect on increasing the germinating capacity of intact seeds. The cause of different response to storage was not determined.

Table III.- Germination of Setaria glauca harvested in 1950 (means for samples and germination dates)

Germin. dates	127-B	127-G	128-B	128-G
Aug. 16, 1950	0	0	0	0
Oct. 16, "	0.5	0.7	15.8	1.2
Dec. 15, "	32.3	36.5	85.7	60.0

Light appeared to be an important factor in stimulating the germination, in all instances having given highly significant positive differ-

ences. Germination in the dark at a lower temperature (20°C.) was considerable but lower than in the light. High constant temperature (30°C.) in the dark was very unfavourable for germination.

Rumex acetosella.

Seeds germinated very poorly (1949 harvest) or did not germinate at all (1950 harvest) soon after collection. The germination improved slowly in dry storage. The seeds stored for 13 months germinated somewhat better at alternating temperatures, Fig. 2: the sample No 107 giving the highest germination percentage - 72.5. In other germination conditions the percentage of sprouting was comparatively low. It was observed that both light and higher temperatures favoured the germination and the differences were highly significant.

Silene noctiflora.

Seeds of 1949 were given the first germination test 45 and 25 days after harvest. By that time all the samples already showed very high germinating capacity, and it stayed this high until the end of the trials.

Seeds harvested in 1950 did not give full germination soon after harvest. The germination improved in dry storage and by the end of three months of storage all the samples both mature and immature germinated very well, Fig. 3. The germination of immature samples (No 118 and 122) increased slower than that of mature ones.

There was a pronounced difference in germination at 30°C. in the dark between 1949 and 1950 samples. Seeds harvested in 1950 did not germinate at 30°C. in the dark for 6-8 weeks. After 12 weeks of dry storage they germinated moderately, the mature samples giving higher percentages than the immature ones. The sample No 109 of the 1949 crop also showed somewhat lower germination at 30°C. in the dark; four weeks after harvest

it gave 65.5%, while seeds of the 1950 crop did not germinate at all after four weeks storage. The samples No 101a and 101b of the 1949 crop germinated very well at 30°C. in the dark. The condition induced in seed by the 30°C. temperature was not changed by placing the seed at 20°C. for 15 days - they still failed to germinate.

Seeds of 1950 showed a pronounced variation at alternating temperatures (20°-30°C.) during eight weeks after harvest. This was probably the result of the higher temperature employed.

There was no difference in germinating capacity between light and dark treatments at 20°C., irrespective of the degree of maturity and of the year of collection.

Portulaca oleracea.

Dry storage was beneficial in increasing the germinating capacity, Fig. 2. Freshly harvested seeds did not germinate at 20°C. On the average the seeds germinated much better at higher temperatures. During the first couple of months after collection better results were obtained at the constant temperature of 30°C., while after prolonged storage the germination was higher at alternating temperatures of 20°-30°C.

Light did not appear to be the most important factor, although it resulted in significantly higher germination at lower temperatures.

P. oleracea seeds germinate rather slowly. Some samples kept germinating to some extent beyond the four week period, but for the purposes of this paper data were only used which were obtained during the germination period of 28 days.

Brassica arvensis.

The seeds collected in 1949 germinated well after three weeks of dry storage, while those cropped in 1950 gave very low germination per-

centages at any of the temperatures and light treatments applied, even after storage of eight weeks.

As far as the germination temperatures were concerned the 1949 seeds on the whole showed no difference whether they were given a germination test at higher or at lower temperatures. This was not the case with the 1950 seed; higher temperatures favoured the germination more than lower temperatures and the difference was highly significant.

Light was beneficial in increasing the germination of B. arvensis seed of both 1949 and 1950 crops and at both lower and higher temperatures, all the differences being highly significant.

The temperature of 30°C. in the dark and of 20°C. in the light favoured germination equally for 1950 seed, though the best conditions were at alternating temperatures of 20°-30°C. in the light as can be seen from Text Table IV.

Table IV.- Germination of Brassica arvensis harvested in 1950 (means for temperature and light treatments and germination dates)

Weeks after harvest	20°C., dark	30°C., dark	20°C., light	20°-30°C., light
0	0	0.5	0.5	0.7
4	0.5	0.2	0	0.2
8	0.5	0.7	1.0	3.5
12	2.5	21.5	14.2	26.0
16	5.5	27.2	31.2	57.5

The germination percentages of the 1949 seed began to drop after nine months of storage (in May, 1950). By 13 months of storage (in September, 1950) the germination was lower than three weeks after harvest in 1949.

But the seeds had not lost their germinating capacity by that time, for after 16 months of storage (in December, 1950) the germination on the average was higher than at any date before.

Plantago lanceolata.

Pronounced differences in germination were encountered between samples. Sample No 102a had the smallest seed most probably caused by the premature ripeness brought about by the heavy attack of grasshoppers. That means that the seed coats and endosperms were not fully developed and were thin, thus the sprouting embryos were able to break them easily. The samples No 102b, 102c, and 106 had heavier seeds, thus the seed coats were better developed and thicker, causing lower germination.

Neither the light nor the temperature under the conditions employed appeared to be important factors in the germination of intact seed.

The germination percentages of the samples No 102a and 106 decreased slightly after eight months of dry storage and again increased slightly after the following six months, Fig. 3. The samples 102b and 102c - incidentally both being harvested later in the season - increased in germination percentage until early spring, by May the germination fell markedly only to increase again by September.

Ambrosia artemisiifolia.

Freshly harvested seeds did not germinate under any conditions used in this experiment. The germination of the 1949 seed increased during the 10 months of storage but only at the alternating temperature of 20°C-30°C. in the light as can be seen from the Text Table V.

It was observed that A. artemisiifolia seeds germinated somewhat after they were left in the germinator beyond the normally used germination period of 28 days.

Table V.- Germination of Ambrosia artemisiifolia harvested in 1949 (means for temperature and light treatments and germination dates)

Germin. dates	20°C., dark	30°C., dark	20°C., light	20°-30°C., light
Nov. 4, 1949	0	0	0	1.0
May 8, 1950	0.2	0	0	1.7
Jul. 18, 1950	1.2	1.2	3.2	24.7
Nov. 22, "	1.7	1.7	4.0	35.7

Chrysanthemum leucanthemum.

Seeds of 1950 germinated well soon after harvest: the germination was over 90% after 2-4 weeks of storage. Germination of 1949 seed was slightly lower, Fig. 3.

On the average, lower temperatures (20°C.) provided better conditions for the germination and the differences were highly significant.

Light is a very important factor in germination of C. leucanthemum seed; it was beneficial at both lower and higher temperatures, the differences being larger at higher temperatures. Exclusion of light at 30°C. inhibited the germination almost completely, while a considerable amount of seeds germinated at 20°C. The differences light vs. dark were highly significant in all instances.

The inhibition of germination by exclusion of light is not deep seated, i.e., seeds in a dark germinator do not become "dark hard". In several trials seeds from the dark germinators - after the routine germination test of 28 days was completed - were transferred on the original blotters into light at 20°C. for 14 days. The germination was almost complete and

and equal from both sources (20°C. and 30°C.), meaning that the temperature inhibition, if any, was also not deep seated, Text Table VI.

Table VI.- Germination of Chrysanthemum leucanthemum seed when, after their failure to sprout in the dark during 28 days, they were given a germination test in the light for 14 days.

		Germ. %		Germ. %
28 days at	20°C., dark -	10.3	30°C., dark -	0.1
+ 14 days at	20°C., light -	79.2	20°C., light -	86.2
Total		89.5		86.3

Discussion.

According to their germinating capacity, freshly harvested seeds form the following two groups: (1) none or poor germination - Brassica arvensis of 1950 collection, Setaria glauca, Ambrosia artemisiifolia, and Rumex acetosella; and (2) fair or good germination - Brassica arvensis of 1949 collection, Silene noctiflora, Portulaca oleracea, Plantago lanceolata, and Chrysanthemum leucanthemum.

Dry storage, on the average, was beneficial in increasing the germinating capacity of seed. The after-ripening (') was slow for A. artemisii-

(') The term "after-ripening" and the verb "after-ripen" have been rather extensively used in the literature dealing with the problem of dormancy in seeds. The usage of these terms is not confined to a particular phase of dormancy. Dormant embryos can be thrown out of dormancy by low temperature stratification, or it can be said that seeds can after-ripen in low temperature stratification. Dry storage or artificial heating can force

folia, R. acetosella, and B. arvensis 1950. S. glauca seed, although after-ripened considerably, failed to reach high germination even after 13 months of storage. There are many reports in the literature showing that seeds after-ripen on dry storage. Even seeds with dormant embryos at least partially after-ripen, although this treatment is not nearly as effective as low temperature stratification.

After-ripening in dry storage reduces or entirely eliminates the need for light in various light-favoured seeds. Crocker (1936) showed that Poa caryopses kept in dry storage for one year germinated equally well in darkness and in light. After-ripening partially eliminated light need in Chloris, Ranunculus, Epilobium, and Oenothera achenes or seeds. Similar results were obtained in our experiments with C. leucanthemum: the germination percentage increased at 20°C. in the dark as a result of dry storage, but it failed to increase at 30°C. in the dark.

As previously mentioned the germinating capacity of B. arvensis 1949 markedly dropped during the summer season of 1950. Two samples of P. lanceolata behaved similarly, although in the latter case the decline in

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the dormant embryos to after-ripen, i.e., induce germination. There is no doubt that during the process of after-ripening some changes of chemical nature occur in the embryo. What these changes are cannot as yet be satisfactorily answered. Dormant seeds with non-dormant embryos can be after-ripened in low temperature stratification, too. In the latter case the stratification treatment affects the seed coats only, for the embryos are non-dormant. Any changes in seed coats promoting the germination and brought about by the effects of temperature application are usually included in the conception of "after-ripening".

germination was not as pronounced as in B. arvensis. This phenomenon, if successfully proved by more extensive experiments, might lead to a statement establishing the existence of seasonal periodicity in germination of B. arvensis seed. Some experimental evidence on this subject can be found in the scientific literature. Brenchley and Warington (1930) working on the natural weed seed populations in soils of Rothamsted and Woburn Experimental Stations found that comparatively few species germinate freely throughout the year. Most species show definite periodicity, the majority of seedlings appearing during the fall or winter, or both, and relatively few in late spring and summer. Leggatt (1946) working with the seeds of three Agrostis species observed a falling off in germination capacity accompanied by an absolute increase in germination speed during the period February-March.

Local observations on B. arvensis showed considerable sprouting in October, 1950, Fig. 4, after the spring sown crop (oats) was harvested in August. On the average, 225,000 sprouts per acre were found. The distribution of sprouts in that field was not uniform: it varied from patches with no sprouts to patches with the population as large as one and a quarter million per acre. It was not possible to distinguish whether the sprouts emerged from seeds shattered in 1950 or from seeds present in soil from previous years but both seemed likely.

Besides B. arvensis, in October 1950 fresh sprouting was observed of C. leucanthemum, A. artemisiifolia, and R. acetosella in comparatively small proportions. Evidence was obtained that the sprouts could not possibly originate from seed shattered in 1950. No young sprouts of S. noctiflora and S. glauca could be found in October, indicating that neither fresh nor old seed have produced sprouts in the fall.

These observations in general agree with the results obtained in

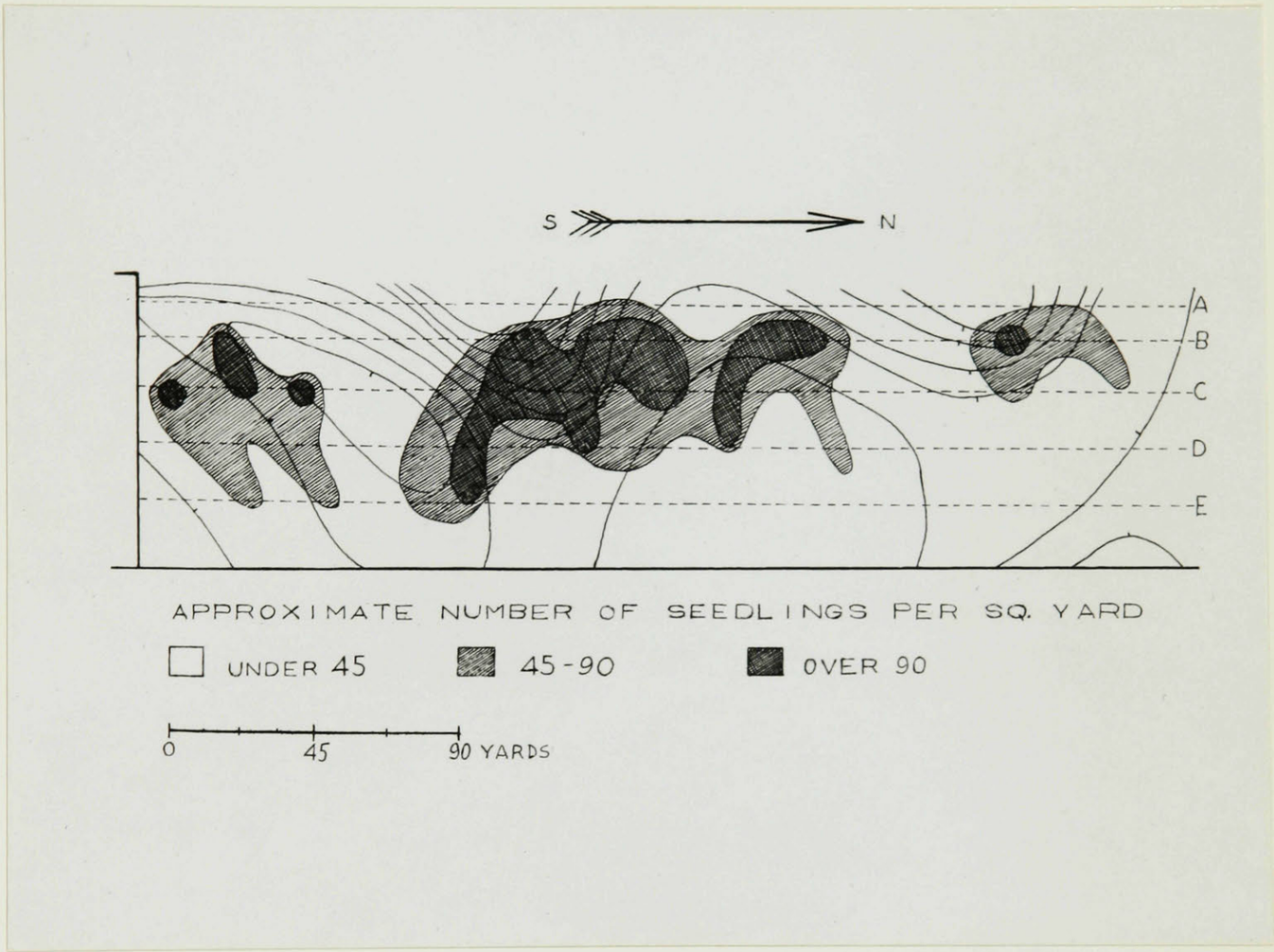

Fig. 4.- Distribution of Brassica arvensis seedlings in a 6 acre field in Jacques Cartier county in October, 1950. Oats were grown in this field until maturity and harvested in August, 1950. The distribution was estimated as follows: the seedlings were counted in an area of one square foot selected at random every 10 yards on the lines A, B, C, D, and E.

the experiments for all except S. noctiflora. Fresh seed of it germinated reasonably well in the laboratory, but failed to produce sprouts when shattered from the pods directly on the ground; they were lying on the surface or had been embedded in the soil under conditions which would be considered as being favourable in the laboratory tests. Also it was observed that in the field of about four acres in which the sample No 101 of S. noctiflora was collected in 1949, not a single plant was found in 1950. The experiments conducted with S. noctiflora do not provide evidence to account for these phenomena.

THE EFFECT OF STRATIFICATION UNDER LABORATORY CONDITIONS

The seeds were stratified on blotting paper, only. Blotting paper was selected not because it was thought to be the best substratum for that purpose, but simply because of technical considerations, e.g., small size of seeds and limited space in the refrigerator.

The seeds used for this experiment were not sterilized. After prolonged treatment in the refrigerator, mould developed on the surface of Setaria glauca, Rumex acetosella, and Ambrosia artemisiifolia seeds, but the infection was never so heavy that it could give any reason to believe that the germination test would not be a valid one.

The stratification date was considered as being the date when the seeds for the whole experiment were put into the refrigerator, no matter how long they were stratified. On the same date a check test of unstratified seed was initiated.

The stratification period or the length of stratification time is expressed in days or weeks (= 7 days) from the beginning of the stratification treatment until the beginning of the germination test.

Seeds were transferred from stratification to the germination substratum when still moist and care was taken to prevent any drying out during this operation.

The results are presented in Figs. 5 and 6, and the statistical analysis in Appendix Tables No 17-29.

Setaria glauca.

The seed of 1949 was given stratification treatments at three dates, viz., 0, 3, and 14 months after collection, Fig. 5.

Freshly harvested mature S. glauca seed reached the highest germination (46%) in 10 weeks of stratification, while the same period of stratification resulted in almost complete germination (89%) of immature seed

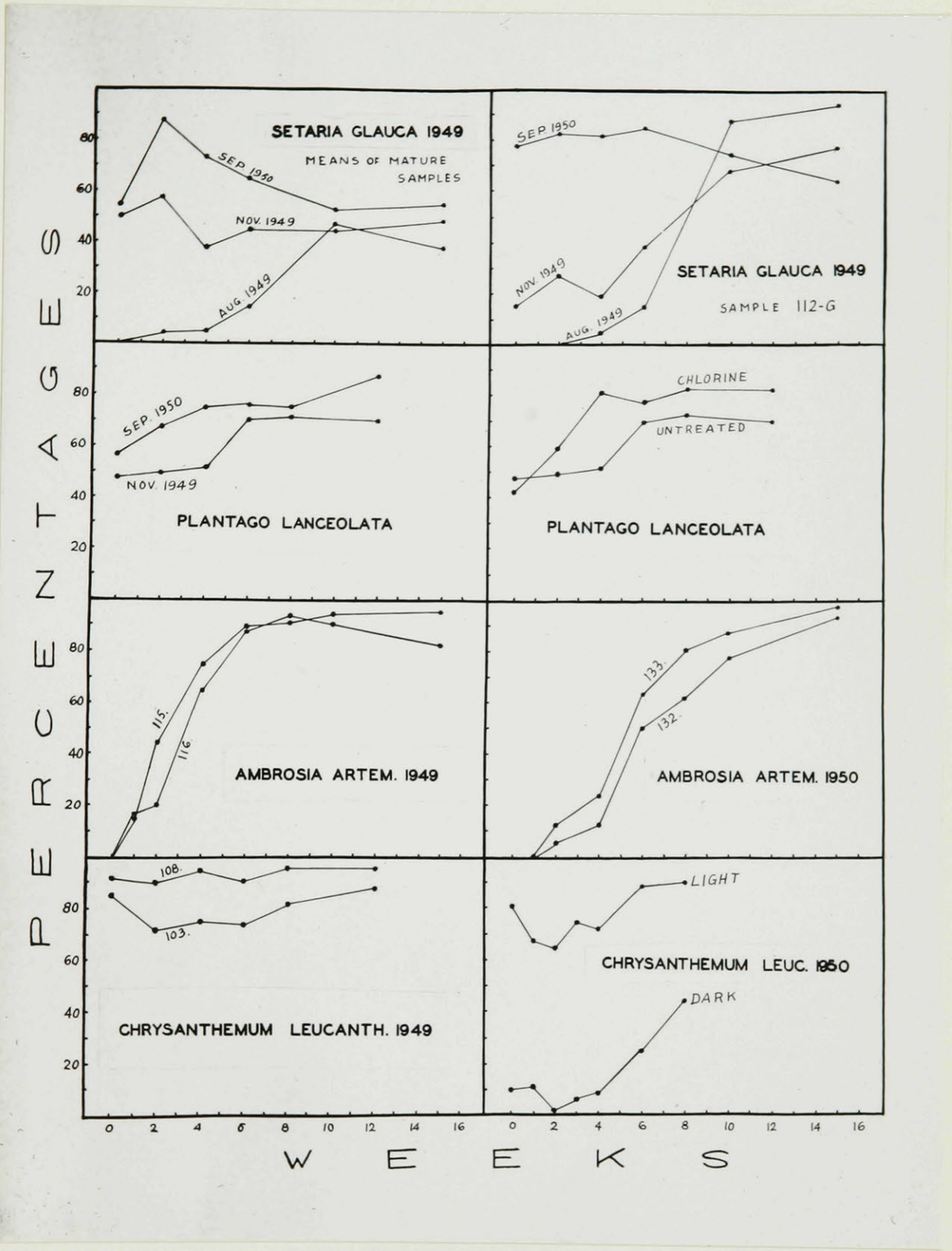

Fig. 5.- The effect of stratification under laboratory conditions upon the germination of Setaria glauca, Plantago lanceolata, Ambrosia artemisiifolia, and Chrysanthemum leucanthemum seed.

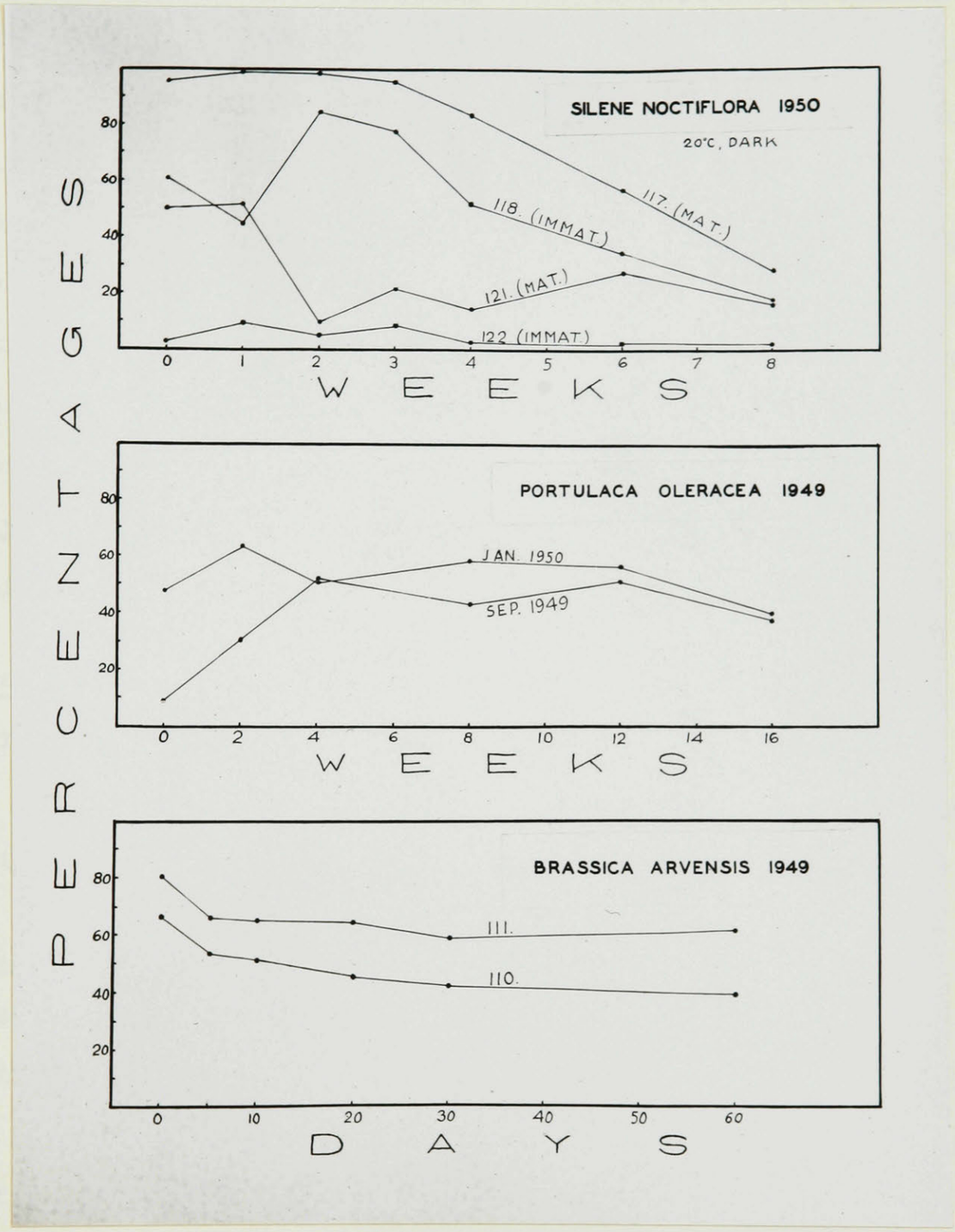

Fig. 6.- The effect of stratification under laboratory conditions upon the germination of Silene noctiflora, Portulaca oleracea, and Brassica arvensis seed.

(sample 112-G). Caryopses, obtained from mature seed kept in dry storage for 10 weeks, germinated as high as 73%, while caryopses from immature seed only 60%. These results show that the low temperature stratification was beneficial in accelerating the after-ripening of embryos of freshly harvested immature S. glauca seed.

It seemed that on the later stratification dates only a short exposure of approximately two weeks of mature seed to low temperatures was beneficial. Stratification was still beneficial to immature seed three months after harvest, while no advantage of stratification was obtained after 14 months of dry storage.

Freshly harvested S. glauca seed of 1950 gave practically no results from stratification for 15 weeks.

Rumex acetosella.

Stratification treatments were given one and five months after collection. In both cases no increase in germination was observed even after the stratification period of 20 weeks.

Silene noctiflora.

Only seeds of the 1950 collection were given a stratification treatment. Stratified seeds were given germination tests at 20°C. and 30°C. both in the dark. There was practically no germination at 30°C., therefore statistical analysis was only carried out on data obtained at 20°C. It appears that the low temperature stratification had a negative effect on the germination of those samples which exhibited higher germination soon after harvest, Fig. 6. Germination of sample No 122 (immature seed) was poor in spite of stratification.

Portulaca oleracea.

Seeds of the 1949 collection were stratified at two dates, viz., 0

and 5 months after harvest. It can be seen from Fig. 6 that the germination of freshly harvested seed was improved by the low temperature stratification of four weeks, but the prolonged treatment was not beneficial. No increase in germination was observed with seed stratified after five months of dry storage.

Brassica arvensis.

Both samples of the 1949 collection showed a decrease in germination after they had been stratified for from 5 to 60 days, Fig. 6. Stratification was ineffective on freshly harvested seed in 1950.

Plantago lanceolata.

A stratification experiment was conducted with seeds stored after harvest for 3 and 13 months. The germination percentages increased because of stratification with high significance at the earlier date. At the later date stratification was also beneficial and in general a higher germination was obtained than at the earlier date.

Table VII.- Germination percentages of Plantago lanceolata seed stratified for 12 weeks

Stratif. dates	Samples		
	102b	102c	106
Nov. 1949	43.5	78.5	88.0
Sep. 1950	71.5	93.5	96.0

The samples varied in the effect of stratification. It is clear from the Text Table VII that for some samples a stratification period of 8-12 weeks can lead to full germination, while for others it is probably too short.

The outer cell layer of the seed coat contains a substance which eagerly absorbs water and forms a translucent mucilage. It can be easily destroyed by any oxidizing agent. As it was thought that this mucilaginous layer might be one of the causes delaying germination, a stratification experiment with seeds subjected to 2% chlorine solution for 30 minutes was carried through. Germination results show, Fig. 5, that the seeds treated with chlorine after-ripened faster and germinated better than seeds with intact mucilage.

Ambrosia artemisiifolia.

Seeds of both collections, 1949 and 1950, were subjected to low temperature stratification. It is evident from Fig. 5 that the intact seeds completely after-ripen in low temperature stratification under laboratory conditions in eight or more weeks. The graphs also show the after-ripening of seed collected in 1950 was slower than of those collected in 1949.

Chrysanthemum leucanthemum.

Stratified seed of the 1949 and 1950 collections showed decreasing germination in the light after the first 4-6 weeks of stratification. At the end of the experiment the germination was practically equal to the unstratified check.

In addition the stratified 1950 seed was given a germination test in darkness. Although C. leucanthemum seeds are very sensitive to light, prolonged stratification appeared to reduce the sensitivity and the seeds were able to germinate to a reasonable extent in the dark, Fig. 5. Unfortunately this experiment was conducted for too short a period.

Discussion.

Summarizing it can be concluded that stratification at low temper-

ature under laboratory conditions using an ordinary commercial refrigerator showed the following effectiveness on breaking the dormancy of seeds:

(1) very effective: Ambrosia artemisiifolia;

(2) effective: Setaria glauca, Plantago lanceolata, Portulaca oleracea, and Chrysanthemum leucanthemum, the latter in the dark;

(3) ineffective or negative effect: Rumex acetosella, Silene noctiflora, Brassica arvensis, and C. leucanthemum, the latter in the light.

Faster after-ripening of intact immature seed of Setaria glauca can be attributed partly to the fact that they have thinner lemmas and paleas which are loosely joined. Consequently the germinating caryopses need not develop a high pressure against hulls in order to enable emergence. That the degree of seed coat development was a factor in the amount of germination, was demonstrated by Chepil (1946). He found that flat and light brown seeds of Atriplex hortensis exhibited virtually no delayed germination, while more spherical and dark brown or black seeds showed very marked longevity in cultivated soil. The same was true with seeds of Atriplex hastata and Axyris amaranthoides.

Decrease of germinating capacity as a result of low temperature stratification under laboratory conditions was observed with Brassica arvensis and Silene noctiflora seed. It was not determined whether the decline in germination was due to reversal of the embryos into secondary dormancy or because some changes occurred in seed coats to inhibit germination. Shuck (1936) found that the tendency to revert into secondary dormancy is very highly developed in the seeds of B. arvensis. He states that the germination of some Brassica seeds can be promoted by prechilling them at 6°C. for 3 to 5 days, but if retained at a low temperature for

20 days, they may fail to germinate when subsequently removed. In the writer's experiments Shuck's assertion was confirmed that potassium nitrate (0.2%) is effective in promoting germination of B. arvensis seed. It was also found that drying and germinating in succession for several times may increase the germination of B. arvensis seed considerably.

THE EFFECT OF STRATIFICATION UNDER SIMULATED FIELD CONDITIONS

These experiments were carried through by two methods: (1) lots of 100 seeds were wrapped in nylon cloth and covered with soil in pots, and (2) 100 seeds were sown in each pot and covered with soil. Thus prepared pots were buried in the ground so that the seeds were two inches below the surface of soil.

A total of 20 samples of the eight weeds were used in these experiments: Setaria glauca - 4 samples; Plantago lanceolata and Rumex acetosella - 3 samples each; Silene noctiflora, Brassica arvensis, Portulaca oleracea, Ambrosia artemisiifolia, and Chrysanthemum leucanthemum - 2 samples each.

Two thirds of the pots with seeds in nylon were taken out of the ground for inspection and further testing on May 1-6th, while the other third was left in the ground until June 14-16th. All the pots with seeds sown in soil were taken into the greenhouse on May 3rd.

The following six groups of data were obtained:

(a) seeds wrapped in nylon:

(1) germination percentage in nylon on May 1-6th,

(2) " " " " on June 14-16th,

(3) " " in the laboratory at 4 temperatures (removed May 1-6th),

(4) " " in the laboratory at 2 temperatures (removed June 14-16th),

(b) seeds sown in soil:

(5) sprouting percentage in the ground as recorded on May 3rd,

(6) germination percentage in the greenhouse.

When the seeds were taken out of the ground for further tests, a portion of the seeds was found already sprouted. This was observed on

both dates, i.e., in May and, six weeks later, in June. The means of observed data are given in Text Table VIII.

Table VIII.- Germination percentages during the stratification under field conditions as recorded on the date when the seeds were taken out of ground.

	Nylon method				Seeds sown in soil	
	May 1-6		June 14-16		May 3	
	Loc. Gr.	Loc. Ba.	Loc. Gr.	Loc. Ba.	Loc. Gr.	Loc. Ba.
Setaria glauca	0	0	54.7	49.6	0	0
Rumex acetosella	2.9	3.3			5.5	0
Silene noctiflora	91.2	84.8	91.5	86.0	68.3	7.0
Portulaca oleracea	0	0	0	0	0	0
Brassica arvensis	66.2	36.0	83.3	47.9	2.3	0
Plantago lanceolata	45.3	45.1	45.4	47.2	50.7	0
Ambrosia artemisiifolia	14.2	5.8	17.5	13.6	11.0	0
Chrysanth. leucanthemum	.3	.5	1.6	1.6	.8	0

All the samples stratified in nylon until May 1-6th were given germination tests in the laboratory under the following temperature and light conditions: (1) 20°C., in dark, (2) 20°C., in light, (3) 30°C., in dark, and (4) 20°-30°C., in light.

One third of the pots with seeds in nylon were kept in the ground after winter stratification until June 14-16th. From the beginning of May the seeds were exposed to continuously rising alternating temperatures. The temperatures were higher and the range of the daily alternation was wider at Loc. Greenhouse than at Loc. Barn. On June 14-16th the seeds were taken out of the ground and given germination test at two temper-

atures: (1) Portulaca oleracea and Ambrosia artemisiifolia at 20°-30°C. in the light and at 30°C. in the dark, (2) all other species at 20°C. and at 30°C. both in the dark.

Table IX.- Summary of significance of comparisons for the germination tests in the laboratory of seeds stratified in nylon until May 1-6th (4 temperature and light treatments)

	Temperature	Light	Locations
Setaria glauca		** Li.	* G.
Rumex acetosella	** Lo.	** Li.	** B.
Portulaca oleracea	** Hi.	** Li.	
Brassica arvensis	** Hi.	** D. at Lo.	** B.
Plantago lanceolata	** Lo.	** Li. at Hi.	** B.
Ambrosia artemisiifolia	** Hi.	* D. at Hi.	
Chrys. leucanthemum	* Lo.	** Li.	

* Significant at .05 level,

** " " .01 "

Letters appearing after the asterisks indicate a positive significance for the treatment indicated:

Lo. - lower temperature (20°C.),

Hi. - higher temperature (30° and 20°-30°C.),

Li. - light,

D. - dark,

G. - location greehouse,

B. - " barn.

The means for temperature and light treatments of seed stratified in nylon until May 1-6th are presented in Fig. 7 and a summary of the significance of comparisons in Text Table IX. Means for seed stratified until June 14-16th are given in Fig. 8 and a summary of the significance of comparisons in Text Table X. Complete data of statistical analysis are presented in Appendix Tables 30-61.

Table X.- Summary of significance of comparisons for germination tests in the laboratory of seed stratified in nylon throughout the winter (for two temperature treatments, two locations, and two stratification periods)

	Temperature	Locations	Stratification period
Rumex acetosella	** Lo.		** J.
Portulaca oleracea	** Alt.		** J.
Brassica arvensis		* B.	
Plantago lanceolata	** Lo.	** B.	** M.
Ambrosia artemisiifolia		** B.	** M.
Chrys. leucanthemum	** Lo.		** J.

* Significant at .05 level,

** " " .01 "

Letters following the asterisks indicate positive significance for the treatments indicated:

Lo. - lower temperature (20°C.),

Alt.- alternating temperature (20°-30°C.),

B. - location barn,

M. - stratification period ending May 1-6th,

J. - " " " June 14-16th.

Seeds sown in soil were covered with 1/4 inch of the same soil and a sheet of chemically pure filter paper was placed over it and then sufficient soil was put on the filter paper in order to provide the two inch depth of burying the seeds in the ground. On May 3rd, when the pots were taken out of the ground, the filter paper proved to be very helpful in removing the excess of soil since it made it possible to leave the seeds at even depths in all the pots. This method worked very well with pots kept at Loc. Barn. At Loc. Greenhouse the filter paper was more or less decomposed and it was impossible to achieve full uniformity in the thickness of the covering soil. It probably was the main reason for the large variation in the results with Chrysanthemum leucanthemum, Rumex acetosella, and Portulaca oleracea at Loc. Gr., the results of which have not been recorded. This experiment was not discarded until September but after May 30th P. oleracea only continued to germinate at a very low rate. Means of the final germination are given in Text Table XI.

Setaria glauca.

No sprouting in nylon of S. glauca seed was observed on May 1-6th but there was a fair amount of sprouting on June 14-16th. Large differences in sprouting percentages between samples were recorded at the latter date. The immature samples (112-G and 113-G) showed much higher sprouting over mature samples (112-B and 113-B) and the differences were highly significant.

The seeds were almost fully after-ripened during winter stratification in the soil when tested in the laboratory on May 1-6th. Immature samples were after-ripened to a greater extent than the mature ones and the difference was highly significant. Both mature and immature samples germinated better in the light than in the dark. The results also

Table XI.- Germination in the greenhouse of seeds sown in soil and stratified under simulated field conditions

	Sown in soil and stratified under field conditions		Unstratified seeds sown in soil (')
	Loc. Gr.	Loc. Ba.	
Setaria glauca	71.3	75.8	60.9
Rumex acetosella	-	37.8	62.7
Silene noctiflora	82.7	96.0 **	96.7
Portulaca oleracea	-	56.5	57.5
Brassica arvensis	83.5	83.5	86.5
Plantago lanceolata	74.5	90.3 **	79.5
Ambrosia artemisiifolia	70.8	77.4 *	6.7
Chrys. leucanthemum	-	66.2	71.0

(') Means for unstratified seed sown in mixed soil 1/4 inch deep (from the experiment on three soil types and three depths).

* Significant at .05 level,

** " " .01 " .

Asterisks indicating significance show the significantly better locations.

show that the inhibition of germination by darkness lessened as a result of winter stratification. Temperature did not appear to be as important a factor in germination of after-ripened seed since the difference between higher and lower temperatures employed in this experiment showed no significance. The seeds evidently after-ripened better at Loc. Gr. since the results obtained were significantly higher than at Loc. Ba.

Seeds kept in the ground until June 14-16th did not germinate in the laboratory at all. After the first germination test all the seeds were hulled and the caryopses were given a germination test at 20°-30°C. in the light when, on the average, 1% of the planted seeds germinated. Afterwards the caryopses were stratified for 30 days and again were given a germination test at 20°-30°C. in the light when, on the average, 3% of the planted seed germinated. An inspection of the embryos after hulling and after all these additional treatments showed that the great majority of them was healthy. These results show that after-ripened S. glauca seeds which did not obtain favourable conditions for germination revert into secondary dormancy, most probably because of the higher temperatures of the advancing season.

All methods of stratification employed under field conditions, were beneficial in overcoming the inhibiting effect of hulls on germination. The effect of stratification in the field was somewhat better than in dry storage in the laboratory for the same period. Dry stored seed gave their highest germination at alternating temperatures in the greenhouse as well as in the laboratory but the germination was lower than those stratified. Winter stratified seeds did not give full germination in the greenhouse most likely because of too wide a range of temperature alternation which probably reached too high a level and therefore part of the seeds reverted into secondary dormancy.

Rumex acetosella.

There was observed but little sprouting of R. acetosella during stratification as recorded on May 1-6th. The data for sprouting on June 14-16th are not presented although the percentages seemed to be higher than at the earlier date. It was not possible to make sure, at the moment of counting, that the difference between the number of seeds planted in

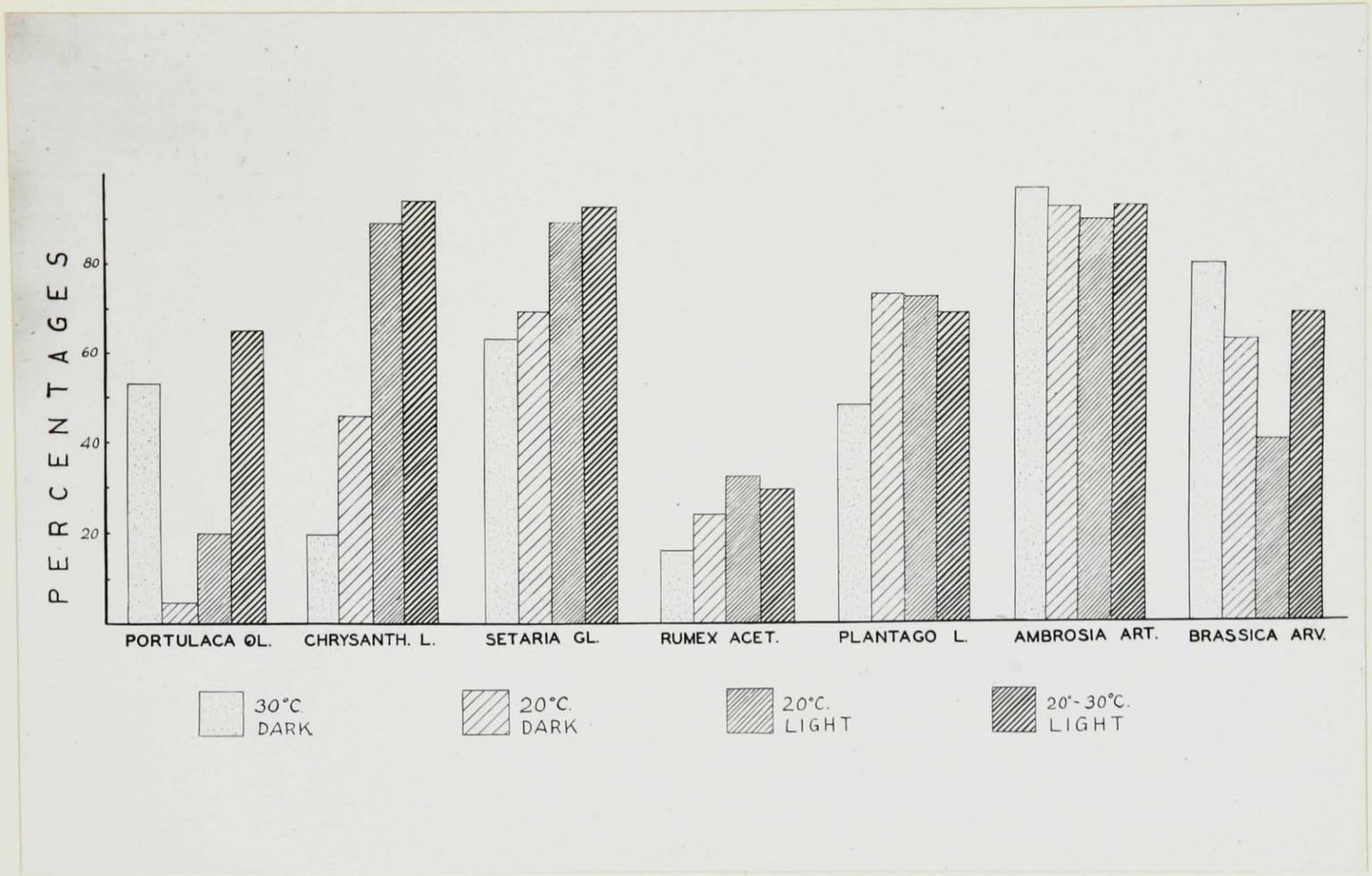

Fig. 7.- Germination at different temperature and light conditions of seed of various species stratified in the field (in nylon) throughout the winter until May 1-6th.

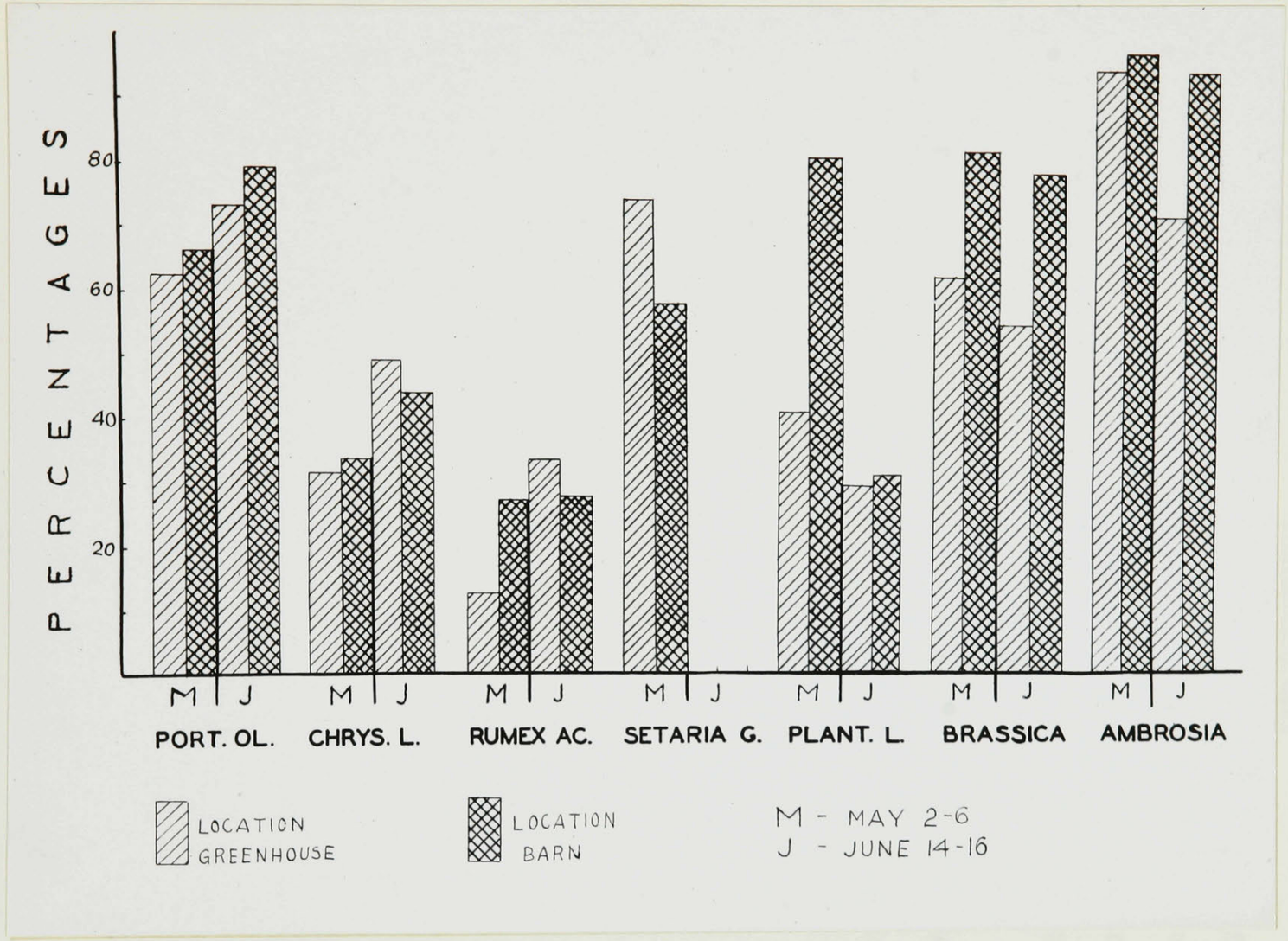

Fig. 8.- Germination of seed of different species stratified under field conditions at two locations for two periods of stratification.

fall and those found to be healthy, but not sprouted on June 14-16th, had all produced sprouts.

Although the germination of R. acetosella seed was in all cases comparatively low, the seed stratified through the winter gave a higher germination in the laboratory tests as compared with unstratified seed. On the average lower temperatures and light provided better conditions for germination in the laboratory, showing highly significant differences.

Considering the stratification periods (until May 1-6th and until June 14-16th) we find that the germination at Loc. Barn was practically the same for both periods, while very large differences for stratification periods were obtained at Loc. Greenhouse and this explains the high significance of the interaction Locations x Stratification periods.

Silene noctiflora.

A large proportion of S. noctiflora seeds were found to be sprouted at the end of both stratification periods and therefore no laboratory germination tests were performed. As the seeds showed very high germinability soon after harvest, it was not expected that any increase in germination would result from stratification. The results obtained show in fact a slight decrease in germination capacity.

Portulaca oleracea.

No sprouted seeds of P. oleracea were found at the end of both stratification periods. At the end of the first period, May 1-6th, the soil temperatures were comparatively low. By the end of May and until June 14-16th the soil temperatures were almost optimal for the germination of this species. Nevertheless there was no sprouting on June 14-16th. This fact can be accounted for by the inhibiting action of factors other than

temperature such as too low partial pressure of oxygen or too high partial pressure of carbon dioxide. The absence of light cannot be considered as being the cause of not sprouting, for other experiments have shown that although light favours the germination of P. oleracea seed it is not essential.

The germination results with P. oleracea seed stratified under field conditions showed that the germination percentages obtained were higher (1) at higher temperatures, (2) with application of light, and (3) after the longer stratification period (June 14-16). All these differences were found as being highly significant, while no significant differences were obtained for locations.

On the whole the stratification under field conditions through the winter did not improve the germination of P. oleracea seed (harvest 1949). It gave results similar to the storage of the seeds under laboratory conditions for the same period of time.

Brassica arvensis.

A considerable sprouting of B. arvensis seed was observed in nylon at the end of both stratification periods. There was more sprouting at Loc. Gr. and the differences were significant at both dates. On May 3rd there was practically no sprouting of seeds sown in the soil.

The seeds stratified until May 1-6th at Loc. Gr. exhibited large variations in response to the different temperature and light treatments given in the laboratory tests. Higher germination percentages were obtained at the higher temperatures. The seeds stratified at Loc. Ba. showed only a slight variation, and the germination was high for all the treatments applied. This can be seen from the Text Table XII. The analysis shows that at lower temperature the seeds germinated better in the dark and the difference was highly significant.

Seeds kept in soil for a longer period - until June 14-16th - showed practically the same trend in germination as those kept for a shorter period; lower germination was obtained from seed stratified at Loc. Gr.

Table XII.- Germination percentages of Brassica arvensis seed stratified under simulated field conditions until May 1-6th

Location	Temperature and light treatments			
	20°C., dark	20°C., light	20°- 30°C., light	30°C., dark
Loc. Gr.	44.9	19.7	57.4	78.0
Loc. Ba.	80.9	61.1	80.2	82.1

On the average, the seeds stratified through the winter under field conditions gave high germination percentages, disregarding the method of stratification, both in the greenhouse and in the laboratory germination tests. Unstratified seeds germinated at a lower rate in the laboratory than those stratified through the winter. On the other hand the germination of unstratified seed in the greenhouse in soil was as high as of those stratified in the soil.

Plantago lanceolata.

A solid proportion of P. lanceolata seed was found sprouted at the end of both stratification periods, with the exception of those sown in soil and stratified at Loc. Ba.

The seeds were completely after-ripened during the stratification under field conditions through the winter. Tests in the laboratory showed that the seeds germinated better at the lower temperatures and the difference was highly significant, indicating that when after-ripened seeds under conditions otherwise favourable for germination are exposed

to higher temperatures, they revert at least partly into secondary dormancy. Seeds from Loc. Gr. and those kept in soil until June 14-16th exhibited pronounced reversal into secondary dormancy.

Ambrosia artemisiifolia.

Small proportions of A. artemisiifolia seeds were found sprouted at the end of both stratification periods. Unsprouted seeds were completely after-ripened during stratification under field conditions through the winter. On May 1-6th the seeds from both locations germinated very well when tested in the laboratory. Although the actual differences were not pronounced, analysis shows that the seeds germinated better at higher temperatures and the difference was highly significant. No significant differences were established for locations.

On June 14-16th the germinability of seeds from Loc. Ba. was still high, while those from Loc. Gr. showed lower germination with highly significant differences. This indicates that after-ripened seeds of A. artemisiifolia when they fail to germinate soon following after-ripening tend to revert to secondary dormancy. The same trend was observed with seeds sown in soil and after-ripened in that condition.

Chrysanthemum leucanthemum.

Sprouting of C. leucanthemum seed in the ground during the winter stratification was inconsiderable. Germination in the laboratory was significantly higher at lower temperatures, but the most important factor was the light. In the dark winter stratified seed germinated better than those unstratified.

Discussion.

Temperature.- Although the range of temperatures at which seeds were given germination tests in the laboratory (the lower limit being

20°C., the upper - 30°C.) was not large enough, nevertheless, considerable evidence was obtained as to the tendency of response to temperature treatments. Taking into consideration the results of germination tests at four temperature and light treatments for seeds of both stratified under field conditions until May 1-6th and unstratified (Text Tables I and IX), we find that the species tested form two groups based on the longevity of plants. The first group, comprising perennial plants - Plantago lanceolata, Chrysanthemum leucanthemum, and Rumex acetosella, responded better to lower temperatures in the laboratory tests, no matter whether they were winter-stratified or unstratified. Some discrepancy can be seen with R. acetosella, unstratified seed of which germinated better at higher temperatures, but the germinating capacity of unstratified seed was in general low, therefore the data are not conclusive. The second group include annual plants with the general tendency to respond better to higher temperatures in the laboratory germination tests. Portulaca oleracea, Brassica arvensis, and **Ambrosia** artemisiifolia germinated definitely better at higher temperatures, while no definite consistency was established with Silene noctiflora and Setaria glauca.

Light.- Light proved to be definitely beneficial to Setaria glauca, Chrysanthemum leucanthemum, Rumex acetosella, and Portulaca oleracea seed, both unstratified and winter-stratified (Text Tables I and IX). C. leucanthemum seed was particularly sensitive to light, although the sensitivity decreased as a result of stratification. There was no uniformity in response to the light treatment of the remaining species and therefore no conclusions can be drawn from the results obtained, except that unstratified seed of Silene noctiflora and Brassica arvensis germinated better in light. The practice of Seed Testing Stations shows, at least with seeds of agricultural plants, that most species respond to light,

others being indifferent, and only a comparatively small number germinate better in darkness. Everson (1949) found that in order to obtain highest germination light should be applied to seeds of Brassica kaber, Portulaca oleracea, Silene noctiflora, and others. Atwater (1939) working on germination problem of cultivated flowers found that plants of Gramineae and Compositae families need light for germination, and that many species of Cruciferae, Caryophyllaceae, and others, respond to light, too. The present experiments confirm these statements.

Location effect.- Germination of B. arvensis and P. lanceolata seed stratified at Loc. Ba. was higher for both stratification periods than from Loc. Gr. No preference for locations was shown by P. oleracea and C. leucanthemum on either of the dates (May 1-6th and June 14-16th). A. artemisiifolia germinated very well from both locations on May 1-6th, while on June 14-16th seeds from Loc. Gr. were already partially reverted into secondary dormancy. R. acetosella, for reasons which are not understood, germinated better from Loc. Ba. on May 1-6th, and there was no difference for locations on June 14-16th.

Length of winter stratification period.- The seven species tested fall into two groups with different trends in germination. (1) Portulaca oleracea, Chrysanthemum leucanthemum, and Rumex acetosella form a group with increasing germination capacity with the higher temperatures of the advancing season (higher germination on June 14-16th with highly significant differences). (2) The second group comprising Brassica arvensis, Ambrosia artemisiifolia, Plantago lanceolata, and Setaria glauca follow the trend of decreasing germination capacity with increasing temperatures of the advancing season. This trend was least distinct and not significant in B. arvensis. With A. artemisiifolia this trend was highly significant only for Loc. Gr. By June 14-16th P. lanceolata showed a pro-

nounced decline in germination while S. glauca was completely reverted into secondary dormancy, by the later date.

The phenomenon of secondary dormancy being very common in nature has been proved experimentally by many investigators. Many of them found that, in the seeds of many species, secondary dormancy may be induced by higher temperatures. Kanipe (1938) observed the development of secondary dormancy in seeds of Alsine media at 30°C. Bibbey (1948) found that seeds of Brassica arvensis germinated well in the spring but showed apparent secondary dormancy when tested in September. By the following spring the seeds in the soil were again highly germinable. Davis (1930a) considers that the development of embryo dormancy during the summer and after-ripening during the winter is probably a general phenomenon with seeds of wild plants in the Temperate Zone.

Sprouting during winter stratification.- On basis of the extent of sprouting in nylon on May 1-6th one can allot the species tested into three groups:

(1) high sprouting: Silene noctiflora, Brassica arvensis, Plantago lanceolata;

(2) low sprouting: Ambrosia artemisiifolia, Rumex acetosella, Chrysanthemum leucanthemum;

(3) no sprouting: Setaria glauca, Portulaca oleracea.

The proportion of sprouting on June 14-16th was essentially the same as on May 1-6th with the exception of S. glauca which gave fairly high percentages on the later date. On May 3rd the seeds sown in soil sprouted as much as the seeds in nylon, except B. arvensis with little sprouting.

Plants of the first group can be considered as being early sprouting species whose seedlings may emerge in spring earlier than the earliest sown spring grain. Bibbey (1935) considers B. arvensis as being early

sprouting species, too. The second and the third groups comprise the species which germinate later in the season after the cereal crops have been sown. Chepil (1946) showed that seeds of Setaria viridis do not germinate very early in the spring and for this reason heavy infestations may occur in early sown spring crops. This appeared to be true also with S. glauca as far as present experiments have shown.

GERMINATION OF DRY STORED SEED

IN THE SOIL

For the purposes of this experiment 20 seed samples were used: Setaria glauca - 4 samples; Rumex acetosella and Plantago lanceolata - 3 samples each; Silene noctiflora, Chrysanthemum leucanthemum, Portulaca oleracea, Brassica arvensis, and Ambrosia artemisiifolia - 2 samples each. Seeds were sown in 4-inch pots filled with sterilized soil. Heavy soil, pure sand, or mixture of heavy soil and sand in equal parts was used for filling the pots. Seeds were sown at three depths: one quarter, one half, and one inch. Sprouts were counted and pulled out at weekly intervals. Means for soil types and depths of sowing are presented in Fig. 9 and the summary of the significance of comparisons in Text Table XIII. The complete set of data and statistical analysis are presented in Appendix Tables 62-69.

Setaria glauca.

Setaria glauca seed germinated better in heavier soils (in heavy soil and in mixed soil) than in pure sand, the differences being highly significant. On the average the mature samples germinated better than the immature ones. Germination percentages were highest at one inch depth rather than nearer the soil surface. General view of the experiment is shown in Fig. 10.

Rumex acetosella.

The best germination of Rumex acetosella seed was obtained in heavier soils, especially in the mixed soil, but only at a depth of one quarter of an inch. The sample No 107 germinated over 80% in mixed soil at a depth of one quarter inch, while the samples No 104 and 105 germinated under the same conditions about 50%. The obtained percentages in that particular instance are unusually high for otherwise untreated seed and this fact remains unaccounted for. There was still some germination one inch deep in all three types of soil.

Silene noctiflora.

Silene noctiflora germinated very well in all three types of soil and at all three depths. The differences were rather small. Analysis shows that there were significant differences between soils in favour of mixed soil, but the differences between depths were not significant.

Table XIII.- Summary of significance of comparisons for the germination tests in three soil types at three depths

	Soils	Depths
Setaria glauca	** S.	* I.
Rumex acetosella	** M.	** Q.
Silene noctiflora	* M.	
Portulaca oleracea	* M.	** Q.
Brassica arvensis		** Q.
Plantago lanceolata	* M.	* Q.
Chrys. leucanthemum	* M.	** Q.

* Significant at .05 level,

** " " .01 " .

Letters appearing after the asterisks indicate a positive significance for the treatment indicated:

S. - heavy soil,

M. - mixed soil,

I. - one inch,

Q. - one quarter of an inch.

The mixed soil was the best germination substratum for the seeds of Portulaca oleracea. With the increasing depth of sowing germination per-

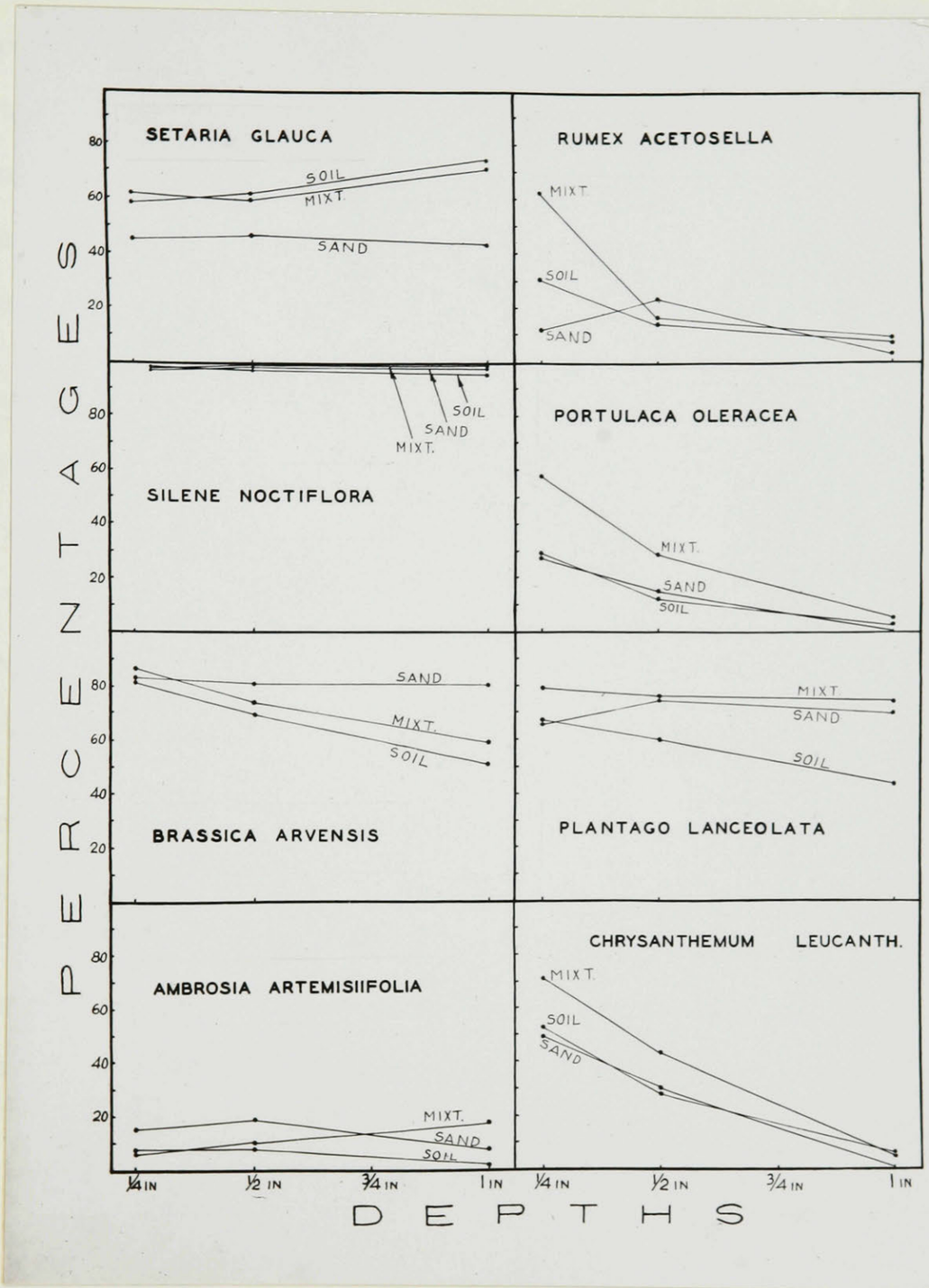

Fig. 9.- Germination under greenhouse conditions of dry stored seed of all the species worked with in three different soils at three depths of sowing.

centages steadily decreased and all the comparisons between depths displayed high significance in favour of shallower planting. Pronounced differences were found between seed samples in mixed soil - sample No 114b was the better one. There was practically no difference between samples in the other two soil types. It is a noteworthy fact that, in spite of smallness, P. oleracea seed sown as deep as one inch managed to produce some sprouts.

Brassica arvensis.

On the average the highest germination of Brassica arvensis was obtained in sand: it was practically the same for all depths applied and there was almost no difference between samples. In heavy soil and in mixed soil, the germination percentages decreased with the increasing depth, with all the comparisons between depths being highly significant.

Plantago lanceolata.

Plantago lanceolata seed germinated best in mixed soil and in sand. In mixed soil it sprouted equally well at all three depths applied. The lowest germination in sand was at one quarter of an inch. In heavy soil the germination percentages steadily decreased with the increasing depth of sowing. The smallest variation between samples was encountered in the mixed soil and the variation increased with the increasing depth of sowing.

Ambrosia artemisiifolia.

Ambrosia artemisiifolia germinated poorly under all conditions, for the seeds did not after-ripen properly in dry storage, and they were not stratified before sowing. The results were not analysed statistically.

Chrysanthemum leucanthemum.

Germination of Chrysanthemum leucanthemum was significantly higher in mixed soil than in the other two types. It germinated best at the depth

of one quarter of an inch in all three soils, and the germination percentages steadily decreased with deeper sowing. It still managed to produce some sprouts from the depth of one inch. All the differences between depths showed high significance. The sample No 108 germinated as high as 88% in mixed soil at a depth of one quarter of an inch. Germination percentages as high as this were never obtained in the dark under laboratory conditions. Probably enough light rays penetrated through the one quarter inch soil layer to stimulate germination.

Discussion.

Depth of sowing.- General means for the depths of sowing show that the plants tested form two groups: (1) neutral, slight increase, or slight decrease of the germination percentages with the increasing depth of sowing, comprising Silene noctiflora, Setaria glauca, and Plantago lanceolata; (2) pronounced decrease in the germination percentages with the increasing depth of sowing including Chrysanthemum leucanthemum, Rumex acetosella, Portulaca oleracea, and Brassica arvensis. This grouping follows the seed size of the plants tested: plants of group (1) produce comparatively large seed (1,000 seed weight more than one gram), while seeds of group (2) are small (1,000 seed weight less than one half of a gram with the exception of B. arvensis).

Significant positive correlation was found between 1,000-seed weight and germination percentages at the sowing depth of one inch in heavy soil and in mixed soil. In other instances the correlation coefficients were positive but not significant, as can be seen from Text Table XIV.

Murphy and Arny (1939) working with 18 species of grasses and legumes in the greenhouse on five soil types found that the seed weight showed a significant positive correlation with the total emergence from the 2- and 3-inch depth of planting; at shallower plantings the correlation was

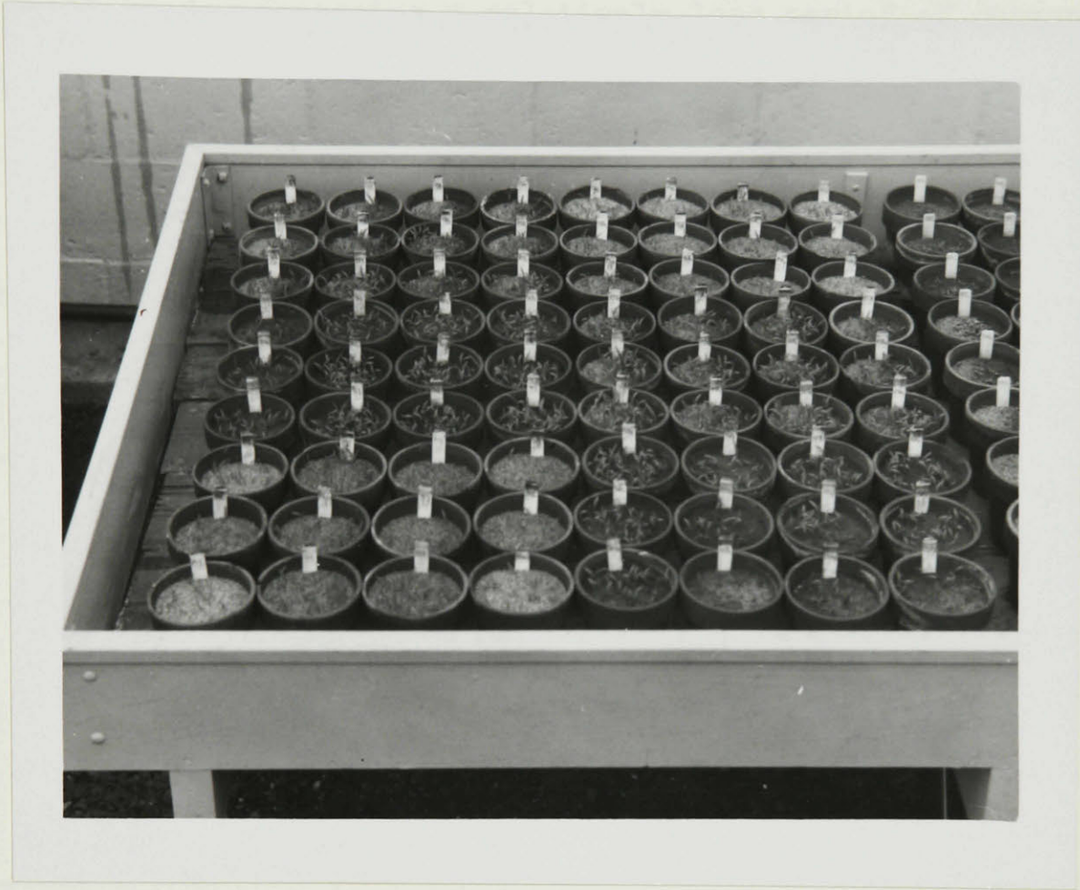

Fig. 10.- General view of Setaria glauca germination experiment in three types of soil at three depths.

not significant. Plummer (1943) in his study on the germination and early seedling development of 12 range grasses concludes that within wide limits, weight of seeds is probably a factor in emergence at the greater depths, but does not appear to be within narrow ranges. Chepil (1946a) found for small seeds possessing a relatively long period of dormancy, that the deeper the seeds were buried in the soil the lower - substantially - was the emergence of seedlings.

Table XIV.- Correlation coefficients (r) of 1,000-seed weight with percentages of total germination for three types of soil and three depths of sowing.

Soil	Depth of sowing in inches		
	1/4	1/2	1
Sand	.278	.321	.444
Mixed soil	.002	.369	.596 *
Heavy soil	.339	.483	.617 *

* Significant at .05 level, r = .532

** " " .01 " , r = .661

On the whole, the question of the depth of sowing is an old one, and the effect of the depth on seed germination is obvious. Nevertheless, this experiment shows that soil stratum as shallow as one inch is a serious barrier for germination of some seed kinds, and that substantial amounts of some weed seeds sprout near the very surface of soil. It leads to the inference that ordinary tillage of soil is of limited effectiveness in the control of weeds, since every plowing or discing exposes only a small proportion of the arable soil to the conditions favourable for weed seed

germination. Repeated tilling before sowing of cultivated plants in spring or the practice of fallowing - disregarding other considerations - thus exposing soil from different depths so far is the most efficient method known to reduce the population of living weed seeds in the soil.

Soils.- Germination in mixed soil was superior to that in heavy soil and in sand for R. acetosella, P. oleracea, P. lanceolata, and C. leucanthemum. S. noctiflora germinated equally well in all three types of soil. The best germination of S. glauca was obtained in both mixed soil and heavy soil. The heavier the soil the lower the germination obtained in B. arvensis but the differences were not significant. As the plants were watered only once every day, the surface of the soil in the pots used to dry out, more or less, which permitted a crust to form on the surface of the heavy soil. Crusted soils inhibit the germination of seeds from a mechanical standpoint and through deficiencies in supply with soil air. Lesser germination in sand probably can be accounted for by inadequate supply of water for the water holding capacity of sand is low. Mixed soil provided best conditions for seed germination since the surface condition remained favourable.

SHARE OF THE SEED COATS IN DELAYING GERMINATION

The aim of experiments on the effect of seed coats in delaying or inhibiting germination was of a general nature, viz., to find out whether the seed coats of the species tested might delay the germination. Depending on the characteristics of seed, different methods were applied in pursuit of the information desired, e.g., scarification with concentrated sulphuric acid, removing the seed enclosing structures, puncturing or cutting the seed, or excising the embryos. As any method of this series took up considerable time, and - of necessity - involved painstaking work on account of the small size of seed, the numbers of seeds dealt with were in many instances too few.

No research on the effect of the seed coat in delaying germination was done with Chrysanthemum leucanthemum. The results of the experiments discussed in previous chapters might give ground to suppose that there is something present in the seed coats of C. leucanthemum that prevents seeds from germination. It is more likely that this "something" is of chemical rather than of physical nature since it inhibits the physiological processes of germination under absence of light. The results of the experiments are presented in Figs. 11-14, Text Tables XV-XVIII, and Appendix Tables 70-77.

Setaria glauca.

In the course of this experiment the germination of S. glauca caryopses (') were compared with the germination of intact seed. The cary-

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(') In Gramineae the pericarp and the remains of the integuments of the single seed are so closely adherent that they cannot be readily separated from each other at maturity. This structure is a caryopsis or fruit, and is more than a seed in a strict morphological sense. Caryopses of many

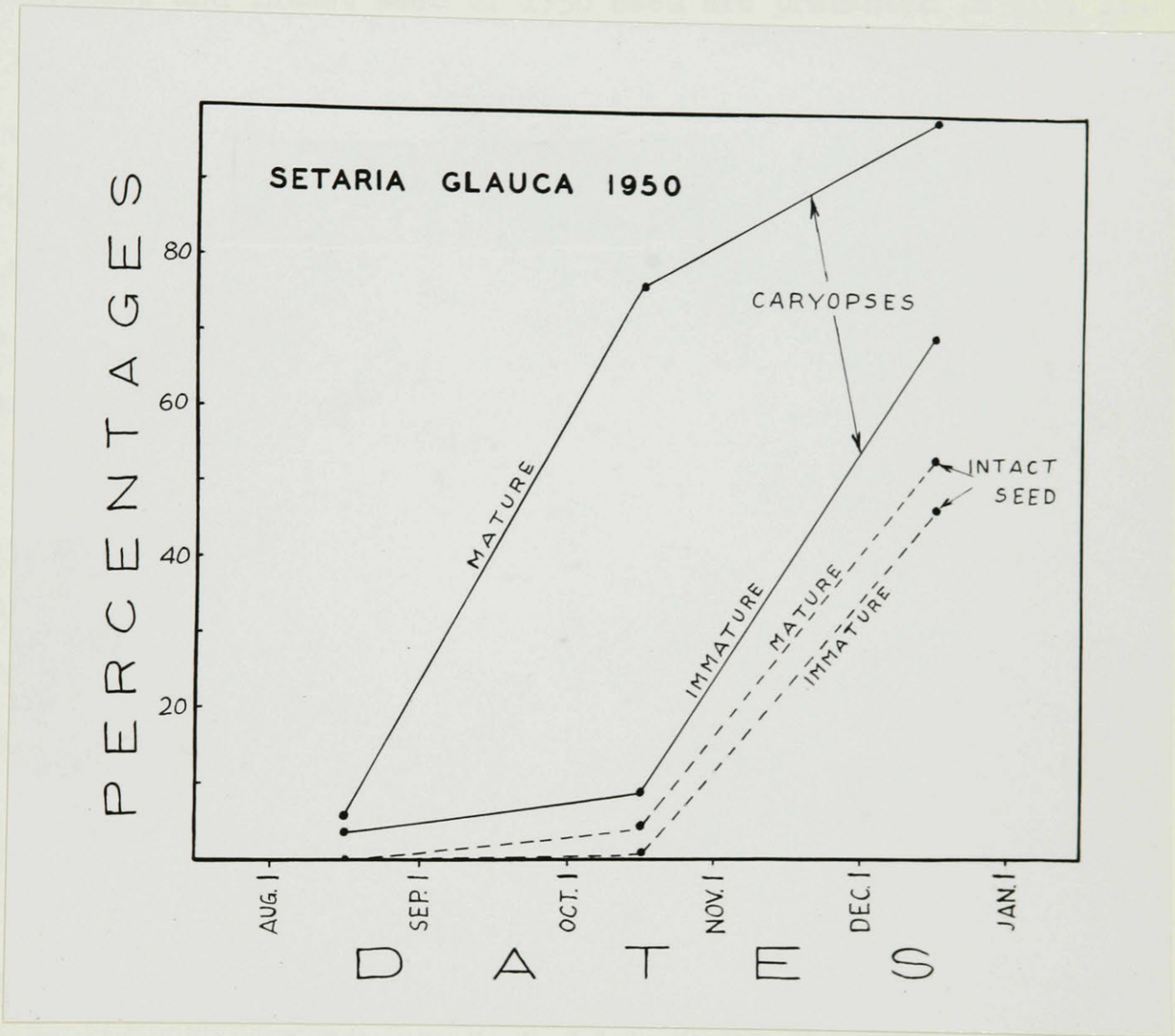

Fig. 11.- The effect of hulling upon the germination of Setaria glauca seed.

opsis of S. glauca is tightly enclosed by lemmas and paleas, both being hard and brittle. Caryopses of all eight samples were given germination tests on three dates in duplicate. Hulls were usually removed one day before the germination test. The means for mature and immature samples of both caryopses and intact seed of 1950 seed are presented in Fig. 11. Data for 1949 seed can be found in Appendix Table 70.

Caryopses obtained from freshly harvested seed germinated poorly in both years of harvesting, 1949 and 1950, while the intact seeds did not germinate at all at that time. The germination percentage of both caryopses and intact seed increased in dry storage. The caryopses obtained from mature seeds which were stored for four months, germinated readily. This was true for both the years 1949 and 1950. The rate of germination increase of caryopses obtained from immature seed was much slower and was almost as slow as that of intact seed. Enough evidence was obtained from these experiments to suppose that embryos of freshly harvested S. glauca seed after-ripen in a comparatively short period of storage.

Rumex acetosella.

The "seed" of R. acetosella is an achene. The hull of the achene is a smooth and shining pericarp, but the great majority of the seeds harvested for this experiment were not shining, for the calyx lobes were adherent to the pericarp. The effect of the pericarp on germination was studied by means of scarification with conc. sulphuric acid.

The seed harvested both in 1949 and 1950 were scarified at two dates.

SPECIES are enclosed in other floral structures, viz., lemmas and paleas, glumes. For the purposes of this paper the term "seed" was used to denote the seed structures we obtain at harvest being fully aware that the same word was used for morphologically different things.

Scarified seeds of the 1950 harvest were given a germination test at two temperatures, viz., 20°C. in the dark and 20°-30°C. in the light, while those harvested in 1949 at 20°-30°C. in the light only.

The application of conc. sulphuric acid on R. acetosella seed increased the germination percentage extremely. Sulphuric acid decomposes the outer layer of the pericarp, more or less. Pericarps so treated are apt to crack and through these cracks, no matter how tiny they may be, water penetrates into the true seed providing the conditions for germination. If the seed coat is thin or the seed is exposed to the action of acid for a longer period, the acid can destroy the coat entirely and damage the seed coat proper or even the embryo. It can kill the embryo or injure it, in the latter case, the seed can produce an abnormal sprout.

Freshly harvested R. acetosella seed - in 1950 - responded to scarification but high germination was not obtained, Fig. 12. The same seed responded much better to scarification after two months of storage. This indicates that although the seed coat plays an important part in delaying the germination of R. acetosella, freshly harvested seed exhibits, to a certain extent, embryo dormancy.

It seemed that the seeds harvested in 1950 were provided with a thicker pericarp, for they needed an application of conc. sulphuric acid for four minutes to reach the highest germination percentage, while the germination of 1949 seed was highest after they were treated for only two minutes.

Silene noctiflora.

The seed coats of S. noctiflora do not hinder the penetration of water into the seed. Seeds harvested in 1949 did not give any clue that the seed coat might be of importance in preventing the sprouting. The situation was different with 1950 seed crop: they failed to germinate at 30 C. in the dark.

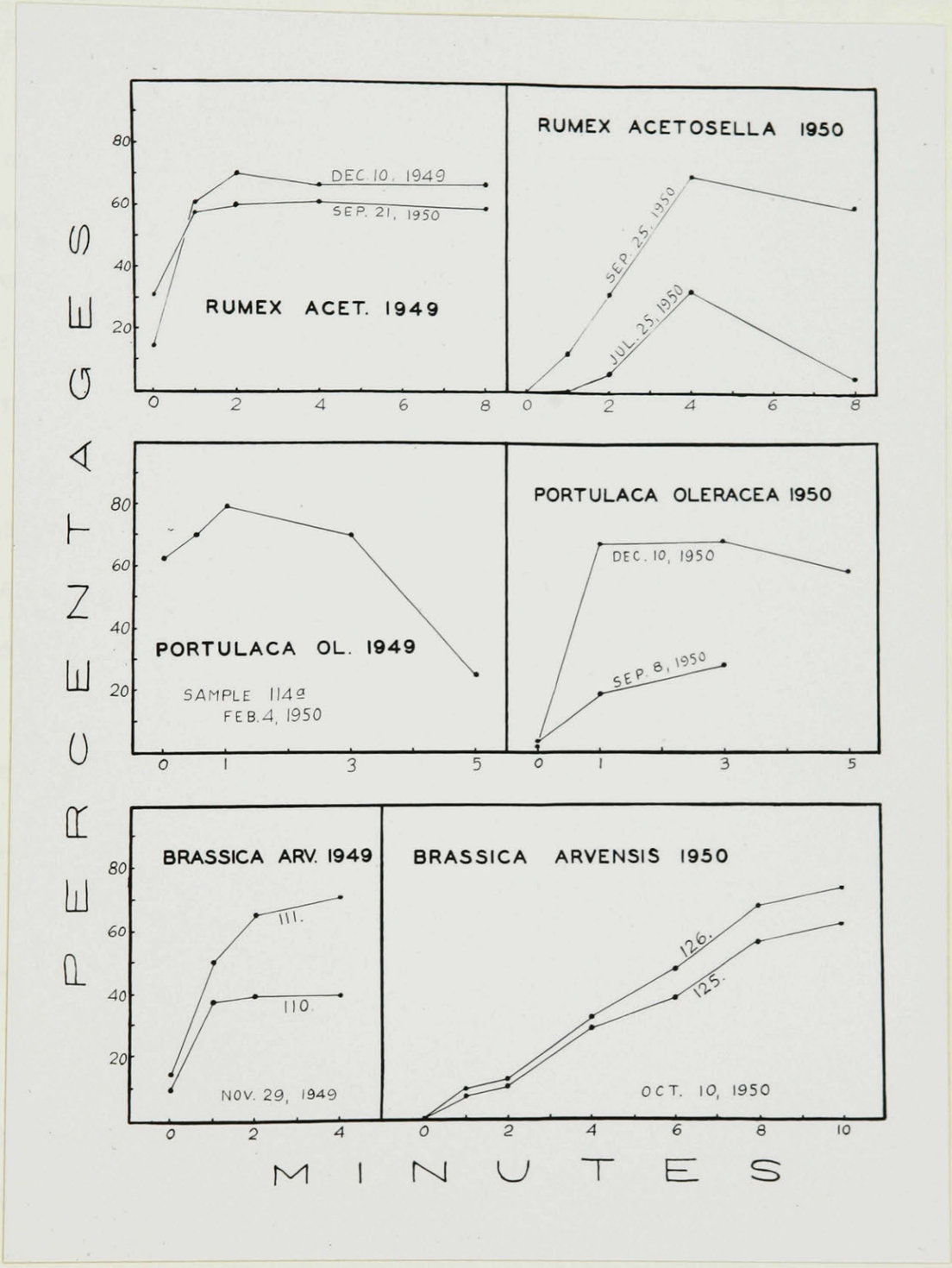

Fig. 12.- The effect of scarification with conc. sulphuric acid upon the germination of Rumex acetosella, Portulaca oleracea, and Brassica arvensis seed.

The failure to germinate was not due to the embryo dormancy. On several occasions seeds which remained unsprouted after routine germination tests were punctured with a dissecting needle at the hilum so that a part of seed coat and endosperm was torn apart. It was impossible to avoid - with these manipulations - injury of the tips of the primary root in a number of seeds, thus causing the development of abnormal sprouts. Seeds so treated germinated very well under conditions where they previously failed to germinate. The results in Text Table XV may serve as an illustration. These results are in line with the experiments discussed in previous chapters and show that the embryos of freshly harvested S. noctiflora seed are not dormant, and that under certain conditions the seed coat may inhibit the germination. No suggestion could be proposed as to the mechanism by which the seed coats inhibit the germination.

Table XV.- The effect of puncturing of Silene noctiflora seed which failed to germinate in 14 days (duplicate tests) - Sample No 131

	Germin. of intact seed	Normal sprouts after puncturing	Abnormal sprouts after puncturing	Total of non dormant embryos
30°C., dark	0	72.0	20.5	92.5
20°C., "	55.0	32.5	10.0	97.5
20°C., light	60.5	33.0	3.5	97.0
20°-30°C., light	89.0	9.5	1.5	100.0

Portulaca oleracea.

The seed of P. oleracea of 1949 which remained dormant after routine germination tests (24 duplicate tests) were scarified for one minute with conc. sulphuric acid and again were given germination test under previous conditions. The results, Fig. 13, show that on the average one third of

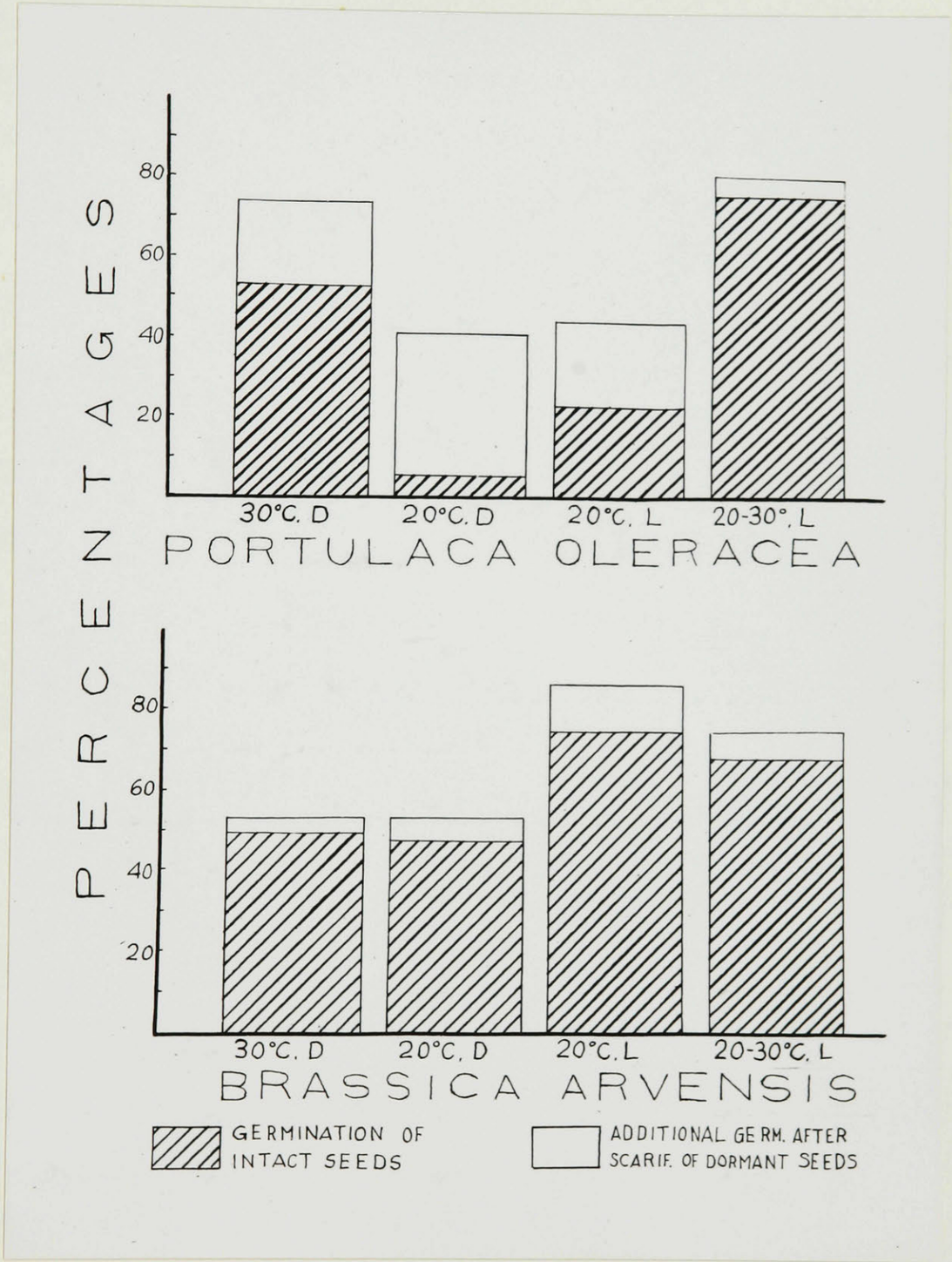

Fig. 13.- The effect of scarification with conc. sulphuric acid upon the germination of dormant seed of Portulaca oleracea and Brassica arvensis.

the scarified seed had produced sprouts.

Freshly harvested 1950 seed germinated very poorly. Application of conc. sulphuric acid increased the germination markedly, Fig. 12. The increase was greater with longer stored seed, indicating that not only the seed coat was responsible for the delayed germination but also that freshly harvested seed had more or less dormant embryos.

Brassica arvensis.

Freshly harvested 1949 seed of B. arvensis were put into the germinator for several days. Those seeds which did not sprout were dried, scarified with conc. sulphuric acid, and again given a germination test. Results, Fig. 12, show that by means of scarification it was possible to increase the germination percentage.

Seeds of 1950 were scarified on two dates: soon after harvest (in August) and two months later (in October). The germination of intact seed on both dates was very poor. Scarification in October increased the germination to a high level but it was not possible to obtain full germination, Fig. 12. Scarification in August increased the germination rate but to a much smaller extent than in October.

Seeds remaining unsprouted after the routine test of intact seed of 1949 in May, 1950, were dried for 3-4 hours and then uniformly scarified with concentrated sulphuric acid for five minutes. On the average 17.1% of those scarified produced normal sprouts, Fig. 13.

These experiments show that the seed coat is very much responsible for the delayed germination of B. arvensis seed, but it seemed that the embryo dormancy was involved too. To clarify the question a comparatively small number of unsprouted seeds from a routine germination test were hulled and again given a germination test. The results are given in Text Table XVI. It is clear that dry stored seeds which did not sprout after

scarification exhibited embryo dormancy in rather high proportions, while embryos of seeds stratified in the field through the winter were almost completely after-ripened.

Table XVI.- Embryo dormancy in Brassica arvensis seeds as determined by hulling the seeds which failed to germinate in 14 days.

Year of harvest	Previous treatment	No of hulled seed	No of normal sprouts	% of normal sprouts
1949	scarification	20	6	30.0
1949	winter stratification	120	99	82.5
1950	scarification	80	19	23.7

Plantago lanceolata.

Scarification of P. lanceolata seed with conc. sulphuric acid proved to be an unsatisfactory method. The coat on the convex part of the seed broke first under the pressure of the expanding embryo thus causing the young sprout to break which can only be classed as being abnormal. To avoid any confusion which might arise in further tests, the idea of scarification of P. lanceolata seed was given up.

Further tests on that line were done with the seed which remained dormant after routine germination tests by cutting the seed ends or by excising the embryos. The results obtained in the laboratory are presented in the Text Table XVII.

Another small experiment was carried out in the greenhouse with the aim of finding out whether the embryos of dormant seed are capable of producing normal seedlings, Fig. 14. The obtained data are given in Text Table XVIII.

Table XVII.- Percentages of normal sprouts produced in the laboratory after excising the embryos of dormant seed

	No of seeds	Normal sprouts	Normal % sprouts
Seed end cut	57	40	70.2
Excised embryos	80	65	81.2

Table XVIII.- The ability of excised embryos to produce normal seedlings in the greenhouse

	No of seeds	Normal seedlings	% normal seedlings
Dormant, seed end cut	80	48	60.0
" excised embryos	67	61	91.0

The results show that the seed coat of P. lanceolata may delay the germination in a large proportion of seeds and that no embryo dormancy was encountered after short storage.

Ambrosia artemisiifolia.

The pericarp of A. artemisiifolia seed is very hard and smooth except for the micropile which is composed of softer tissue. It seems that the pericarp does not inhibit the entrance of water and the exchange of gases, although it may retard the process considerably. The proper seed coat is very thin and of living cells. According to Davis (1930), the proper seed coat of Ambrosia trifida inhibits the gaseous exchange and thus the seeds cannot germinate. It was observed in our experiments with A. artemisiifolia that with the advanced age the seed coat becomes

less firmly adherent to the seed itself and it is easier to remove. It is possible, therefore, that the inhibition of gaseous exchange lessens with the aging of seeds and the rate of after-ripening increases.

The effect of the pericarp and seed coat on the germination was studied using seeds freed from the pericarp. Two months after harvest hulled 1950 seed germinated as high as 55% (300 hulled seeds were tested) at 20°-30°C. in the light, while the germination of intact seed was 7% only, under the same conditions.

Seeds of 1949 hulled after eight months of storage sprouted at 20°-30°C. in the light as high as 50% (intact seeds at the same conditions - 25%), while seeds hulled after 13 months of storage germinated 95% (intact seed - 35%). The germination percentage of hulled seed at 30°C. in dark was low after 8 months of storage (20%) and high after 13 months (88%).

These results show that the delayed germination of A. artemisiifolia seed is caused partly by seed coats and partly by embryo dormancy, the latter disappearing in dry storage in approximately one year.

Discussion.

Summarizing the results discussed in this chapter we find that the seed coats play an important role in delaying the germination in seeds of Setaria glauca, Rumex acetosella, Portulaca oleracea, Brassica arvensis, Plantago lanceolata, and Ambrosia artemisiifolia. The seed coat of Silene noctiflora plays, in certain instances, a part in inhibiting the germination at higher temperatures, and in Chrysanthemum leucanthemum in light sensitivity. No embryo dormancy was observed in seeds of C. leucanthemum, S. noctiflora, and P. lanceolata. A short period of dormancy after harvest was found in S. glauca, R. acetosella, P. oleracea, B. arvensis, and long lasting embryo dormancy was observed in seeds A. artemisiifolia.

Fig. 14.- Plantago lanceolata seedlings obtained from excised embryos of seed which failed to germinate under laboratory conditions; seedlings from: (a) intact seed, (b) excised embryos, (c) dormant seeds cut at one end, (d) untreated dormant seeds.

As far as Setaria glauca is concerned the experiments show that lemmas and paleas play an important part in delaying the germination of intact seed, but they do not show the mechanism involved. Some indication was obtained that tightly joined and hard hulls, especially in mature seed, prevent the caryopsis from expanding and consequently the emergence of seedling. It seems that water penetrates through hulls quite easily and that the pericarp of the caryopsis does not prevent water uptake of the embryo. Similar conclusions were drawn by Akamine (1944) on Paspalum notatum. Caryopses of P. notatum are enclosed in tightly joined and tough lemmas and paleas - very much like S. glauca. He concluded that the cause of low germination is the presence of tough lemmas and paleas enclosing the caryopses and preventing maximum expansion of the embryo and the seed. Germination was increased by acid scarification and by removing of the hull. In seeds of Urochloa pallulans he found the same situation.

There are many more plants where the germination is prevented mechanically by seed coats. Crocker, Thornton, and Schroeder (1946) found that the breaking pressure of Carya ovata shells was 670 pounds at harvest and the pressure was rapidly reduced by storage in moist soil. There was a direct relationship between lowering of breaking pressure and germination. Muller (1914) (cit. Crocker, Thornton, and Schroeder, 1946) demonstrated that the average breaking strength of the dry Corylus avelana shells was more than double the average growth pressure of the growing embryo but the breaking strength of the shell was greatly reduced by imbibation of water. This weakening was sufficient on the average to bring the breaking strength of the shell a little below the growing pressure of the embryo of C. avelana. The original strength of the shell returned when the coat was again dried. It is quite logical, therefore, that some seeds are held in a dormant state in the soils because the force of the

expanding contents is not sufficient to rupture the coats.

In the literature one can find reports indicating that the hulls of certain Gramineae seed may prevent germination by means of inhibiting substances. So, Harrington and Crocker (1923) believe in the possibility that inhibitory substances are held within the coats of Sorghum halepensis and that these maintain the embryo in a dormant condition.

As far as the influence of seed coats in delaying the germination of Plantago lanceolata seed is concerned, Crocker (1906) had no doubt that the delay is due to the seed coats. Recently Cooper (1942) showed that mature seeds of P. lanceolata contain the embryo, embedded in an abundant endosperm occupying the major part of the seed, and a papery seed coat. According to Eames and McDaniels (1947) the seed coat of P. lanceolata consists of merely two layers of cells. It is therefore not likely that the seed coat proper (pericarp) is the main cause in delaying the germination. The observations made in the course of the present experiments would lead to the assumption that the endosperm is more to blame than the pericarp, since the endosperm is of tough, compact, and vitreous texture, thus probably being capable of preventing water entrance and also restricting gaseous exchange.

Comparison of the seed coat effects in delaying the germination between seeds collected in 1949 and in 1950 provides reason to believe that 1950 seeds of S. glauca, B. arvensis, and R. acetosella had stronger coats which were capable of delaying germination to a greater extent than coats of seeds from the 1949 collection. There can be no doubt that meteorological conditions during the growing and ripening of seeds were responsible at least in part. The summer of the 1949 season was very warm and dry, while 1950 summer was cooler and more humid. As the cooler and moister conditions retard the process of seed ripening, the plants are being simultaneously provided with better conditions to develop vegetative organs,

consequently the seed enclosing structures grow stronger. It is also obvious that inherent factors in the parent are of importance, too.

SUMMARY AND CONCLUSIONS

1. Dormancy in seeds of eight weeds was studied in 1949 and 1950. A total of 41 seed samples were collected from wild growing plants in the Province of Quebec. The degree of dormancy was determined by the rate of germination. The presence of dormancy in freshly harvested seed and the effect of dry storage as well as winter-stratification on after-ripening was studied by means of germination tests in the laboratory at four temperature and light treatments. The effect of low temperature stratification on after-ripening was examined by subjecting the seeds to low temperatures in a commercial refrigerator and to winter temperatures in the field. The germinating capacity of dry-stored intact seed was also studied using as a germination substratum three types of soil at three depths. The effect of the seed coats in delaying germination was studied by means of hulling, scarification with conc. sulphuric acid, etc.
2. Freshly harvested seed (1) did not germinate or the germination was poor in Setaria glauca, Ambrosia artemisiifolia, Rumex acetosella, and 1950 Brassica arvensis, and (2) the germination was fair or good in Silene noctiflora, Portulaca oleracea, Plantago lanceolata, Chrysanthemum leucanthemum, and 1949 B. arvensis.
3. Dry storage was beneficial in increasing the germinating capacity. After-ripening during storage was slow in A. artemisiifolia, R. acetosella, and B. arvensis. The light sensitivity of C. leucanthemum at 20°C. declined on dry storage.
4. Some evidence was secured that the germination of B. arvensis and P. lanceolata declines in dry storage during the summer months to rise again with approaching winter season.
5. Stratification at low temperature under laboratory conditions proved to be (1) very effective on A. artemisiifolia; (2) effective on S. glauca, P. lanceolata, P. oleracea, and C. leucanthemum, the latter

partially by losing its light sensitivity at 20°C.; (3) no effect or a negative effect on R. acetosella, S. noctiflora, B. arvensis, and C. leucanthemum - the latter in light.

6. In the laboratory germination tests, the seeds of (1) perennial plants - P. lanceolata, C. leucanthemum, and R. acetosella - responded better to lower temperatures, while (2) most annual plants germinated better at higher temperatures - P. oleracea, B. arvensis, and A. artemisiifolia. No definite consistency was established with S. noctiflora and S. glauca.
7. Light proved to be definitely beneficial for germination of C. leucanthemum, S. glauca, R. acetosella, and P. oleracea seed both stratified and unstratified.
8. Seeds stratified under field conditions throughout the winter and kept in the ground under the rising soil temperatures until June 14-16th showed (1) increase in germinating capacity of P. oleracea, C. leucanthemum, and R. acetosella; (2) falling off in germinating capacity of S. glauca, P. lanceolata, A. artemisiifolia, and B. arvensis. Seeds of the group (2) reverted completely (S. glauca) or partially (P. lanceolata, A. artemisiifolia) into secondary dormancy with the rising temperatures of the advancing season.
9. Experiments on winter stratification in the field shows that the species tested fall into three groups as to the earliness of sprouting in spring:- (1) early sprouting species - S. noctiflora, B. arvensis, and P. lanceolata; (2) intermediate - A. artemisiifolia, R. acetosella, and C. leucanthemum; and (3) late sprouting species - S. glauca and P. oleracea.
10. Pronounced decline in germination with the deeper sowing (range used in the experiment was from 1/4 to 1 inch) was encountered with C. leu-

canthemum, P. oleracea, R. acetosella, and B. arvensis seed.

11. It was found that the seed coats of the species tested play a more or less important part in delaying the germination. Results of the experiments indicated that (1) the hulls (lemmas and paleas) of S. glauca prevent the embryo and endosperm from expanding thus checking the germination; (2) the seed coats inhibit the penetration of water into the seed or interfere with the gaseous exchange in R. acetosella, P. oleracea, B. arvensis, P. lanceolata, and A. artemisiifolia; (3) by some unknown method the seed coat (or endosperm?) inhibits the germination of S. noctiflora at the temperature of 30°C.; (4) probably the seed coat is primarily responsible for the light sensitivity of C. leucanthemum seed.

12. (1) No embryo dormancy was observed in seeds of C. leucanthemum, S. noctiflora, and P. lanceolata; (2) short period of dormancy after harvest was found in S. glauca, R. acetosella, P. oleracea, and B. arvensis; and (3) long lasting embryo dormancy was perceived in A. artemisiifolia.

13. Freshly harvested intact seeds of S. glauca do not germinate. Intact seeds after-ripen in dry storage, but 14 month storage did not result in high germination. Progress of after-ripening was faster in mature seeds than in immature ones under dry storage conditions. Light is an important factor in germination of S. glauca seed. Higher constant temperatures, 30°C., were apt to inhibit germination. Low temperature stratification in the laboratory resulted in faster after-ripening and higher germination percentages of intact immature seed of 1949 collection over the mature ones, but freshly harvested 1950 seed did not show any effect of low temperature stratification for 15 weeks. Winter stratified seeds began to sprout in the field late in spring and by the beginning of summer the immature seeds had produced more sprouts than

the mature ones. Almost complete after-ripening was the result of winter stratification; the immature seeds were more after-ripened than the mature ones. The sensitivity to light lessened as a result of winter stratification. Prolonged exposure of after-ripened seed to higher temperatures of late spring caused the reversal into secondary dormancy. Dry stored seeds germinated better in the heavier soils. Hulling experiments show that freshly harvested seeds have dormant embryos. Dormancy of the embryos of mature seed disappears in comparatively short period of storage. Hard, brittle, and tightly joined lemmas and paleas seemed to be the cause of delaying the germination of intact mature seed which have after-ripened embryos.

14. Rumex acetosella seeds practically fail to germinate shortly after harvest. Germinating capacity rises slowly in dry storage giving the best results in alternating temperature in light. The seeds did not respond to low temperature treatment in the laboratory, even stratified as long as five months, but the stratified seeds under field conditions germinated better than those unstratified. Dry stored seed germinated best in moderately heavy soils near the surface, although they managed to produce some sprouts from the depth of one inch. The application of conc. sulphuric acid increased the germination extremely. Freshly harvested seeds did not respond to the same extent to scarification treatment as did the seeds stored for at least two months. This is evidence that although the seed coats play an important part in delaying germination, freshly harvested seeds exhibit embryo dormancy to a certain extent.

15. Mature seeds of Silene noctiflora germinated better than immature ones soon after harvest. Three months after harvest all the samples germinated very well, except at constant 30°C. temperature. All seeds of

the 1949 collection germinated very well at 30°C. but one sample, the germination of which was somewhat lower at that temperature. Low temperature stratification in the laboratory resulted in a decline in germinating capacity of some 1950 samples, while other samples remained unaffected, and if did not overcome the inhibition of germination at 30°C. In the winter stratification experiments the seeds sprouted to a great extent early in the spring. Dry stored 1949 seeds germinated very well on blotting paper in the laboratory and in soil in the greenhouse. Embryos of freshly harvested S. noctiflora seed were not dormant.

16. Freshly collected Portulaca oleracea seeds did not germinate at 20°C., while at higher temperatures the germination was poor. On the average higher temperatures provided better conditions for germination than the lower ones. Soon after collection seeds showed some response to low temperature stratification in the laboratory. Stratification under field conditions was as effective as the storage under laboratory conditions for the same period of time. Dry stored seeds sown in soil germinated better in medium heavy soil and better the nearer the surface. Scarification with conc. sulphuric acid increased the germinating capacity markedly. Increase in germination because of scarification was higher with dry stored seed than with the freshly collected material, thus not only seed coat is responsible for delaying germination, but freshly collected seeds have more or less dormant embryos.

17. Brassica arvensis seed of 1949 germinated well soon after collection, while those of 1950 germinated poorly, even after storage of eight weeks. Falling off in germinating capacity of dry stored seed was observed during the summer season of 1950, increasing again the next winter. Stratification in the laboratory had a negative effect on 1949 seed, and no effect on 1950 seed. Seed stratified through winter

under field conditions showed high germination percentages, higher than unstratified seed. In soil both stratified and unstratified seeds germinated equally well. Scarification with conc. sulphuric acid increased the germinating capacity considerably; those stored for a certain period of time benefited more from scarification. Thus the seed coat is responsible to a great extent for delaying germination , but the embryo dormancy is involved, too. Embryos efter-ripen during winter stratification.

18. Stratification in the laboratory was beneficial in raising the germinating capacity of Plantago lanceolata seed. After oxidising the mucilaginous layer of the seed coat by chlorine, the seeds after-ripened at low temperature stratification faster and to a higher degree than those with intact mucilage. In the field the seeds sprouted early in the spring. Complete after-ripening was the result of stratification under field conditions throughout the winter. Thus after-ripened seeds following exposure to rising temperatures of the advancing season revert, at least partly, into secondary dormancy. As the proper seed coat (pericarp) is built up of only two layers of cells, it is not likely that it might inhibit the water uptake or markedly restrict the gaseous exchange. The strongly developed, compact, and vitrous endosperm, which surrounds the embryo, is responsible for delaying the germination. It was found that the embryos of dry stored seed are not dormant.

19. Ambrosia artemisiifolia seeds do not germinate soon after collection. They after-ripen very slowly in dry storage. Stratification in the laboratory for about two months or in the field throughout the winter resulted in complete after-ripening. Very poor germination was obtained from unstratified dry stored seed in the soil. Delayed germination is partly caused by seed coats and partly by embryo dormancy,

the latter disappearing in dry storage in approximately one year.

20. Chrysanthemum leucanthemum seeds germinated well soon after collection. On the average the temperature of 20°C. provided better conditions for germination than the higher temperatures. Light is a very important factor for germination of C. leucanthemum seed. Exclusion of light at 30°C. inhibits the germination almost completely. The inhibition of germination by exclusion of light is not deep seated since seeds transferred from the dark germinator to light germinate well. Stratification at low temperatures under laboratory conditions did not improve the germination in the light, but prolonged stratification appeared to reduce the sensitivity to it; the same was true for seed stratified under field conditions. Unstratified seeds germinated best near the surface, but also produced some sprouts from as deep as one inch. The evidence obtained shows that embryos of C. leucanthemum seeds are not dormant.

SUGGESTIONS FOR FUTURE RESEARCH

The problem of dormancy in weed seeds need more research. On the basis of results obtained and the experience gained in the course of the experiments described in this paper some points on the technique and the following problems might be suggested for future research.

1. In germination tests in the laboratory a wider range of temperatures should be used, preferably from constant 15°C. to constant 30°C. (in some instances to 35°C.), including alternating temperatures. Provision should be made for the germination in both light and darkness. It should be possible to maintain the light intensity and the duration of the daily light constant throughout the period of the experiments.
2. Seed stratified at low temperatures should be given germination tests in a wider range of temperatures.
3. Complete description of the anatomical structure of seeds would be a great help in planning the experiments as well as in interpreting the results.
4. The effects on germination of reduced partial pressure of oxygen, of increased partial pressure of carbon dioxyde, and both combined, should be studied. The influence of both air composition and higher temperatures on inducing secondary dormancy in seeds might be of particular interest.
5. The differences in embryo dormancy and seed coat development should be investigated in relation to the meteorological conditions of the year of harvest. Lines of the same genetical origin should be used for these experiments.
6. The differences, if any, of dormancy in seeds from plants grown in soils of different fertility and under different conditions of competition by other plants need to be elucidated.
7. More extensive studies on the decline in germination of seed stratified

under laboratory conditions would be of great interest. The low temperature applied for stratification should be as constant as possible (the range of alternation not larger than 2°C.).

8. A special attention should be given to Silene noctiflora or any other important species maturing and shedding seeds early in the season and apparently showing no dormancy in the laboratory tests. The experiments should be devised to approximate as closely as possible the conditions in which seeds are placed after they have been shed on the surface of soil.
9. The problem of light penetration through soil in relation to the germination of weed seeds would be worth while investigating, as well as the physiological problem as to how light stimulates or inhibits the germination of certain seeds.
10. The problem of inheritance of dormancy in weed seeds is also of great interest.

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LIST OF APPENDIX TABLES

Table

A P P E N D I X

Table 1

List of samples

	Sample	Date of seed collection	Seeds collected in county	1000 seed weight in grams	Weight of 1,000 caryopses in gms.
Setaria glauca	112-B	Aug.2, 1949	Jacques Cartier	3.7	2.04
	112-G*)	" 2 "	" "	3.0	1.50
	113-B	" 10 "	Chateauguay-	3.7	1.99
	113-G*)	" 10 "	Huntingdon	3.4	1.85
	127-B	" 10, 1950	Jacques Cartier	3.5	1.91
	127-G*)	" 10 "	" "	2.7	1.31
	128-B	" 11 "	" "	3.6	1.96
	128-G*)	" 11 "	" "	2.7	1.38
Rumex acetosella	104	July 12,1949	Jacques Cartier	0.49	
	105	" 13 "	Stanstead	0.51	
	107	" 15 "	"	0.50	
	123	" 20,1950	Jacques Cartier	0.47	
	124	" 20 "	" "	0.52	
Silene noctiflora	101a	July 4,1949	Jacques Cartier	1.2	
	101b	" 6 "	" "	1.2	
	109	" 25 "	" "	1.0	
	117	" 6 1950	" "	1.1	
	118*)	" 20 "	" "	1.0	
	121	" 20 "	" "	0.9	
	122*)	Oct. 3 "	" "	0.7	
	131			0.9	
Portulaca oleracea	114a	Sep.5, 1949	Jacques Cartier	0.11	
	114b	"21 "	" "	0.12	
	129	" 1 1950	" "	0.10	
	130	" 1 "	" "	0.08	
Brassica arvensis	110	July 30,1949	Jacques Cartier	2.0	
	111	Aug. 1 "	St.Hyacinthe-Bagot	1.8	
	125	Aug. 10,1950	Jacques Cartier	1.7	
	126	Aug. 10 "	" "	1.6	
Plantago lanceolata	102a	July 2,1949	Jacques Cartier	0.6	
	102b	" 25 "	" "	1.0	
	102c	Aug. 9 "	" "	0.8	
	106	July 13 "	Stanstead	1.1	

*) Immature seeds.

Table 1 (concluded)

	Sample	Date of seed collection	Seeds collected in county	1000 seed weight in grams
Ambrosia artemisiifolia	115	Sep. 30, 1949	Jacques Cartier	4.3
	116	Oct. 5 "	" "	4.5
	132	Oct. 5, 1950	" "	4.4
	133	" 5 "	" "	5.0
Chrysanthemum leucanthemum	103	July 6, 1949	Jacques Cartier	0.30
	108	" 15 "	Stanstead	0.31
	119	" 14, 1950	Jacques Cartier	0.30
	120	" 14 "	" "	0.28

Tables No. 2-16

Applying to the Chapter IV

Germination of freshly harvested seed and the effect of dry storage.

Table 2

Setaria glauca, 1949. [1]

Germination dates	Samples	Observed data 20°C, dark		30°C, dark		20°C, light		20-30°C, light	
Aug.22,1949	112-B	0 [2]	0 [2]	0	0	0	0	0	0
	112-G	0	0	0	0	0	0	0	0
	113-B	0	0	0	0	0	0	0	0
	113-G	0	0	0	0	0	0	0	0
Mar.12,1950	112-B	48	49	5	12	75	67	60	67
	112-G	34	31	1	3	70	65	66	65
	113-B	64	68	16	7	65	64	63	65
	113-G	32	45	0	4	52	55	48	35
May 9, 1950	112-B	52	45	2	4	67	65	57	69
	112-G	36	39	4	0	74	75	72	63
	113-B	68	54	11	9	75	73	75	72
	113-G	42	45	5	6	55	65	50	55
Sep.9, 1950	112-B	36	31	1	1	60	58	55	61
	112-G	42	34	2	1	79	84	76	78
	113-B	68	49	2	1	70	60	46	54
	113-G	52	48	1	2	68	68	55	61
		Transformed data							
Aug.22,1949	112-B	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
	112-G	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
	113-B	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
	113-G	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Mar.12,1950	112-B	43.9	44.4	12.9	20.3	60.0	54.9	50.8	54.9
	112-G	35.7	33.8	5.7	10.0	56.8	53.7	54.3	52.5
	113-B	53.1	55.6	23.6	15.3	52.5	53.1	52.3	52.3
	113-G	34.4	42.1	2.6	11.5	46.1	47.9	43.9	36.3
May 9, 1950	112-B	46.1	42.1	8.1	11.5	54.9	53.7	49.0	56.2
	112-G	36.9	38.6	11.5	2.6	59.3	60.0	58.1	52.5
	113-B	55.6	47.3	19.4	17.5	60.0	58.7	60.0	58.1
	113-G	40.4	41.0	12.9	14.2	47.9	52.5	45.0	47.9
Sep.9, 1950	112-B	36.9	33.8	5.7	5.7	50.8	49.6	47.9	51.4
	112-G	40.4	35.7	8.1	5.7	62.7	66.4	60.7	62.0
	113-B	55.6	44.4	8.1	5.7	56.8	50.8	42.7	47.3
	113-G	46.1	43.9	5.7	8.1	55.6	55.6	47.9	51.4

1) In all the headings of the appendix tables, the year standing after the name of plant indicates the year in which the seeds were collected.

2) Duplicate tests.

Table 2 (concluded)

Source	D.F.	M.S.	F.	5%	1%
Samples	5	144.15	3.34** 2)	2.82	4.26
Mat. vs Imm.	1	168.14	3.90	4.06	7.26
Mature	1	157.18	3.65		
Immature	1	107.12	2.49		
Temperatures	3	7,405.74	172.02**		
Hi. vs Lo.[1]	1	5,782.15	134.31**		
Li. vs D. at Hi.	1	15,098.27	350.71**		
Li. vs D. at Lo.	1	1,336.81	31.05**		
Germin. dates	3	11,192.32	259.98**		
Temp. x germ. d.	9	845.86	19.64**	2.10	2.84
Error	45	43.05			
Duplicates	64	6.77			
Total	127				

1) Li. = light; D. = dark; Hi. = higher temperatures, Lo. = lower temperatures.

2) * Significant at .05 level.
** " " .01 "

Means and N.D.

Temperatures		Germ. Dates		Samples	
20°C, dark	= 32.8	Aug.22, 1949	= 2.6	112-B	= 30.2
30°C "	= 8.5	Mar.12, 1950	= 39.6	112-G	= 30.8
20°C, light	= 41.9	May 9 "	= 41.2	113-B	= 33.5
20-30°C "	= 39.3	Sep. 9 "	= 39.0	113-G	= 28.2
N.D. (.05)	= 3.30	N.D. (.05)	= 3.30	N.D.(.05)	= 3.30
(.01)	= 4.41	(.01)	= 4.41	(.01)	= 4.41

Table 3

Setaria glauca, 1950.

Germination dates	Samples	Observed data							
		20°C, dark		30°C, dark		20°C, light		20-30°C, light	
Aug.16,1950	127-B	0	0	0	0	0	0	0	0
	127-G	0	0	0	0	0	0	0	0
	128-B	0	0	0	0	0	0	0	0
	128-G	0	0	0	0	0	0	0	0
Oct.16,1950	127-B	0	1	0	0	2	0	0	0
	127-G	0	0	0	0	0	2	2	0
	128-B	13	17	0	0	19	29	9	8
	128-G	0	1	0	0	2	4	0	0
Dec.15,1950	127-B	27	23	0	0	48	44	25	27
	127-G	30	30	1	0	42	43	33	41
	128-B	89	77	8	10	91	94	85	78
	128-G	50	54	6	2	75	69	50	62

Table 4

Rumex acetosella, 1949.

Germination dates	Temperature	Observed data 104		105		107	
Aug.21, 1949	20°C, dark	0	0	3	2	0	0
	30°C "	0	2	1	1	0	0
	20°C, light	5	2	5	3	2	1
	20-30°C "	2	2	6	8	3	6
Mar.12, 1950	20°C, dark	5	0	17	11	2	3
	30°C "	3	1	11	7	12	7
	20°C, light	14	9	19	19	26	8
	20-30°C "	19	19	29	36	26	19
May 11, 1950	20°C, dark	3	3	12	17	12	8
	30°C "	4	1	17	12	3	9
	20°C, light	12	9	16	27	18	11
	20-30°C "	11	12	22	27	26	22
Sep.12, 1950	20°C, dark	5	3	9	13	8	5
	30°C "	8	1	13	12	16	18
	20°C, light	17	10	21	19	28	31
	20-30°C "	45	46	56	41	73	72
		Transformed data					
Aug.21, 1949	20°C, dark	2.6	2.6	10.0	8.1	2.6	2.6
	30°C "	2.6	8.1	5.7	5.7	2.6	2.6
	20°C, light	12.9	8.1	12.9	10.0	8.1	5.7
	20-30°C "	8.1	8.1	14.2	16.4	10.0	14.2
Mar.12, 1950	20°C, dark	12.9	2.6	24.4	19.4	8.1	10.0
	30°C "	10.0	5.7	19.4	15.3	20.3	15.3
	20°C, light	22.0	17.5	25.8	25.8	30.7	16.4
	20-30°C "	25.8	25.8	32.6	36.9	30.7	25.8
May 11, 1950	20°C, dark	10.0	10.0	20.3	24.4	20.3	16.4
	30°C "	11.5	5.7	24.4	20.3	18.5	17.5
	20°C, light	20.3	17.5	23.6	31.3	25.1	19.4
	20-30°C "	19.4	20.3	28.0	31.3	30.7	28.0
Sep.12, 1950	20°C, dark	12.9	10.0	17.5	21.1	16.4	12.9
	30°C "	16.4	5.7	21.1	20.3	23.6	25.1
	20°C, light	24.4	18.4	27.3	25.8	31.9	33.8
	20-30°C "	42.1	42.7	48.4	39.8	58.7	58.1

Table 4 (concluded)

Source	D.F.		M.S.	F.	5%	1%
Samples	2		492.68	16.55**	3.32	5.39
Temperatures	3		1,442.85	48.48**	2.92	4.51
Hi. vs Lo.[1]		1	495.94	16.66**	4.17	7.56
Li. vs D. at Lo.		1	805.24	27.06**		
Li. vs D. at Hi.		1	3,027.37	101.72**		
Germin. dates	3		1,588.79	53.38**		
Temp. x germ. d.	9		165.36	5.55**	2.21	3.06
Error	30		29.76			
Duplicates	48		11.25			
Total	95					

Means and N.D.

Germin. dates		Temperatures	
Aug. 21, 1949	= 7.7	20°C, dark	= 12.4
Mar. 12, 1950	= 20.0	30°C "	= 13.1
May 11 "	= 20.2	20°C, light	= 20.6
Sep. 12 "	= 27.3	20-30°C "	= 29.0
N.D. (.05)	= 3.20	N.D. (.05)	= 3.20
(.01)	= 4.32	(.01)	4.32

1) Hi. = higher temperatures, Li. = light

Lo. = lower " D. = dark

Table 5

Rumex acetosella, 1950

Germination dates	Temperat.	Observed data 123		124	
Jul. 25, 1950	20°C, dark	0	0	0	0
	30°C "	0	0	0	0
	20°C, light	0	0	0	0
	20-30°C "	0	0	0	0
Sep. 25, 1950	20°C, dark	1	1	0	0
	30°C "	1	0	0	0
	20°C, light	0	1	0	0
	20-30°C "	3	0	0	1

Table 6

Silene noctiflora, 1949.

Germination dates	Temperat.	Observed data 101a		101b		109	
Aug.20, 1949	20°C, dark	98	100	100	100	100	100
	30°C "	100	100	100	99	71	60
	20°C, light	99	100	100	100	100	100
	20-30°C "	100	100	100	99	100	99
Mar.11, 1950	20°C, dark	100	100	100	100	100	100
	30°C "	94	99	100	98	81	94
	20°C, light	100	100	100	97	100	100
	20-30°C "	100	100	100	100	100	100
May 13, 1950	20°C, dark	100	100	100	100	100	100
	30°C "	99	97	95	97	96	95
	20°C, light	99	100	100	100	100	100
	20-30°C "	100	99	100	100	100	99
		Transformed data					
Aug.20, 1949	20°C, dark	81.9	87.4	87.4	87.4	87.4	87.4
	30°C "	87.4	87.4	87.4	84.3	57.4	50.8
	20°C, light	84.3	87.4	87.4	87.4	87.4	87.4
	20-30°C "	87.4	87.4	87.4	84.3	87.4	84.3
Mar.11, 1950	20°C, dark	87.4	87.4	87.4	87.4	87.4	87.4
	30°C "	75.8	84.3	87.4	81.9	64.2	75.8
	20°C, light	87.4	87.4	87.4	80.0	87.4	87.4
	20-30°C "	87.4	87.4	87.4	87.4	87.4	87.4
May 13, 1950	20°C, dark	87.4	87.4	87.4	87.4	87.4	87.4
	30°C "	84.3	80.0	77.1	80.0	78.5	77.1
	20°C, light	84.3	87.4	87.4	87.4	87.4	87.4
	20-30°C "	87.4	84.3	87.4	87.4	87.4	84.3

Table 6 (concluded)

Source	D.F.	M.S.	F.	5%	1%
Samples	2	118.00	1.55	3.42	5.66
Temperatures	3	330.96	4.35*	3.03	4.76
Hi. vs Lo.[1]	1	346.72	4.56*	4.28	7.88
Li. vs D. at Hi.	1	644.32	8.47**		
Li. vs D. at Lo.	1	1.83			
Germin. dates	2	13.18			
Temp. x germ. d.	6	9.44			
Error	23	76.00			
Duplicates	36	6.29			
Total	71				

Means and N.D.

Germin. dates		Temperatures	
Aug. 20, 1949	= 83.9	20°C, dark	= 87.1
Mar. 11, 1950	= 84.8	30°C "	= 78.2
May 13 "	= 85.4	20°C, light	= 86.7
		20-30°C "	= 86.7
N.D. (.05)	= 5.14	N.D.(.05)	= 5.94
		(.01)	= 8.03

1) Hi. = higher temperatures, Li. = light

Lo. = lower " D. = dark

Table 7

Silene noctiflora, 1950.

Weeks after harvest	Samples	Observed data 20°C, dark		30°C, dark		20°C, light		20-30°C, light	
0	117	99	92	0	0	100	94	100	100
	118	74	47	0	0	57	49	71	72
	121	55	47	0	0	6	23	61	56
	122	5	0	0	0	2	1	25	16
2	117	99	95	0	0	85	88	85	96
	118	52	64	0	0	43	67	61	85
	121	23	18	1	0	39	16	67	53
	122	10	4	1	8	3	11	15	14
4	117	96	98	0	0	99	98	100	100
	118	69	81	1	2	81	91	14	57
	121	76	94	0	0	93	89	46	56
	122	38	35	0	0	37	69	19	39
6	117	100	99	0	1	100	100	97	99
	118	98	99	0	0	95	92	13	13
	121	90	90	0	0	96	88	98	96
	122	75	80	1	0	77	82	85	92
8	117	100	99	1	0	100	100	100	100
	118	100	100	0	0	99	99	98	91
	121	99	100	67	54	99	100	94	70
	122	97	97	23	17	96	94	82	36
12	117	100	100	43	62	99	100	100	100
	118	99	99	5	4	100	98	97	98
	121	100	100	42	34	100	100	100	100
	122	99	98	5	8	99	99	100	98

Table 7 (continued)

Weeks after harvest	Samples	Transformed data 20°C, dark		30°C, dark		20°C, light		20-30°C, light	
0	117	84.3	75.6	2.6	2.6	87.4	75.8	87.4	87.4
	118	59.3	45.3	2.6	2.6	49.0	44.4	57.4	58.1
	121	46.7	45.3	2.6	2.6	14.2	28.7	51.4	48.4
	122	12.9	2.6	2.6	2.6	8.1	5.7	30.0	23.6
2	117	84.3	77.1	2.6	2.6	67.2	69.7	67.2	78.5
	118	46.1	53.1	2.6	2.6	41.0	54.9	51.4	67.2
	121	28.7	25.1	5.7	2.6	38.6	23.6	54.9	46.7
	122	18.4	11.5	5.7	16.4	10.0	19.4	22.8	22.0
4	117	78.5	81.9	2.6	2.6	84.3	81.9	87.4	87.4
	118	56.2	64.2	5.7	8.1	64.2	72.5	22.0	49.0
	121	60.7	75.8	2.6	2.6	74.7	70.6	42.7	48.4
	122	38.1	36.3	2.6	2.6	37.5	36.2	25.8	38.6
6	117	87.4	84.3	2.6	5.7	87.4	87.4	80.0	84.3
	118	81.9	84.3	2.6	2.6	77.1	73.6	21.1	21.1
	121	71.6	71.6	2.6	2.6	78.5	69.7	81.9	78.5
	122	60.0	63.4	5.7	2.6	61.3	64.9	67.2	73.6
9	117	87.4	84.3	5.7	2.6	87.4	87.4	87.4	87.4
	118	87.4	87.4	2.6	2.6	84.3	84.3	81.9	72.5
	121	84.3	87.4	54.9	47.3	84.3	87.4	75.8	56.8
	122	80.0	80.0	28.7	24.4	78.5	75.8	64.9	36.9
12	117	87.4	87.4	41.0	51.9	84.3	87.4	87.4	87.4
	118	84.3	84.3	12.9	11.5	87.4	81.9	80.0	81.9
	121	87.4	87.4	40.4	35.7	87.4	87.4	87.4	87.4
	122	84.3	81.9	12.9	16.4	84.3	84.3	87.4	81.9

Table 7 (concluded)

Source	D.F.	M.S.	F.	5%	1%
Samples	3	5,731.11	13.48xx	2.74	4.08
Mat. vs Imm.	1	9,992.19	23.50xx	3.98	7.01
Mature	1	4,430.88	10.42xx		
Immature	1	2,770.27	6.51x		
Temperatures	3	35,242.68	82.90xx		
Hi. vs Lo.[1]	1	40,690.54	95.72xx		
Li. vs D.[1] at Hi.	1	65,015.64	152.93xx		
Li. vs D. at Lo.	1	21.85			
Germin. dates	5	7,169.18	16.86xx	2.35	3.29
Temp. x germ. dat.	15	500.96	1.17	1.84	
Error	70	425.11			
Duplicates	96	12.16			
Total	191				

Means and N.D.

Germination dates

Weeks after harvest
0 = 35.8
2 = 35.0
4 = 46.1
6 = 54.3
8 = 65.0
12 = 71.0
N.D.(.05)= 10.25
(.01)= 13.65

Temperatures

20°C, dark = 66.2
30°C " = 10.6
20°C, light = 65.3
20-30°C" = 62.6
N.D.(.05) = 8.38
(.01) = 11.16

Samples

117 = 65.2
118 = 49.3
121 = 51.6
122 = 38.6
N.D.(.05) = 8.38
(.01) =11.16

1) Hi. = higher temperatures, Li. = light
Lo. = lower " D. = dark

Table 8

Portulaca oleracea, 1949.

Germination dates	Temperat.	Observed 114a		114b		Transformed 114a		114b	
Sep.29, 1949	20°C, dark	0	0	0	0	2.6	2.6	2.6	2.6
	30°C "	39	18	8	28	38.6	25.1	16.4	31.9
	20°C, light	0	0	0	0	2.6	2.6	2.6	2.6
	20-30°C "	17	4	7	6	24.4	11.5	15.3	14.2
May 8, 1950	20°C, dark	14	10	5	4	22.0	18.4	12.9	11.5
	30°C "	41	42	63	59	39.8	40.4	52.5	50.2
	20°C, light	24	27	33	35	29.3	31.3	35.1	36.3
	20-30°C "	70	77	80	84	56.8	61.3	63.4	66.4
Sep.7, 1950	20°C, dark	17	12	10	7	24.4	20.3	18.4	15.3
	30°C "	41	52	72	79	39.8	46.1	58.1	62.7
	20°C, light	38	39	12	24	38.1	38.6	20.3	29.3
	20-30°C "	71	84	96	98	57.4	66.4	78.5	81.9

Source	D.F.	M.S.	F.	5%	1%
Samples	1	34.34			
Temperatures	3	3,492.69	33.63xx	3.59	6.22
Hi. vs Lo.[1]	1	9,542.88	91.89xx	4.84	9.65
Li. vs D.[1] at Lo.	1	552.00	5.31x		
Li. vs D. at Hi.	1	383.20	3.68		
Germin. dates	2	4,545.99	43.77xx	3.98	7.20
Temp. x germ. dat.	6	332.99	3.20x	3.09	5.07
Error	11	103.85			
Duplicates	24	18.88			
Total	47				

Means and N.D.

Germin. dates

Sep. 29, 1949	= 12.4
May 8, 1950	= 39.2
Sep. 7 "	= 43.5
N.D. (.05)	= 7.92
(.01)	= 11.20

Temperatures

20°C, dark	= 12.8
30°C "	= 41.8
20°C, light	= 22.4
20-30°C "	= 49.8
N.D. (.05)	= 9.15
(.01)	= 12.94

1) Hi. = higher temperatures, Li. = light
Lo. = lower " D. = dark

Table 9

Portulaca oleracea, 1950.

Germination dates	Temperat.	Observed data 129		130	
Sep. 7, 1950	20°C, dark	0	0	0	0
	30°C "	3	5	6	11
	20°C, light	0	0	0	0
	20-30°C "	0	5	7	1
Dec. 9, 1950	20°C, dark	0	0	0	0
	30°C "	13	2	49	25
	20°C, light	0	0	0	0
	20-30°C "	3	2	3	0

Table 10

Brassica arvensis, 1949.

Germination dates	Temperat.	Observed 110		Observed 111		Transformed 110		Transformed 111	
Aug.21, 1949	20°C, dark	22	30	41	49	28.0	33.2	39.8	44.4
	30°C "	23	17	61	64	28.7	24.4	51.4	53.1
	20°C, light	48	40	81	62	43.9	39.2	64.2	51.9
	20-30°C "	68	64	80	82	55.6	53.1	63.4	64.9
Mar.11, 1950	20°C, dark	69	71	60	70	56.2	57.4	50.8	56.8
	30°C "	34	40	58	49	35.7	39.2	49.6	44.4
	20°C, light	65	51	67	67	53.7	45.6	54.9	54.9
	20-30°C "	78	72	82	77	62.0	58.1	64.9	61.5
May 9, 1950	20°C, dark	52	41	47	45	46.1	39.8	43.3	42.1
	30°C "	36	29	66	66	36.9	32.6	54.5	54.5
	20°C, light	76	71	69	80	60.7	57.4	56.2	63.4
	20-30°C "	77	62	63	63	61.5	51.9	52.5	52.5
Sep.12, 1950	20°C, dark	20	41	29	25	26.6	39.8	32.6	30.0
	30°C "	30	19	37	31	33.2	25.8	37.5	33.8
	20°C, light	58	33	46	41	49.6	35.1	42.7	39.8
	20-30°C "	18	6	15	35	25.1	14.2	22.8	35.1
Dec.4, 1950	20°C, dark	64	49	49	50	53.1	44.4	44.4	45.0
	30°C "	64	65	75	81	55.1	52.5	60.0	64.2
	20°C, light	75	80	79	80	60.0	63.4	62.7	65.4
	20-30°C "	69	66	92	86	56.2	54.3	73.6	68.0

Source	D.F	M.S.	F.	5%	1%
Samples	1	830.76	11.28xx	4.38	8.18
Temperatures	3	652.27	8.85xx	3.13	5.01
Hi. vs Lo.[1]	1	.01			
Li. vs D.[1] at Lo.	1	1,090.98	14.82xx		
Li. vs D. at Hi.	1	865.85	11.76xx		
Germin. dates	4	1,413.85	19.20xx	2.90	4.50
Temp. x germ. dat.	12	182.58	2.47x	2.31	3.30
Error	19	73.64			
Duplicates	40	17.48			
Total	79				

1) Hi. = higher temperatures, Li. = light
Lo. = lower " D. = dark

Table 10 (concluded)

Means and N.D.

Germination dates		Temperatures	
Aug. 21, 1949	= 46.2	20°C, dark	= 42.7
Mar. 11, 1950	= 52.8	30°C "	= 43.2
May 9 "	= 50.3	20°C, light	= 53.1
Sep. 12 "	= 52.7	20-30°C "	= 52.5
Dec. 4 "	= 57.4	N.D. (.05)	= 5.66
N.D. (.05)	= 6.33	(.01)	= 7.75
(.01)	= 8.66		

Table 11

Brassica arvensis, 1950.

Weeks after harvest	Temperat.	Observed 125		Observed 126		Transformed 125		Transformed 126	
0	20°C, dark	0	0	0	0	2.6	2.6	2.6	2.6
	30°C "	1	0	0	1	5.7	2.6	2.6	5.7
	20°C, light	0	0	0	2	2.6	2.6	2.6	8.1
	20-30°C "	0	1	2	0	2.6	5.7	8.1	2.6
4	20°C, dark	1	0	1	0	5.7	2.6	5.7	2.6
	30°C "	0	0	0	1	2.6	2.6	2.6	5.7
	20°C, light	0	0	0	0	2.6	2.6	2.6	2.6
	20-30°C "	0	0	1	0	2.6	2.6	5.7	2.6
8	20°C, dark	2	0	0	0	8.1	2.6	2.6	2.6
	30°C "	0	0	2	1	2.6	2.6	8.1	5.7
	20°C, light	2	0	1	1	8.1	2.6	5.7	5.7
	20-30°C "	2	4	5	3	8.1	11.5	12.9	10.0
12	20°C, dark	1	1	6	2	5.7	5.7	14.2	8.1
	30°C "	13	11	35	27	21.1	19.4	36.3	31.3
	20°C, light	6	10	25	16	14.2	18.4	30.0	23.6
	20-30°C "	21	19	36	28	27.3	25.8	36.9	31.9
16	20°C, dark	6	9	5	2	14.2	17.5	12.9	8.1
	30°C "	13	16	43	37	21.1	23.6	41.0	37.5
	20°C, light	23	23	40	39	28.7	28.7	39.2	38.6
	20-30°C "	41	47	70	72	39.8	43.3	56.8	58.1

Source	D.F.	M.S.	F.	5%	1%
Samples	1	366.36	9.50xx	4.38	8.18
Temperatures	5	591.61	15.34xx	3.13	5.01
Hi. vs Lo.[1]	1	953.58	24.73xx		
Li. vs D.[1] at Lo.	1	493.51	12.80xx		
Li. vs D. at Hi.	1	327.75	8.50xx		
Germin. dates	4	2,615.52	67.84xx	2.90	4.50
Temp. x germ. d.	12	177.90	4.61xx	2.31	3.30
Error	19	38.55			
Duplicates	40	5.37			

1) Hi. = higher temperatures, Li. = light.
Lo. = lower " D. - dark.

Table 11 (concluded)

Means and N.D.

Germ. weeks after harvest		Temperatures	
0	= 3.8	20°C, dark	= 6.4
4	= 3.4	30°C "	= 14.0
8	= 6.2	20°C, light	= 13.5
12	= 21.8	20-30°C "	= 18.7
16	= 51.8	N.D. (.05)	= 4.10
N.D.(.05)	= 4.58	(.01)	= 5.61
(.01)	= 6.26		

Table 12

Plantago lanceolata, 1949

Germ. dates	Samples	Observed data 20°C, dark		30°C, dark		20°C, light		20-30°C, light	
Aug.20, 1949	102a	96	90	95	95	95	89	91	93
	102b	30	47	8	26	27	21	7	14
	102c	44	56	51	44	40	47	44	39
	106	58	51	48	67	55	51	72	59
Mar. 10, 1950	102a	92	89	85	89	82	94	82	80
	102b	75	61	52	37	64	59	45	22
	102c	81	76	45	55	75	78	63	66
	106	33	34	32	53	28	39	49	40
May 9, 1950	102a	89	82	89	62	88	87	90	85
	102b	32	45	6	5	29	35	38	27
	102c	60	64	25	19	54	58	66	51
	106	29	31	39	31	35	36	51	44
Sep.8, 1950	102a	90	84	87	83	92	87	94	89
	102b	56	67	56	41	57	40	40	50
	102c	81	79	57	70	77	80	60	78
	106	31	28	41	57	45	45	46	54
		Transformed data							
Aug.20, 1949	102a	78.5	71.6	77.1	77.1	77.1	70.6	72.5	74.7
	102b	33.2	43.3	16.4	30.7	31.3	27.3	15.3	22.0
	102c	41.6	36.9	33.8	41.6	39.2	43.3	41.6	36.9
	106	49.6	45.6	43.9	54.9	47.9	45.6	58.1	50.2
Mar.10, 1950	102a	73.6	70.6	67.2	70.6	64.9	75.8	64.9	63.4
	102b	58.7	51.4	46.1	37.5	53.1	50.2	41.0	28.0
	102c	64.2	60.7	42.1	47.9	60.0	62.0	52.5	54.3
	106	35.1	35.7	34.4	46.7	31.9	38.6	44.4	39.2
May 9, 1950	102a	70.6	64.9	70.6	51.9	69.7	68.9	71.6	67.2
	102b	34.4	42.1	14.2	12.9	32.6	36.3	38.1	31.3
	102c	50.8	53.1	30.0	25.8	47.3	49.6	54.3	45.6
	106	32.6	33.8	38.6	33.8	36.3	36.9	45.6	41.6
Sep.8, 1950	102a	71.6	66.4	68.9	65.6	73.6	68.9	75.8	70.6
	102b	48.4	54.9	36.9	39.8	49.0	39.2	39.2	45.0
	102c	64.2	62.7	49.0	56.8	61.3	65.4	50.8	62.0
	106	33.8	31.9	39.8	49.0	42.1	42.1	42.7	47.3

Table 12 (concluded)

Source	D.F.	M.S.	F.	5%	1%
Samples	5	6,954.25	55.04**	2.81	4.24
Temperatures	3	281.72	2.23		
Hi. vs Lo.[1]	1	541.20	4.28*	4.08	7.31
Li. vs D.[1] at Hi.	1	289.42	2.29		
Li. vs D. at Lo.	1	14.54			
Germin. dates	3	512.25	4.05*		
Temp. x germ. dat.	9	85.37			
Error	46	126.34			
Duplicates	64	21.47			
Total	127				

Means and N.D.

Germination dates

Aug.20, 1949	= 47.8
Mar.10, 1950	= 52.1
May 10 "	= 44.8
Sep. 8 "	= 53.5
N.D. (.05)	= 6.08
(.01)	= 8.13

Temperatures

20°C, dark	= 52.1
30°C "	= 45.4
20°C, light	= 51.1
20-30°C "	= 49.6
N.D. (.05)	= 6.08
(.01)	= 8.13

Samples

102a	= 70.2
102b	= 56.9
102c	= 49.5
106	= 41.5
N.D. (.05)	= 6.08
(.01)	= 8.13

1) Hi. = higher temperatures, Li. = light

Lo. = lower " D. = dark

Table 15

Ambrosia artemisiifolia, 1949.

Germination dates	Temperat.	Observed data 115		116	
Nov.4, 1949	20°C, dark	0	0	0	0
	30°C "	0	0	0	0
	20°C, light	0	0	0	0
	20-30°C "	2	1	1	0
May 8, 1950	20°C, dark	0	0	1	0
	30°C "	0	0	0	0
	20°C, light	0	0	0	0
	20-30°C "	0	2	2	3
Jul.18, 1950	20°C, dark	0	1	1	3
	30°C "	2	2	0	1
	20°C, light	2	5	5	1
	20-30°C "	15	26	27	31
Nov.22, 1950	20°C, dark	3	2	2	0
	30°C "	0	4	0	3
	20°C, light	1	1	6	8
	20-30°C "	35	25	41	42

Table 14

Ambrosia artemisiifolia, 1950.

Germination dates	Temperat.	Observed data 132		133	
Oct. 9, 1950	20°C, dark	0	0	0	0
	30°C "	0	0	0	0
	20°C, light	0	0	0	0
	20-30°C "	0	0	0	0
Dec. 9, 1950	20°C, dark	0	0	0	0
	30°C "	0	0	0	0
	20°C, light	0	0	0	0
	20-30°C "	6	3	12	7

Table 15

Chrysanthemum leucanthemum, 1949.

Germination dates	Temperat.	Observed 105		108		Transformed 105		108	
Aug.21, 1949	20°C, dark	53	27	40	49	35.1	31.5	39.2	44.4
	30°C "	4	5	3	1	11.5	12.9	10.0	5.7
	20°C, light	78	86	91	91	62.0	68.0	72.5	72.5
	20-30°C "	84	87	95	89	66.4	68.9	77.1	70.6
Mar.11, 1950	20°C, dark	31	27	49	53	33.8	31.3	44.4	35.1
	30°C "	6	4	9	7	14.2	11.5	17.5	15.3
	20°C, light	89	92	92	94	70.6	73.6	75.6	75.8
	20-30°C "	71	70	95	90	57.4	56.8	77.1	71.6
May 11, 1950	20°C, dark	15	22	32	30	22.8	28.0	34.4	33.2
	30°C "	1	4	2	2	5.7	11.5	8.1	8.1
	20°C, light	97	86	96	98	80.0	68.0	78.5	81.9
	20-30°C "	90	87	94	91	71.6	68.9	75.8	72.5
Sep.12, 1950	20°C, dark	29	26	28	28	32.6	30.7	31.9	31.9
	30°C "	1	5	5	8	5.7	12.9	12.9	16.4
	20°C, light	77	87	91	94	61.5	68.9	72.5	75.8
	20-30°C "	82	81	89	84	64.9	64.2	70.6	66.4

Source	D.F.	M.S.	F.	5%	1%
Samples	1	453.15	19.21xx	4.54	8.68
Temperatures	3	13,675.47	679.71xx	3.29	5.42
Hi. vs Lo.[1]	1	2,689.72	114.02xx		
Li. vs D.[1] at Lo.	1	11,834.91	501.70xx		
Li. vs D. at Hi.	1	26,501.77	1,123.43xx		
Germin. dates	3	18.34			
Temp. x germ. dat.	9	54.66	2.31	2.59	
Error	15	23.59			
Duplicates	32	10.72			
Total	63				

1) Hi. = higher temperatures, Li. = light
Lo. = lower " D. = dark

Table 15 (concluded)

Means and N.D.

Germination dates		Temperatures	
Aug. 21, 1949	= 46.7	20°C, dark	= 33.7
Mar. 11, 1950	= 47.5	30°C "	= 11.2
May 11 "	= 46.8	20°C, light	= 72.2
Sep. 12 "	= 45.0	20-30°C "	= 68.8
N.D. (.05)	= 3.64	N.D. (.05)	= 3.64
(.01)	= 5.04	(.01)	5.04

Table 16

Chrysanthemum leucanthemum, 1950.

Weeks after harvest	Temperat.	Observed 119		Observed 120		Transformed 119		Transformed 120	
0	20°C, dark	2	2	12	25	8.1	8.1	20.3	30.0
	30°C "	0	0	0	1	2.6	2.6	2.6	5.7
	20°C, light	78	88	82	74	62.0	69.7	64.9	59.3
	20-30°C "	69	74	75	74	56.2	59.3	60.0	59.3
1	20°C, dark	24	12	16	11	29.3	20.3	23.6	19.4
	30°C "	1	0	0	2	5.7	2.6	2.6	8.1
	20°C, light	85	83	86	79	67.2	65.6	68.0	62.7
	20-30°C "	85	86	71	72	67.2	68.0	57.4	58.1
2	20°C, dark	7	3	14	22	15.3	10.0	22.0	28.0
	30°C "	0	0	0	0	2.6	2.6	2.6	2.6
	20°C, light	94	92	90	94	75.8	73.6	71.6	75.8
	20-30°C "	84	76	36	41	66.4	60.7	36.9	39.8
3	20°C, dark	11	13	52	45	19.4	21.1	46.1	42.1
	30°C "	0	0	1	1	2.6	2.6	5.7	5.7
	20°C, light	97	95	94	89	80.0	77.1	75.8	70.6
	20-30°C "	67	67	75	82	54.9	54.9	60.0	64.9
4	20°C, dark	16	17	46	39	23.6	24.4	42.7	38.6
	30°C "	0	1	1	8	2.6	5.7	5.7	16.4
	20°C, light	95	92	96	94	77.1	73.6	78.5	75.8
	20-30°C "	94	97	96	98	75.8	80.0	78.5	68.0
6	20°C, dark	48	47	59	55	43.9	43.3	50.2	47.9
	30°C "	1	1	10	6	5.7	5.7	18.4	14.2
	20°C, light	93	91	99	95	74.7	72.5	84.3	77.1
	30°C "	97	91	95	96	80.0	72.5	77.1	78.5
8	20°C, dark	36	20	47	37	36.9	26.6	43.3	37.5
	30°C "	1	3	7	0	5.7	10.0	15.3	2.6
	20°C, light	99	99	98	98	84.3	84.3	81.9	81.9
	20-30°C "	85	92	95	96	67.2	73.6	77.1	78.5

Table 16 (concluded)

Source	D.F.	M.S.	F.	5%	1%
Samples	1	224.58	2.69	4.21	7.68
Temperatures	3	28,029.00	335.75xx	2.96	4.60
Hi. vs Lo.[1]	1	7,062.79	84.61xx		
Li. vs D.[1] at Hi.	1	49,402.98	591.80xx		
Li. vs D. at Lo.	1	27,621.24	330.87xx		
Germin. dates	6	756.10	9.05xx	2.46	3.56
Temp. x germ. d.	18	109.16	1.30	1.97	2.63
Error	27	83.48			
Duplicates	56	11.77			
Total	111				

Means and N.D.

Germin. weeks after harvest

0	= 35.7
1	= 39.1
2	= 36.6
3	= 42.7
4	= 47.9
6	= 52.9
8	= 50.4
N.D.(.05)	= 6.62
(.01)	= 8.95

Temperatures

20°C, dark	= 29.4
30°C "	= 6.0
20°C, light	= 73.7
20-30°C "	= 65.4
N.D.(.05)	= 5.00
(.01)	= 6.76

1) Hi. = higher temperatures, Li. = light

Lo. = lower " D. = dark

Tables No. 17-29

Applying to the Chapter V

The effect of stratification under laboratory conditions.

Table 17

Setaria glauca, 1949.

Stratif. dates	Stratif. periods, weeks	112-B		112-G		113-B		113-G	
		Observed data							
Aug.22, 1949	0	0	0	0	0	0	0	0	0
	2	7	7	0	0	1	1	0	0
	4	10	11	7	2	2	0	1	0
	6	26	36	17	12	0	0	8	3
	10	52	67	87	91	56	31	35	27
	15	57	46	94	96	25	26	23	27
Nov.29, 1949	0	49	61	14	17	39	53	35	20
	2	58	67	30	24	49	56	16	15
	4	40	45	22	16	34	29	16	18
	6	51	52	39	38	46	31	14	9
	10	50	48	72	66	35	45	21	26
	15	53	58	78	78	37	45	20	13
Sep.9, 1950	0	55	61	76	78	46	54	55	61
	2	86	95	86	80	85	82	77	82
	4	87	65	84	80	65	75	69	70
	6	69	74	85	86	59	60	46	39
	10	52	48	78	72	56	55	25	23
	15	67	61	65	66	43	51	32	22
		Transformed data							
Aug.22, 1949	0	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
	2	15.3	15.3	2.6	2.6	5.7	5.7	2.6	2.6
	4	18.4	19.4	15.3	8.1	8.1	2.6	5.7	2.6
	6	30.7	36.9	24.4	20.3	2.6	2.6	16.4	10.0
	10	46.1	54.9	68.9	72.5	36.6	33.8	36.3	31.3
	15	49.0	42.7	75.8	78.5	30.0	30.7	28.7	31.3
Nov.29, 1949	0	44.4	51.4	22.0	24.4	38.6	46.7	36.3	26.6
	2	49.6	54.9	33.2	29.3	44.4	48.4	23.6	22.8
	4	39.2	42.1	28.0	23.6	35.7	32.6	23.6	25.1
	6	45.6	46.1	38.6	38.1	42.7	33.8	22.0	17.3
	10	45.0	43.9	58.1	54.3	36.3	42.1	27.3	30.7
	15	46.7	49.6	62.0	62.0	37.5	42.1	26.6	21.1
Sep.9, 1950	0	47.9	51.4	60.7	62.0	42.7	47.3	47.9	51.4
	2	68.0	77.1	68.0	63.4	67.2	64.9	61.3	64.9
	4	68.9	53.7	66.4	63.4	53.7	60.0	56.2	56.8
	6	56.2	59.3	67.2	68.0	50.2	50.8	42.7	38.6
	10	46.1	43.9	62.0	58.1	48.4	47.9	30.0	28.7
	15	54.9	51.4	53.7	54.3	41.0	45.6	34.4	28.0

Table 17 (concluded)

Source	D.F	M.S.	F.	5%	1%
Samples	3	2,100.61	13.27**	2.79	4.20
Mat. vs Imm.	1	347.82	2.19	4.03	7.17
Mature	1	1,310.73	8.28**		
Immature	1	4,643.27	29.34**		
Stratif. dates	2	12,387.40	78.28**	3.18	5.06
Stratif. periods	5	884.11	5.58**	2.40	3.41
Str. dat. x str. per.	10	1,516.03	9.58**	2.02	2.70
Error	51	158.24			
Duplicates	72	9.97			
Total	143				

Means and N.D.

Stratif. dates		Stratif. periods		Samples	
Aug.22, 1949	= 21.7	0	= 30.1	112-B	= 43.6
Nov.29 "	= 37.8	2	= 37.2	112-G	= 44.3
Sep.9, 1950	= 53.8	4	= 33.7	113-B	= 35.1
N.D. (.05)	= 5.12	6	= 35.8	113-G	= 28.2
(.01)	= 6.85	10	= 45.1	N.D.(.05)	= 5.95
		15	= 44.9	(.01)	= 7.93
		N.D.(.05)	= 7.29		
		(.01)	= 9.75		

Table 18

Setaria glauca, 1950.

Stratif. periods, weeks.	Observed data							
	127-B		127-G		128-B		128-G	
0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	1	0
6	0	0	1	1	2	0	0	0
10	1	0	5	5	1	0	4	3
15	1	3	13	12	4	12	3	20

Table 19

Rumex acetosella, 1949.

Stratific. date	Stratif. periods, weeks.	Observed data					
		104		105		107	
Aug.21, 1949	0	2	2	6	8	3	6
	2	3	4	14	7	13	5
	4	5	2	10	8	7	16
	8	2	3	11	12	7	14
	12	4	6	3	15	12	8
	20	4	6	21	16	8	33
Nov.29, 1949	0	3	13	25	13	24	8
	2	6	3	12	14	6	15
	4	0	4	13	14	13	15
	8	2	0	10	8	3	2
	12	1	0	13	14	13	10
	20	2	1	14	11	11	8

Table 20

Silene noctiflora, 1950.

Stratif. periods weeks	Observed data							
	117		118		121		122	
0	99	92	74	47	53	47	5	0
1	98	99	55	55	58	45	10	9
2	99	97	86	82	11	9	9	1
3	97	94	76	78	19	25	14	4
4	87	80	51	53	21	8	3	2
6	62	52	30	39	19	36	4	1
8	22	36	9	24	15	20	3	2
	Transformed data							
0	84.3	73.6	59.5	43.3	46.7	43.3	12.9	2.6
1	81.9	84.3	56.3	46.7	49.6	42.1	18.4	17.5
2	84.3	80.0	68.0	64.9	19.4	17.5	17.5	5.7
3	80.0	75.8	60.7	62.0	25.8	30.0	22.0	11.5
4	68.9	63.4	45.6	46.7	27.3	16.4	10.0	8.1
6	51.9	46.1	33.2	38.6	25.8	36.9	11.5	5.7
8	28.0	36.9	17.5	29.3	22.8	26.6	10.0	8.1

Source	D.F.	M.S.	F.	5%	1%
Samples	3	7,792.15	31.33**	3.16	5.09
Mat. vs Imm.	1	5,520.29	22.19**	4.41	8.28
Mature	1	9,260.16	37.23**		
Immature	1	8,596.01	34.56**		
Stratif. periods	6	717.77	2.88*	2.66	4.01
Error	18	248.69			
Duplicates	28	28.34			
Total	55				

Means and N.D.

Stratif. periods

Weeks:	0	= 45.7
	1	= 47.1
	2	= 44.7
	3	= 46.0
	4	= 35.8
	6	= 31.2
	8	= 22.4
N.D.	(.05)	= 16.55
	(.01)	= 22.69

Samples

117	= 67.1
118	= 46.6
121	= 30.7
122	= 11.5
N.D. (.05)	= 12.52
(.01)	= 17.16

Table 21

Portulaca oleracea, 1949

Stratif. dates	Stratif. periods. weeks	Observed data			
		114a		114b	
Sep.29, 1949	0	17	4	7	6
	2	22	28	42	27
	4	55	46	75	48
	8	59	37	61	55
	12	57	45	66	59
	16	49	30	53	36
Jan.27, 1950	0	22	29	67	70
	2	53	65	53	85
	4	45	70	42	45
	8	45	64	54	70
	12	54	48	64	61
	16	28	31	41	59
		Transformed data			
Sep.29, 1949	0	24.4	11.5	15.5	14.2
	2	28.0	31.9	40.4	31.5
	4	36.5	42.7	60.0	43.9
	8	38.6	37.5	51.4	36.3
	12	37.5	42.1	54.5	50.2
	16	44.4	33.2	55.1	36.9
Jan.27, 1950	0	28.0	32.6	54.9	56.8
	2	46.7	53.7	46.7	65.6
	4	42.1	56.8	40.4	42.1
	8	42.1	53.1	47.3	56.8
	12	47.3	43.9	53.1	51.4
	16	51.9	33.8	39.8	50.2

Table 21 (concluded)

Source	D.F.	M.S.	F.	5%	1%
Samples	1	496.01	6.28*	4.84	9.65
Stratif. dates	1	1,197.00	15.17**		
Stratif. periods	5	293.24	3.71*	3.20	5.32
Str. dat. x str. per.	5	304.61	3.86*		
Error	11	78.87			
Duplicates	24	40.60			
Total	47				

Means and N.D.

Stratif. dates

Sep. 1949 = 36.6
Jan. 1950 = 46.5

Stratif. periods

Weeks: 0 = 29.7
2 = 43.0
4 = 45.1
8 = 45.4
12 = 47.5
16 = 58.2
N.D. (.05) = 9.77
(.01) = 13.81

Table 22

Brassica arvensis, 1949.

Stratif. periods, days.	Observed				Transformed			
	110		111		110		111	
0	68	64	80	82	55.6	53.1	63.4	64.9
5	55	51	68	64	47.9	45.6	55.6	53.1
10	52	49	63	68	46.1	44.4	52.5	55.6
20	40	50	67	62	39.2	45.0	54.9	51.9
30	40	45	59	58	39.2	42.1	50.2	49.6
60	33	45	56	66	35.1	42.1	48.4	54.3

Source	D.F.	M.S.	F.	5%	1%
Samples	1	590.04	29.21**	6.61	16.26
Stratif. periods	5	110.03	5.44*	5.05	10.97
Error	5	20.20			
Duplicates	12	7.00			
Total	23				

Means and N.D.

Stratif. periods:
0 = 59.2
5 = 50.5
10 = 49.6
20 = 47.7
30 = 45.5
60 = 45.0
N.D. (.05) = 8.14
(.01) = 12.77

Table 23

Brassica arvensis, 1950.

Stratif. periods, days.	20°C, dark				20°C, light			
	125		126		125		126	
0	0	0	0	0	0	0	0	2
3	0	0	4	1	0	0	1	2
5	0	0	1	0	0	0	0	0
10	0	2	2	1	0	1	1	0
20	0	0	3	2	1	0	2	2
30	0	1	1	1	0	0	1	0
60	6	6	8	4	1	2	0	5

Table 24

Plantago lanceolata, 1949.

Stratif. date	Stratif. periods, weeks.	Observed data					
		102b		102c		106	
Nov.29,1949	0	30	41	56	65	47	45
	2	36	36	68	74	41	42
	4	30	29	65	59	61	65
	6	62	42	77	70	84	86
	8	51	55	89	74	91	96
	12	45	44	85	74	84	92
Sep.8,1950	0	40	50	60	78	46	54
	2	70	61	75	87	58	53
	4	59	68	88	87	67	80
	6	65	69	76	84	81	81
	8	48	54	85	83	89	92
	12	73	70	95	92	95	97
		Transformed data					
Nov.29,1949	0	33.2	39.8	48.4	53.7	43.3	42.1
	2	36.9	36.9	55.6	59.3	39.8	40.4
	4	33.2	32.6	53.7	50.2	51.4	53.7
	6	51.9	40.4	61.3	56.8	66.4	68.0
	8	33.8	47.9	70.6	59.5	72.5	78.5
	12	41.0	41.6	65.6	59.3	66.4	73.6
Sep.8,1950	0	39.2	45.0	50.8	62.0	42.7	47.3
	2	56.8	51.4	58.7	68.9	49.6	46.7
	4	50.2	55.6	69.7	68.9	54.9	63.4
	6	53.7	56.2	60.7	66.4	64.2	64.2
	8	43.9	47.3	67.2	65.6	70.6	75.6
	12	58.7	56.8	77.1	75.6	77.1	80.0

Table 24 (concluded)

Source	D.F.	M.S.	F.	5%	1%
Samples	2	1,960.57	21.38XX	3.44	5.72
Strat. dates	1	1,085.78	11.84XX	4.30	7.94
Strat. periods	5	603.58	6.58XX	2.66	3.99
Str.dat. x str.per.	5	93.25	1.02		
Error	22	91.70			
Duplicates	36	17.01			
Total	71				

Means and N.D.

Stratific. dates

Nov. 29, 1949 = 51.6
Sep. 8, 1950 = 59.4

Stratific. periods

0 = 45.6
2 = 50.1
4 = 53.1
6 = 59.2
8 = 60.9
12 = 64.2
N.D. (.05) = 8.07
(.01) = 11.00

Table 25

Plantago lanceolata, 1949.

Treatment	Stratif. periods, weeks.	Observed data 102b		102c		106	
Disinfected (chlorine)	0	26	21	40	46	72	50
	2	56	46	73	62	61	59
	4	72	71	85	89	80	87
	6	58	66	80	85	87	91
	8	81	69	81	87	93	91
	12	52	71	90	88	98	98
Intact	0	30	41	56	65	47	45
	2	36	36	68	74	41	42
	4	30	29	65	59	61	65
	6	62	42	77	70	84	86
	8	31	55	89	74	91	96
	12	43	44	83	74	84	92
				Transformed data			
Disinfected	0	30.7	27.5	59.2	42.7	58.1	45.0
	2	48.4	42.7	58.7	51.9	51.4	50.2
	4	58.1	57.4	67.2	70.6	63.4	68.9
	6	49.6	54.3	63.4	67.2	68.9	72.5
	8	64.2	56.2	64.2	68.9	74.7	72.5
	12	46.1	57.4	71.6	69.7	81.9	81.9
Intact	0	33.2	39.8	48.4	53.7	43.3	42.1
	2	36.9	36.9	55.6	59.3	39.8	40.4
	4	33.2	32.6	53.7	50.2	51.4	53.7
	6	51.9	40.4	61.3	56.8	66.4	68.0
	8	33.8	47.9	70.6	59.3	72.5	78.5
	12	41.0	41.6	65.6	59.3	66.4	73.6

Table 25 (concluded)

Source	D.F.	M.S.	F.	5%	1%
Samples	2	2,207.84	30.27**	3.44	5.72
Disinfect. treatment	1	924.50	12.68**	4.30	7.94
Stratif. periods	5	929.13	12.74**	2.66	3.99
Disinf. x str. per.	5	147.07	2.02		
Error	22	72.92			
Duplicates	36	18.11			
Total	71				

Means and N.D.

Disinfection

Intact = 51.6
Chlorine = 58.8

Stratification periods

Weeks: 0 = 41.9
2 = 47.7
4 = 55.0
6 = 60.1
8 = 63.6
12 = 65.0
N.D.(.05) = 7.20
(.01) = 9.81

Table 26

Ambrosia artemisiifolia, 1949.

Stratif. periods. weeks	Observed				Transformed			
	115		116		115		116	
0	0	1	1	1	2.6	5.7	5.7	5.7
1	17	12	15	16	24.4	20.3	22.8	23.6
2	45	42	25	15	42.1	40.4	30.0	22.8
4	73	77	60	68	58.7	61.3	50.8	55.6
6	89	89	86	88	70.6	70.6	68.0	69.7
8	91	92	90	95	72.5	73.6	71.6	77.1
10	95	92	91	90	77.1	73.6	72.5	71.6
15	93	96	82	83	74.7	78.5	64.9	65.6

Source	D.F.	M.S.	F.	5%	1%
Samples	1	147.49	3.87	5.59	
Strat. per.	7	2,870.68	75.30XX	3.79	7.00
Error	7	38.12			
Duplicates	16	5.44			
Total	31				

Means and N.D.

Strat. periods:
0 = 4.9
1 = 22.8
2 = 33.8
4 = 56.6
6 = 69.7
8 = 72.1
10 = 72.1
15 = 70.5

N.D. (.05) = 10.29
(.01) = 15.26

Table 27

Ambrosia artemisiifolia, 1950.

Stratif. periods, weeks	Observed				Transformed			
	132		133		132		133	
0	0	0	0	0	2.6	2.6	2.6	2.6
1	0	0	2	1	2.6	2.6	8.1	5.7
2	3	8	12	13	10.0	16.4	20.3	21.1
4	12	14	22	25	20.3	22.0	28.0	30.0
6	51	49	58	68	45.6	44.4	49.6	55.6
8	65	60	80	81	53.7	50.8	63.4	64.2
10	79	76	90	85	62.7	60.7	71.6	67.2
15	92	95	97	99	73.6	77.1	80.0	84.3

Source	D.F.	M.S.	F.	5%	1%
Samples	1	355.11	31.90XX	5.59	12.25
Strat. periods	7	3,388.52	304.45XX	3.79	7.00
Error	7	11.13			
Duplicates	16	4.84			
Total	31				

Means and N.D.

Strat. periods:
0 = 2.6
1 = 4.7
2 = 16.9
4 = 25.1
6 = 48.8
8 = 58.0
10 = 65.5
15 = 78.7

N.D. (.05) = 5.57
(.01) = 8.26

Table 28

Chrysanthemum leucanthemum, 1949.

Stratif. periods, weeks	Observed				Transformed			
	103		108		103		108	
0	84	87	95	89	66.4	68.9	77.1	70.6
2	69	73	91	89	56.2	58.7	72.5	70.6
4	79	71	97	92	62.7	57.4	80.0	73.6
6	71	76	93	87	57.4	60.7	74.7	68.9
8	85	79	94	96	65.6	62.7	75.8	78.5
12	88	87	95	94	69.7	68.9	77.1	75.8

Source	D.F.	M.S.	F.	5%	1%
Samples	1	815.50	47.97xx	6.61	16.26
Strat. periods	5	43.08	2.53	5.05	
Error	5	17.00			
Duplicates	12	7.91			
Total	23				

Means:

Stratif. periods

0 = 70.7
2 = 64.5
4 = 68.4
6 = 65.4
8 = 70.7
12 = 72.8

Table 29

Chrysanthemum leucanthemum, 1950.

Stratif. periods, weeks	Observed data: 20°C, dark 119		120		20°C, light 119		120	
0	2	2	12	25	78	88	82	74
1	8	1	17	16	69	60	62	77
2	2	0	2	2	65	62	63	69
3	1	4	7	12	78	71	76	71
4	6	0	16	12	69	64	72	81
6	26	18	28	29	86	90	90	89
8	32	42	50	53	88	91	88	94
	Transformed data							
0	8.1	8.1	20.3	30.0	62.0	69.7	64.9	59.3
1	16.4	5.7	24.4	23.6	56.2	50.8	51.9	61.3
2	8.1	2.6	8.1	8.1	53.7	51.9	52.5	56.2
3	5.7	11.5	15.3	20.3	62.0	57.4	60.7	57.4
4	14.2	2.6	23.6	20.3	56.2	53.1	58.1	64.2
6	30.7	25.1	31.9	32.6	68.0	71.6	71.6	70.6
8	34.4	40.4	45.0	46.7	69.7	72.5	69.7	75.8

Source	D.F.	M.S.	F.	5%	1%
Samples	1	434.57	12.20**	4.67	9.07
Light treatm.	1	24,244.48	680.64**		
Strat. periods	6	689.55	19.35**	2.92	4.62
Light x str.per.	6	76.20	2.13		
Error	13	35.62			
Duplicates	28	15.67			
Total	55				

Means and N.D.

Strat. periods, in light		Strat. periods, in dark	
0	= 64.0	0	= 16.6
1	= 55.0	1	= 17.5
2	= 53.6	2	= 6.7
3	= 59.4	3	= 13.2
4	= 57.9	4	= 15.2
6	= 70.4	6	= 30.1
8	= 71.9	8	= 41.6
N.D. (.05)	= 9.07	N.D. (.05)	= 9.07
(.01)	= 12.64	(.01)	= 12.64

Tables No. 30-61

Applying to the Chapter VI

The effect of stratification under field conditions.

Table 30

A. Germination following the stratification under field conditions as recorded on the date when the seeds were taken out of ground (complete data from which the text table No. III was prepared).

		Nylon Method				Seeds sown in soil.	
		May 1-6		June 14-16		May 3	
		Loc.Gr.	Loc.Ba.	Loc.Gr.	Loc.Ba.	Loc.Gr.	Loc.Ba.
Setaria glauca	112-B	0	0	47.5	17.2	0	0
	112-G	0	0	93.7	82.7	0	0
	113-B	0	0	11.2	24.5	0	0
	113-G	0	0	66.5	74.2	0	0
Rumex acetosella	104	3.5	3.4			6.3	0
	105	4.2	3.9			8.0	0
	107	1.0	2.6			2.3	0
Silene noctiflora	101b	86.4	79.7	84.5	85.0	54.7	8.0
	109	96.0	90.0	98.5	87.0	82.0	6.0
Portulaca oleracea	114a	0	0	0	0	0	0
	114b	0	0	0	0	0	0
Sinapis arvensis	110	67.5	26.9	79.2	40.7	3.0	0
	111	65.0	45.2	87.5	55.2	1.7	0
Plantago lanc.	102b	32.1	38.2	31.5	41.5	52.0	0
	102c	57.5	61.5	66.0	58.7	60.3	0
	106	46.4	35.7	38.7	41.5	39.7	0
Ambrosia artem.	115	14.5	5.1	17.2	18.2	8.3	0
	116	14.0	6.5	17.7	9.0	13.7	0
Chrysanth. leucanth.	103	.5	.1	2.0	1.0	.3	0
	108	.2	.9	1.2	2.2	1.3	0

B. Germination in nylon following the stratification under field conditions.

Tables 31-40

(a) Germination in nylon as recorded on May 1-6th. Tables 31-35.

Table 31

Silene noctiflora, 1949.

Repl.	Location	Samples	Observed				Transformed			
1	Gr.	101b	78	81	93	82	62.0	64.2	74.7	64.9
		109	95	94	94	96	77.1	75.8	75.8	78.5
	Ba.	101b	54	49	78	81	47.3	44.4	62.0	64.2
		109	84	90	86	93	66.4	71.6	68.0	74.7
2	Gr.	101b	86	87	96	88	68.0	68.9	78.5	69.7
		109	96	95	98	100	78.5	77.1	81.9	87.4
	Ba.	101b	94	97	96	89	75.8	80.0	78.5	70.6
		109	87	94	95	91	68.9	75.8	77.1	72.5

Source	D.F.	M.S.	F.	5%	1%
Replicates	1	591.68	5.83	10.13	34.12
Samples	1	556.11	3.60		
Locations	1	226.84	1.46		
Sampl. x Loc.	1	26.28			
Error	3	154.43			
Quadruplicates	24	27.98			
Total	31				

Means:

Locations: Loc. Gr. = 73.3
Loc. Ba. = 68.6

Samples: 101b = 66.4
109 = 75.4

Table 32

Brassica arvensis, 1949.

Repl.	Location	Samples	Observed				Transformed			
1	Gr.	110	62	70	59	71	51.9	56.8	50.2	57.4
		111	74	52	54	51	59.3	46.1	47.3	45.6
	Ba.	110	16	15	20	20	23.6	22.8	26.6	26.6
		111	44	45	42	42	41.6	42.1	40.4	40.4
2	Gr.	110	69	65	69	75	56.2	53.7	56.2	60.0
		111	74	72	80	65	59.5	58.1	63.4	52.5
	Ba.	110	30	38	37	39	33.2	38.1	37.5	38.6
		111	52	45	43	49	46.1	42.1	41.0	44.4

Source	D.F.	M.S.	F.	5%	1%
Replicates	1	323.21	25.77**	10.13	34.12
Samples	1	201.75	16.08**		
Locations	1	2,608.22	207.99**		
Loc. x Samp.	1	324.49	25.87**		
Error	3	12.54			
Quadruplicates	24	16.45			
Total	31				

Means:

Locations: Loc. Gr. = 54.6
Loc. Ba. = 36.6

Samples: 110 = 43.1
111 = 48.1

Table 35

Plantago lanceolata, 1949.

Repl.	Location	Samples	Observed				Transformed			
1	Gr.	102b	37	42	35	35	37.5	40.4	36.3	36.3
		102c	60	49	52	65	50.8	44.4	46.1	53.7
		106	57	49	37	43	49.0	44.4	37.5	41.0
	Ba.	102b	25	35	50	58	30.0	36.3	45.0	49.3
		102c	51	67	72	56	45.6	54.9	58.1	48.4
		106	18	23	58	45	25.1	28.7	49.6	42.1
2	Gr.	102b	24	29	21	34	29.3	32.6	27.3	35.7
		102c	59	56	62	57	50.2	48.4	51.9	49.0
		106	57	50	42	36	49.0	45.0	40.4	36.9
	Ba.	102b	28	30	34	46	31.9	33.2	35.7	42.7
		102c	56	66	58	66	48.4	54.3	49.6	54.3
		106	40	32	32	38	39.2	34.4	34.4	38.1

Source	D.F.	M.S.	F.	5%	1%
Replicates	1	31.52	1.75	6.61	13.27
Samples	2	887.27	48.80**	5.79	
Locations	1	0.25			
Sampl. x Loc.	2	120.77	6.64*		
Error	3	18.18			
Quadruplicates	36	30.85			
Total	47				

Means and N.D.

Locations: Loc. Gr. = 42.2
Loc. Ba. = 42.0

Samples: 102b = 36.2
102c = 50.5
106 = 39.6
N.D. (.05) = 3.85
(.01) = 6.04

(b) Germination in nylon as recorded on June 14-16th. Tables 34-37.

Table 34

Setaria glauca, 1949.

Locations	Samples	Observed				Transformed			
Gr.	112-B	45	44	44	57	42.1	41.6	41.6	49.0
	112-G	95	95	93	97	77.1	77.1	74.7	80.0
	113-B	5	15	15	10	12.9	22.8	22.8	18.4
	113-G	78	53	69	66	62.0	46.7	56.2	54.3
Ba.	112-B	16	15	18	20	23.6	22.8	25.1	26.6
	112-G	86	82	85	82	68.0	64.9	65.6	64.9
	113-B	17	25	27	29	24.4	30.0	31.3	32.6
	113-G	67	80	73	77	54.9	63.4	58.7	61.3

Source	D.F.	M.S.	F.	5%	1%
Samples	3	3,691.11	9.86**	9.28	29.46
Mat. vs Imm.	1	9,877.14	26.38**	10.13	34.12
Mature	1	372.49			
Immature	1	823.69	2.20		
Locations	1	117.04			
Error	3	374.35			
Quadruplicates	24	14.08			
Total	31				

Means and N.D.

Locations: Loc. Gr. = 48.7
Loc. Ba. = 44.9

Samples: 112-B = 34.0
112-G = 71.5
113-B = 24.4
113-G = 57.2

N.D. (.05) = 30.75
(.01) = 56.47

Table 35

Silene noctiflora, 1949.

Location	Samples	Quadruplicates Observed			
Gr.	101b	87	82	89	80
	109	99	98	98	99
Ba.	101b	72	92	89	87
	109	84	89	89	86
		Transformed			
Gr.	101b	68.9	64.9	70.6	63.4
	109	84.3	81.9	81.9	84.3
Ba.	101b	58.1	73.6	70.6	68.9
	109	66.4	70.6	70.6	68.0

Source	D.F.	M.S.	F.	5%
Samples	1	297.56	1.31	161
Locations	1	178.22		
Error	1	226.51		
Quadrupl.	12	15.77		
Total	15			

Means:

Locations: Gr. = 75.0
Ba. = 68.5

Samples: 101b = 67.4
109 = 76.0

Table 36

Brassica arvensis, 1949.

Locations	Samples	Quadruplicates Observed			
Gr.	110	75	82	80	80
	111	88	89	90	83
Ba.	110	47	33	50	33
	111	64	49	54	54
		Transformed			
Gr.	110	60.0	64.9	63.4	63.4
	111	69.7	70.6	71.6	65.6
Ba.	110	43.3	35.1	45.0	35.1
	111	53.1	44.4	47.3	47.3

Source	D.F.	M.S.	F.	5%	1%
Samples	1	220.52	57.87	161	4052
Locations	1	1,993.62	523.25*		
Error	1	3.81			
Quadrupl.	12	13.08			
Total	15				

Means:

Locations: Gr. = 66.1
Ba. = 43.8

Samples: 110 = 51.3
111 = 58.7

Table 37

Plantago lanceolata, 1949.

Locations	Samples	Quadruplicates Observed			
Gr.	102b	35	29	29	33
	102c	66	66	62	70
	106	42	38	44	31
Ba.	102b	36	45	45	40
	102c	62	52	72	49
	106	29	55	34	48
		Transformed			
Gr.	102b	36.3	32.6	32.6	35.1
	102c	54.3	54.5	51.9	56.8
	106	40.4	38.1	41.6	33.8
Ba.	102b	36.9	42.1	42.1	39.2
	102c	51.9	46.1	58.1	44.4
	106	32.6	47.9	35.7	43.9

Source	D.F.	M.S.	F.	5%
Samples	2	534.95	10.34	19.00
Locations	1	7.15		
Error	2	51.69		
Quadrupl.	18	19.08		
Total	23			

Means:

Locations: Gr. = 42.3
Ba. = 43.4

Samples: 102b = 37.1
102c = 52.2
106 = 39.2

(c) Germination in nylon for two stratification periods. Tables 38-40.

Table 38

Silene noctiflora, 1949.

Germ. Dat.	Location	Samples	Observed				Transformed			
May 1-6	Gr.	101b	78	81	93	82	62.0	64.2	74.7	64.9
		109	95	94	94	96	77.1	75.8	75.8	78.5
	Ba.	101b	54	49	78	81	47.3	44.4	62.0	64.2
		109	84	90	96	93	66.4	71.6	68.0	74.7
June 14-16	Gr.	101b	87	82	89	80	68.9	64.9	70.6	63.4
		109	99	98	98	99	84.3	81.9	81.9	84.3
	Ba.	101b	72	92	89	87	58.1	73.6	70.6	68.9
		109	84	89	89	86	66.4	70.6	70.6	68.0

Source	D.F.	M.S.	F.	5%	1%
Samples	1	937.44	9.57	10.13	34.12
Locations	1	177.66	1.81		
Germ. dates	1	510.40	5.21		
Loc. x germ. dat.	1	13.78			
Error	3	97.95			
Quadruplicates	24	26.47			
Total	31				

Means:

Locations: Gr. = 73.3
Ba. = 65.3

Germ. Dates: May 1-6 = 66.9
June 14-16 71.6

Samples:
101b = 63.9
109 = 74.7

Table 39

Brassica arvensis, 1949.

Germ. dates	Location	Samples	Observed				Transformed			
May 1-6	Gr.	110	62	70	59	71	51.9	56.8	50.2	57.4
		111	74	52	54	51	59.5	46.1	47.5	45.6
	Ba.	110	16	15	20	20	23.6	22.8	26.6	26.6
		111	44	45	42	42	41.6	42.1	40.4	40.4
June 14-16	Gr.	110	75	82	80	80	60.0	64.9	63.4	63.4
		111	88	89	90	83	69.7	70.6	71.6	65.6
	Ba.	110	47	33	50	33	43.3	35.1	45.0	35.1
		111	64	49	54	54	53.1	44.4	47.3	47.3

Source	D.F.	M.S.	F.	5%	1%
Samples	1	353.11	2.41	10.13	34.12
Locations	1	3,384.58	23.16**		
Germ. dates	1	1,263.78	8.65		
Loc. x g. dat.	1	24.67			
Error	3	146.08			
Quadruplicates	24	14.04			
Total	31				

Means:

Locations	Germ. Dates	Samples
Gr. = 59.0	May 1-6 = 42.4	110 = 45.4
Ba. = 38.4	June 14-16 = 55.0	111 = 52.0

Table 40

Plantago lanceolata, 1949.

Germ. dates	Locations	Samples	Observed				Transformed			
May 1-6	Gr.	102b	37	42	35	35	37.5	40.4	36.3	36.3
		102c	60	49	52	65	50.8	44.4	46.1	53.7
		106	57	49	37	43	49.0	44.4	37.5	41.0
	Ba.	102b	25	35	50	58	30.0	36.3	45.0	49.6
		102c	51	67	72	56	45.6	54.9	58.1	48.4
		106	18	25	58	45	25.1	28.7	49.6	42.1
June 14-16	Gr.	102b	35	29	29	35	36.3	32.6	32.6	35.1
		102c	66	66	62	70	54.3	54.3	51.9	56.8
		106	42	38	44	31	40.4	38.1	41.6	33.8
	Ba.	102b	36	45	45	40	36.9	42.1	42.1	39.2
		102c	62	52	72	49	51.9	46.1	58.1	44.4
		106	29	35	34	48	32.6	47.9	35.7	43.9

Source	D.F.	M.S.	F.	5%	1%
Samples	2	841.25	20.14**	5.14	10.92
Locations	1	1.74			
Germ. Dates	1	0.09			
Loc. x Germ. dat.	1	6.09			
Error	6	41.75			
Quadruplicates	36	33.47			
Total	47				

Means and N.D.

Locations	Germ. Dates	Samples	
Gr. = 42.7	May 1-6 = 42.9	102b =	38.0
Ba. = 43.1	June 14-16 = 42.8	102c =	51.2
		106 =	39.5
		N.D. (.05) =	5.58
		(.01) =	8.46

C. Germination in the laboratory at four temperatures of seed stratified in nylon under field conditions until May 1-6. Tables 41-47.

Table 41

Setaria glauca, 1949.

A. Temperat.	Samples	Observed				Transformed			
		Loc.	Gr.	Loc.	Ba.	Loc.	Gr.	Loc.	Ba.
20°C, dark	112-B	71	82	26	29	57.4	64.9	30.7	32.6
	112-G	85	88	81	81	67.2	69.7	64.2	64.2
	113-B	68	65	58	55	55.6	53.7	49.6	47.9
	113-G	96	97	42	80	78.5	80.0	40.4	63.4
30°C, dark	112-B	64	57	53	66	53.1	49.0	46.7	54.3
	112-G	80	81	65	74	63.4	64.2	53.7	59.3
	113-B	30	46	35	37	33.2	42.7	36.3	37.5
	113-G	93	85	77	62	74.7	67.2	61.3	51.9
20°C, light	112-B	94	97	88	87	75.8	80.0	69.7	68.9
	112-G	93	90	89	91	74.7	71.6	70.6	72.5
	113-B	89	83	76	62	70.6	65.6	60.7	51.9
	113-G	98	95	100	95	81.9	77.1	87.4	77.1
20-30°C, light.	112-B	99	94	97	94	84.3	75.8	80.0	75.8
	112-G	84	73	91	90	66.4	58.7	72.5	71.6
	113-B	92	93	97	92	73.6	74.7	80.0	73.6
	113-G	96	97	96	99	78.5	80.0	78.5	84.3

Table 41 (continued)

B.

Source	D.F.	S.S.	C.M.[1]	M.S.	F.	5%	1%
Samples	5	2,166.65	(1)	722.22	5.64**	3.07	4.87
Mat. vs Imm.	1	1,605.00	(2)	1,605.00	12.54**	4.32	8.02
Mature	1	263.35	(3)	263.35	2.05		
Immature	1	298.30	(4)	298.30	2.33		
Locations	1	592.31	(5)	592.31	4.63*		
Temperatures	3	5,793.50	(6)	1,951.10	15.09**		
Hi.vs Lo.[2]	1	5.82	(7)	5.82			
Li.vs.D.[2] at Hi.	1	4,045.51	(8)	4,045.51	31.63**		
Li. vs D. at Lo.	1	1,741.97	(9)	1,741.97	13.61**		
Loc. x Temp.	3	794.63	(10)	264.88	2.07		
Error	21	2,686.05	(11)	127.90			
Duplicates	32	718.93	(12)	22.46			
Total	63	12,751.87	(13)				

1) C.M. = Calculation Methods.

S.S. were calculated the following way:

(1) = from table D.

(2) = " " D, mature (112-B & 113-B) vs immature (112-G & 113-G).

(3) = " " D, 112-B vs 113-B.

(4) = " " D, 112-G vs 113-G.

(5) = " " D,

(6) = " " E,

(7) = " " E, higher temp. (30°C,D. & 20-30°C,L.) vs lower temp. (20°C,D. & 20°C, Li.)

(8) = " " E, 30°C, D. vs 20-30°C, Li.

(9) = " " E, 20°C, D. vs 20°C, Li.

(10) = [(5) + (6)] subtracted from total S.S. for table E.

(11) = (13) - [(1) + (5) + (6) + (10) + (12)]

(12) = total S.S. for table C subtracted from (13)

(13) = total S.S. for table A (transformed data).

Table 41 (continued)

C.

	Sampl.	20°D.	30°D.	20°L.	20-30°L.
Loc. Gr.	112-B	122.3	102.1	155.8	160.1
	112-G	136.9	127.6	146.3	125.1
	113-B	109.3	75.9	136.2	148.3
	113-G	158.5	141.9	159.0	158.5
Loc. Ba.	112-B	63.3	101.0	138.6	155.8
	112-G	128.4	113.0	143.1	144.1
	113-B	97.5	75.8	112.6	153.6
	113-G	103.8	113.2	164.3	162.8

D.

	112-B	112-G	113-B	113-G	Totals
Loc. Gr.	540.3	535.9	469.7	617.9	2163.8
Loc. Ba.	458.7	528.6	437.5	544.3	1969.1
Totals	999.0	1064.5	907.2	1162.2	4132.9

E.

	20°D.	30°D.	20°L.	20-30°L.	Totals
Loc. Gr.	527.0	447.5	597.3	592.0	2163.8
Loc. Ba.	393.0	401.0	558.8	616.3	1969.1
Totals	920.0	848.5	1156.1	1208.3	4132.9

Table 41 (concluded)

Means:

Temperatures		Locations		Samples	
20°C, D. =	57.5	Loc. Gr. =	67.6	112-B =	62.4
30°C, D. =	55.0	Loc. Ba. =	61.5	112-G =	66.5
20°C, L. =	72.5			113-B =	56.7
20-30°C, L. =	75.5			113-G =	72.6

Necessary differences for significance:

1) Samples — S.E. diff. = $\sqrt{\frac{127.90}{16} .2}$ = 3.99

2) Temp. — N.D.(.05) = S.E.diff. x $t_{(5\%, D.F. = 21)}$ = 3.99 x 2.08=

N.D.(.01) = S.E.diff. x $t_{(1\%, D.F. = 21)}$ = 3.99 x 2.83=1

3) Locations S.E. diff. = $\sqrt{\frac{127.90}{32} .2}$ = 2.82

N.D.(.05) = 2.82 x 2.08 = 5.86

N.D. (.01) = 2.82 x 2.83 = 7.98

Table 42

Rumex acetosella, 1949.

Temperat.	Sample	Observed Loc. Gr.		Observed Loc. Ba.		Transformed Loc. Gr.		Transformed Loc. Ba.	
20°C, dark	104	7.5	15.5	17.0	18.0	15.9	21.4	24.4	25.1
	105	8.4	32.7	36.0	37.0	16.8	34.9	36.9	37.5
	107	20.2	14.0	60.0	25.0	26.7	22.0	50.8	30.0
30°C, dark	104	6.9	2.0	15.2	12.1	15.2	8.1	22.9	20.4
	105	19.4	12.8	31.0	32.0	26.1	21.0	33.8	34.4
	107	9.4	9.0	22.0	22.0	17.9	17.5	28.0	28.0
20°C, light	104	15.6	21.0	25.9	33.7	23.3	27.3	29.3	35.5
	105	29.2	36.6	25.5	36.7	32.7	37.2	30.3	37.4
	107	38.0	40.4	40.9	45.4	38.1	39.3	39.8	42.4
20-30°C, light	104	14.0	10.1	28.2	26.1	22.0	18.3	32.1	30.7
	105	26.3	24.8	42.7	36.8	31.0	29.9	40.8	37.3
	107	30.3	30.3	41.1	37.0	33.4	33.4	39.9	37.5

Source	D.F.	M.S.	F.	5%	1%
Samples	2	465.44	26.88xx	3.74	6.51
Locations	1	795.44	45.95xx	4.60	8.86
Temperatures	3	310.01	17.91xx	3.34	5.56
Hi. vs Lo.[1]	1	189.61	10.95xx		
Li. vs D. at Hi.	1	553.92	30.84xx		
Li. vs D. at Lo.	1	206.51	11.93xx		
Loc. x Temp.	3	42.67	2.46		
Error	14	17.31			
Duplicates	24	22.16			
Total	47				

Means and N.D.

Locations

Gr. = 25.4
Ba. = 33.5

Temperatures

20°C, dark = 28.5
30°C, " = 22.8
20°C, light = 34.4
20-30oC " = 32.2
N.D.(.05) = 3.63
(.01) = 5.06

Samples

104 = 23.3
105 = 32.2
105 = 32.8
N.D.(.05) = 3.14
(.01) = 4.38

1) Hi. = higher temperatures, Li. = light
Lo. = lower " D. = dark

Table 43

Portulaca oleracea, 1949.

Location	Temperatures	Observed 114a		114b		Transformed 114a		114b	
Gr.	20°C, dark	6	5	6	4	14.2	12.9	14.2	11.5
	30°C "	46	30	46	68	42.7	33.2	42.7	55.6
	20°C, light	20	13	18	31	26.6	21.1	25.1	33.8
	20-30°C "	67	73	85	86	54.9	58.7	67.2	68.0
Ba.	20°C, dark	5	3	3	5	12.9	10.0	10.0	12.9
	30°C "	55	52	57	77	47.9	46.1	49.0	61.3
	20°C, light	20	14	21	22	26.6	22.0	27.3	28.0
	20-30°C "	69	61	79	83	56.2	51.4	62.7	65.6

Source	D.F.	M.S.	F.	5%	1%
Samples	1	297.07	12.86XX	5.59	12.25
Locations	1	1.75			
Temperatures	3	3,694.03	159.98XX	4.35	8.45
Hi. vs Lo.[1]	1	9,594.59	415.55XX		
Li. vs D.[1] at Hi.	1	704.90	30.52XX		
Li. vs D. at Lo.	1	782.60	33.89XX		
Loc. x temp.	3	46.45	2.01		
Error	7	23.09			
Duplicates	16	19.09			
Total	31				

Means and N.D.

Temperatures		Locations		Samples	
20°C, dark	= 12.3	Gr.	= 36.4	114a	= 33.3
30°C "	= 47.3	Ba.	= 36.9	114b	= 39.6
20°C, light	= 26.3				
20-30°C "	= 60.6				
N.D. (.05)	= 5.66				
(.01)	= 8.40				

1) Hi. = higher temperatures, Li. = light
Lo. = lower " D. = dark

Table 44

Brassica arvensis, 1949.

Location	Temperatures	Observed 110		Observed 111		Transformed 110		Transformed 111	
Gr.	20°C, dark	42.1	40.0	26.8	70.8	40.5	39.2	31.2	57.3
	30°C "	78.0	68.0	80.4	85.6	62.0	55.6	63.7	67.7
	20°C, light	16.1	22.8	7.7	32.2	23.7	28.5	16.1	34.6
	20-30°C "	55.0	52.0	55.0	67.6	47.9	46.1	47.9	55.3
Ba.	20°C, dark	91.5	91.8	80.4	60.0	73.0	73.4	63.7	50.8
	30°C, "	80.0	86.3	86.2	75.9	63.4	68.4	68.2	60.6
	20°C, light	65.7	56.5	60.4	61.9	54.2	48.7	51.0	51.9
	20-30°C "	74.6	73.8	86.0	86.3	59.7	59.2	68.0	68.3

Source	D.F.	M.S.	F.	5%	1%
Samples	1	5.12	36.98XX	5.59	12.25
Locations	1	2,197.84	15.04XX	4.35	8.45
Temperatures	3	893.77	26.43XX		
Hi. vs Lo.[1]	1	1,570.80	3.44		
Li. vs D.[1] at Hi.	1	204.49	15.24XX		
Li. vs D. at Lo.	1	906.01	3.57		
Loc. x temp.	3	212.40			
Error	7	59.42			
Duplicates	16	45.12			
Total	31				

Means and N.D.

Temperatures		Locations		Samples	
20°C, dark	= 53.6	Gr.	= 44.8	110	= 52.8
30°C "	= 63.7	Ba.	= 61.4	111	= 53.5
20°C, light	= 38.6				
20-30°C "	= 56.5				
N.D. (.05)	= 9.08				
(.01)	= 13.47				

1) Hi. = higher temperatures, Li. = light
Lo. = lower " D. = dark

Table 45

Plantago lanceolata, 1949.

Temperat.	Samples	Observed Loc. Gr.		Observed Loc. Ba.		Transformed Loc. Gr.		Transformed Loc. Ba.	
20°C, dark	102b	23.8	17.3	85.4	95.4	29.2	24.6	67.5	77.6
	102c	57.5	55.0	96.0	88.0	49.5	46.7	78.5	69.7
	106	90.7	86.2	95.0	89.5	72.2	68.2	77.1	71.1
30°C, dark	102b	1.5	9.2	52.1	78.5	7.0	17.7	46.2	62.4
	102c	29.2	25.7	64.3	54.6	32.7	30.5	53.3	47.6
	106	31.8	65.0	83.4	83.8	34.3	53.7	66.0	66.3
20°C, light	102b	44.8	33.8	89.0	78.5	42.0	35.5	70.6	62.4
	102c	63.5	56.8	82.0	76.5	52.8	48.9	64.9	61.0
	106	74.5	84.0	100.0	89.7	59.7	66.4	87.4	71.3
20-30°C, light	102b	21.6	33.4	72.8	63.0	27.7	35.3	58.6	52.5
	102c	60.5	56.0	75.8	85.3	51.1	48.4	59.2	67.5
	106	89.7	86.0	97.1	92.0	71.3	68.0	80.2	73.6

Source	D.F.	M.S.	F.	5%	1%
Samples	2	2,171.90	18.63xx	3.74	6.51
Locations	1	5,618.17	48.21xx	4.60	8.86
Temperatures	3	841.58	7.22xx	3.34	5.56
Hi. vs Lo.[1]	1	1,255.25	10.60xx		
Li. vs D.[1] at Hi.	1	1,286.28	11.04xx		
Li. vs D. at Lo.	1	3.22			
Loc. x temp.	3	101.99			
Error	14	116.52			
Duplicates	24	35.82			
Total	47				

Means and N.D.

Temperatures		Locations		Samples	
20°C, dark	= 61.0	Gr.	= 44.7	102b	= 44.8
30°C "	= 45.1	Ba.	= 66.4	102c	= 55.3
20°C, light	= 60.2			106	= 67.9
20-30°C "	= 57.8			N.D. (.05)	= 8.15
				(.01)	= 11.35

1) Hi. = higher temperatures, Li. = light
Lo. = lower " D. = dark

Table 46

Ambrosia artemisiifolia, 1949.

Location	Temperatures	Observed 115		116		Transformed 115		116	
Gr.	20°C, dark	89.1	94.3	95.1	88.6	70.7	76.2	77.2	70.3
	30°C "	97.8	97.7	95.8	95.0	81.5	81.3	78.2	77.1
	20°C, light	92.1	89.5	92.6	88.6	73.7	71.1	74.2	70.3
	20-30°C "	88.2	91.5	93.7	90.8	69.9	73.0	75.5	72.5
Ba.	20°C, dark	92.8	98.1	90.6	92.0	74.4	82.1	72.1	73.6
	30°C "	96.8	94.7	97.9	98.9	79.7	76.7	81.7	84.0
	20°C, light	89.6	91.4	90.3	84.0	71.2	72.9	71.9	66.4
	20-30°C "	95.7	94.8	93.5	95.0	78.0	76.8	75.2	77.8

Source	D.F.	M.S.	F.	5%	1%
Samples	1	4.06			
Locations	1	15.19	1.39		
Temperatures	3	100.77	9.27**	4.35	8.45
Hi. vs Lo.[1]	1	154.87	14.24**	5.59	12.25
Li. vs D.[1] at Hi.	1	108.68	10.00*		
Li. vs D. at Lo.	1	38.75	3.56		
Loc. x temp.	3	12.31	1.13		
Error	7	10.87			
Duplicates	16	7.44			
Total	31				

Means and N.D.

Temperatures		Locations	Samples
20°C, dark	= 74.6	Gr. = 74.5	115 = 75.6
30°C "	= 80.0	Ba. = 75.9	116 = 74.9
20°C, light	= 71.5		
20-30°C "	= 74.8		
N.D. (.05)	= 3.87		
(.01)	= 5.74		

1) Hi. = higher temperatures, Li. = light
Lo. = lower " D. = dark

Table 47

Chrysanthemum leucanthemum, 1949.

Location	Temperatures	Observed 103		Observed 108		Transformed 103		Transformed 108	
Gr.	20°C, dark	58.0	46.5	52.0	45.5	49.6	43.0	46.1	42.4
	30°C "	6.0	14.1	19.0	15.2	14.2	22.1	25.8	22.9
	20°C, light	79.0	87.0	94.0	94.0	62.7	68.9	75.8	75.8
	20-30°C "	97.0	90.0	99.0	98.0	80.0	71.9	84.3	81.9
Ba.	20°C, dark	30.0	36.0	58.0	48.0	33.2	36.9	49.6	43.9
	30°C "	18.0	15.0	35.0	34.0	25.1	22.8	36.3	35.7
	20°C, light	85.9	81.0	95.9	95.0	67.9	64.2	78.3	77.1
	20-30°C "	88.0	88.0	97.1	97.8	69.7	69.7	80.2	81.5

Source	D.F.	M.S.	F.	5%	1%
Samples	1	578.00	25.27xx	5.59	12.25
Locations	1	0.78			
Temperatures	3	4,722.24	206.48xx	4.35	8.45
Hi. vs Lo.[1]	1	262.21	11.46x		
Li. vs D.[1] at Hi.	1	10,712.25	468.39xx		
Li. vs D. at Lo.	1	3,192.25	139.58xx		
Loc. x temp.	3	75.64	3.30		
Error	7	22.87			
Duplicates	16	9.73			
Total	31				

Means and N.D.

Temperatures		Locations	Samples
20°C, dark	= 43.1	Gr. = 54.2	103 = 50.1
30°C "	= 25.6	Ba. = 54.5	108 = 58.6
20°C, light	= 71.3		
20-30°C "	= 77.4		
N.D. (.05)	= 5.64		
(.01)	= 8.36		

1) Hi. = higher temperatures, Li. = light
Lo. = lower " D. = dark

D. Germination tests in the laboratory of seed stratified in nylon under field conditions (for two temperatures, two locations, and two stratifications periods). Tables 48-53.

Table 48

Rumex acetosella, 1949.

Germ. dates	Locations	Samples	Observed 20°C, dark		Observed 30°C, dark		Transformed 20°C, dark		Transformed 30°C, dark	
May 1-6	Gr.	104	7.5	13.3	6.9	2.0	15.9	21.4	15.2	8.1
		105	8.4	32.7	19.4	12.8	16.8	34.9	26.1	21.0
		107	20.2	14.0	9.4	9.0	26.7	22.0	17.9	17.5
	Ba.	104	17.0	18.0	15.2	12.1	24.4	25.1	22.9	20.4
		105	36.0	37.0	31.0	32.0	36.9	37.5	33.8	34.4
		107	60.0	25.0	22.0	22.0	50.8	30.0	28.0	28.0
June 14-16	Gr.	104	31.8	29.7	17.1	7.9	34.3	33.0	24.4	16.3
		105	51.2	68.6	55.1	14.0	45.7	55.9	47.9	22.0
		107	25.9	32.9	32.1	41.5	29.3	35.0	34.5	40.1
	Ba.	104	23.1	25.3	15.9	10.9	28.7	30.2	23.5	19.3
		105	31.1	36.3	30.4	42.9	33.9	37.0	33.5	40.9
		107	43.6	37.9	12.8	20.5	41.3	38.0	21.0	26.9

Source	D.F.	M.S.	F.	5%	1%
Samples	2	609.21	16.00**	3.68	6.36
Locations	1	148.75	3.90	4.54	8.68
Germ. dates	1	651.95	17.12**		
Temperatures	1	540.69	14.20**		
Loc. x germ. dat.	1	622.80	13.36**		
Loc. x temp.	1	0.03			
Germ. dat. x temp.	1	10.92			
Error	15	38.06			
Duplicates	24	40.26			
Total	47				

Means and N.D.

Temperatures		Germination Dates		Samples		Locations	
20°C, dark	= 32.7	May 1-6th	= 25.7	104	= 22.7	Gr.	= 27.6
30°C "	= 26.0	June 14-16th	= 33.0	105	= 34.9	Ba.	= 31.1
				107	= 30.4		
				N.D. (.05)	= 4.64		
				(.01)	= 6.45		

Table 49

Portulaca oleracea, 1949.

Germ. dates	Locations	Temperatures	Observed 114a		114b		Transformed 114a		114b	
May 1-6	Gr.	30°C, dark	46	30	46	68	42.7	33.2	42.7	55.6
		20-30°C, light	67	73	85	86	54.9	58.7	67.2	68.0
		30°C, dark	55	52	57	77	47.9	46.1	49.0	61.3
		20-30°C, light	69	61	79	83	56.2	51.4	62.7	65.6
June 14-16	Ba.	30°C, dark	70	66	84	86	56.8	54.3	66.4	68.0
		20-30°C, light	57	78	84	83	37.5	62.0	66.4	65.6
		30°C, dark	75	64	89	91	60.0	53.1	70.6	72.5
		20-30°C, light	65	71	90	91	52.5	57.4	71.6	72.5

Source	D.F.	M.S.	F.	5%	1%
Samples	1	1,262.53	61.52**	5.32	11.26
Locations	1	79.38	3.86		
Germ. dates	1	480.50	23.41**		
Temperatures	1	255.12	12.33**		
Loc. x germ. dat.	1	8.00			
Loc. x temp.	1	30.42	1.48		
Germ. dat. x temp.	1	468.18	22.81**		
Error	8	20.52			
Duplicates	16	55.73			
Total	31				

Means:

Temperatures		Germination dates		Locations		Samples	
30°C, dark	= 55.0	May 1-6	= 55.9	Gr.	= 56.2	114a	= 51.4
20-30°C, light	= 60.6	June 14-16	= 61.7	Ba.	= 59.4	114b	= 64.1

Table 50

Brassica arvensis, 1949.

Germ. dates	Locations	Temperatures	Observed 110		Observed 111		Transformed 110		Transformed 111	
May 1-6	Gr.	20°C, dark	42.1	40.0	26.8	70.8	40.5	39.2	31.2	57.3
		30°C "	78.0	68.0	80.4	85.6	62.0	55.6	63.7	67.7
	Ba.	20°C "	91.5	91.8	80.4	60.0	73.0	73.4	63.7	50.8
		30°C "	80.0	86.3	86.2	75.9	63.4	68.3	68.2	60.6
June 14-16	Gr.	20°C "	48.0	61.2	75.0	72.6	43.9	51.9	60.0	58.4
		30°C "	5.0	45.0	70.0	58.8	12.9	42.1	56.8	50.1
	Ba.	20°C "	79.2	59.7	86.1	96.1	62.9	50.6	68.1	78.6
		30°C "	64.0	53.7	93.5	91.5	53.1	47.1	75.2	73.0

Source	D.F.	M.S.	F.	5%	1%
Samples	1	646.20	2.07	5.32	11.26
Locations	1	1,758.24	5.63*		
Germin. dates	1	92.48			
Temperatures	1	8.82			
Loc. x germ. dat.	1	25.56			
Loc. x temp.	1	52.53			
Germ. dat. x temp.	1	649.80	2.08		
Error	8	311.96			
Duplicates	16	26.42			
Total	31				

Means:

Temperatures	Germination dates	Locations	Samples
20°C, dark = 56.4	May 1-6th = 58.7	Gr. = 49.5	110 = 52.5
30°C " = 57.5	June 14-16th = 55.3	Ba. = 64.4	111 = 61.5

Table 51

Plantago lanceolata, 1949.

Germ. dates	Locations	Samples	Observed 20°C, dark		Observed 30°C, dark		Transformed 20°C, dark		Transformed 30°C, dark	
May 1-6	Gr.	102b	23.8	17.3	1.5	9.2	29.2	24.6	7.0	17.7
		102c	57.5	53.0	29.2	25.7	49.3	46.7	32.7	30.5
		106	90.7	86.2	51.8	65.0	72.2	68.2	34.3	53.7
	Ba.	102b	85.4	95.4	52.1	78.5	67.5	77.6	46.2	62.4
		102c	96.0	88.0	64.3	54.6	78.5	69.7	53.3	47.6
		106	95.0	89.5	83.4	83.8	77.1	71.1	66.0	66.3
June 14-16	Gr.	102b	12.3	5.6	0	0	20.5	13.7	2.6	2.6
		102c	55.3	55.3	21.0	10.0	56.5	36.5	27.3	18.4
		106	62.1	71.0	57.2	42.1	52.0	57.4	49.1	40.5
	Ba.	102b	17.2	9.1	0	0	24.3	17.6	2.6	2.6
		102c	31.6	29.2	13.3	13.7	34.2	32.7	21.4	21.7
		106	78.8	60.1	77.3	42.4	62.6	50.8	61.7	40.6

Source	D.F.	M.S.	F.	5%	1%
Samples	2	4,004.47	29.18**	3.68	6.36
Locations	1	2,311.57	16.84**	4.54	8.68
Germ. dates	1	5,618.17	40.94**		
Temperatures	1	2,728.57	19.88**		
Loc. x germ. dat.	1	1,891.28	13.78**		
Loc. x temp.	1	7.44			
Germ. dat. x temp.	1	91.02			
Error	15	137.20			
Duplicates	24	39.85			
Total	47				

Means and N.D.

Temperatures		Germination Dates		Samples		Locations	
20°C, dark	= 48.8	May 1-6th	= 52.0	102b	= 26.2	Gr.	= 34.3
30°C "	= 33.7	June 14-16th	= 30.4	102c	= 39.8	Ba.	= 48.3
				106	= 57.7		
				N.D. (.05)	= 8.82		
				(.01)	= 12.21		

Table 52

Ambrosia artemisiifolia, 1949.

Germ. dates	Locations	Temperatures	Observed 115		Observed 116		Transformed 115		Transformed 116	
May 1-6	Gr.	30°C, dark	97.8	97.7	95.8	95.0	81.5	81.3	78.2	77.1
		20-30°C, light	88.2	91.5	93.7	90.8	69.9	73.0	75.5	72.3
	Ba.	30°C, dark	96.8	94.7	97.9	98.9	79.7	76.7	81.7	84.0
		20-30°C, light	95.7	94.8	93.5	95.0	78.0	76.8	75.2	77.8
June 14-16	Gr.	30°C, dark	78.2	68.2	72.7	50.7	62.2	55.7	58.5	45.4
		20-30°C, light	77.5	78.8	67.8	72.1	61.7	62.6	55.4	58.1
	Ba.	30°C, dark	93.9	96.5	91.4	93.5	75.7	78.9	72.9	75.2
		20-30°C, light	97.6	92.2	90.2	90.8	81.1	75.8	71.8	72.3

Source	D.F.	M.S.	F.	5%	1%
Samples	1	43.24	2.29	5.32	11.26
Locations	1	832.32	44.15**		
Germ. dates	1	983.46	52.17**		
Temperatures	1	27.01	1.43		
Loc. x germ. dat.	1	457.53	24.27**		
Loc. x temp.	1	1.36			
Germ. dat. x temp.	1	91.12	4.83		
Error	8	18.85			
Duplicates	16	10.46			
Total	31				

Means:

Temperatures		Germination Dates		Locations		Samples	
30°C, dark	= 72.8	May 1-6	= 77.4	Gr.	= 66.8	115	= 73.0
20-30°C, light	= 70.9	June 14-16	= 66.3	Ba.	= 77.0	116	= 70.7

Table 55

Chrysanthemum leucanthemum, 1949.

Germ. dates	Locations	Temperatures	Observed 103		Observed 108		Transformed 103		Transformed 108	
May 1-6	Gr.	20°C, dark	58.0	46.5	52.0	45.5	49.6	43.0	46.1	42.4
		30°C, "	6.0	14.1	19.0	15.2	14.2	22.1	25.8	22.9
	Ba.	20°C, "	50.0	56.0	58.0	48.0	55.2	36.9	49.6	43.9
		30°C, "	18.0	15.0	35.0	34.0	25.1	22.8	36.5	35.7
June 14-16	Gr.	20°C, "	82.5	73.8	78.8	74.7	65.3	59.2	62.6	59.8
		30°C, "	26.5	6.1	22.0	30.9	31.0	14.3	28.0	33.8
	Ba.	20°C, "	69.6	71.7	82.0	75.0	56.5	57.9	64.9	60.0
		30°C, "	13.0	6.1	26.8	11.2	21.1	14.3	31.2	19.6

Source	D.F.	M.S.	F.	5%	1%
Samples	1	288.60	7.06*	5.32	11.26
Locations	1	3.85			
Germ. dates	1	527.31	12.90**		
Temperatures	1	5,850.91	143.19**		
Loc. x germ. dat.	1	65.83	1.61		
Loc. x temp.	1	47.77	1.16		
Germ. dat. x temp.	1	732.48	17.92**		
Error	8	40.86			
Duplicates	16	23.25			
Total	31				

Means:

Temperatures	Germination dates	Locations	Samples
20°C, dark = 51.9	May 1-6 = 34.3	Gr. = 38.7	103 = 35.4
30°C " = 24.9	June 14-16 = 42.5	Ba. = 38.1	108 = 41.4

E. Stratification experiment under field conditions of seed sown in soil.

Tables 54-61.

Table 54

Setaria glauca, 1949.

A.)

Locations	Samples	Observed Rep.1	Observed Rep.2	Observed Rep.3	Transformed Rep.1	Transformed Rep.2	Transformed Rep.3
Gr.	112-B	80	64	74	63.4	53.1	59.3
	112-G	64	71	83	53.1	57.4	65.6
	113-B	53+)	60	44	46.7	50.8	41.6
	113-G	81	87	95	64.2	68.9	77.1
Ba.	112-B	79	68	89	62.7	55.6	70.6
	112-G	86	60	62	68.0	50.8	51.9
	113-B	65	74	69	53.7	59.3	56.2
	113-G	87	85	86	68.9	67.2	68.0

Source	D.F.	S.S.	C.M. [1]	M.S.	F.	5%	1%
Replicates	2	47.57	(1)	23.78			
Samples	3	968.16	(2)	322.72	7.90xx	3.41	5.74
Mat. vs Imm.	1	323.40	(3)	323.40	7.93x	4.67	9.07
Mature	1	265.08	(4)	265.08	6.50x		
Immature	1	379.68	(5)	379.68	9.31xx		
Locations	1	41.87	(6)	41.87	1.02		
Sampl. x loc.	3	148.85	(7)	49.62	1.21		
Error	13	529.77	(8)	40.75			
Total	22	1,736.22	(9)				

1) Calculation methods.

Subsidiary tables.

B.)

	Rep.1	Rep.2	Rep.3	Totals
Loc. Gr.	227.4	230.2	243.6	701.2
Loc. Ba.	253.3	232.9	246.7	732.9
Totals	480.7	463.1	490.3	1,434.1

Table 54 (concluded)

C.)

	112-B	112-G	113-B	115-G	Totals
Loc. Gr.	175.8	176.1	139.1	210.2	701.2
Loc. Ba.	188.9	170.7	169.2	204.1	732.9
Totals	364.7	346.8	308.3	414.3	1434.1

Calculation methods of sums of squares.

(1) - from table B.
(2) - from table C.
(3) - " " " (112-B & 113-B) vs 112-G & 115-G).
(4) - " " " (112-B vs 113-G.
(5) - " " " 112-G vs 113-G.
(6) - " " B.
(7) - [(2) + (6)] subtracted from total S.S. for table C.
(8) - [(1) + (2) + (6) + (7)] subtracted from (9)
(9) - total S.S. for table A.

Means:

Locations	Samples
Gr. = 58.4	112-B = 60.8
Ba. = 61.6	112-G = 57.8
	115-B = 51.4
	115-G = 69.0

Necessary difference for significance.

Samples:

S.E. diff. = $\sqrt{\frac{40.75}{6} \times 2} = 3.68$

N.D.(.05) = S.E.diff. x $t_{D.F.=13}$ = 3.68 x 2.16 = 8.01

N.D.(.01) = 3.68 x 3.01 = 11.07

±) The value of missing plot was calculated according to the formula given by Goulden (1949).

$$X = \frac{pP \times qQ - T}{(p-1)(q-1)}, \text{ where}$$

p = number of treatments,
q = number of blocks,
P = total of all the plots receiving the same treatment as the missing plot,
Q = total of all the plots in the same block as the missing plot,
T = total of all plots.

Table 55

Rumex acetosella, 1949.

Location	Sample	Observed data		
		Rep.1	Rep.2	Rep.3
Gr.	104	27	8	14
	105	33	20	47
	107	40	3	6
Ba.	104	34	31	25
	105	62	32	36
	107	48	38	34

Table 56

Silene noctiflora, 1949.

Locations	Samples	Observed Rep.1	Rep.2	Rep.3	Transformed Rep.1	Rep.2	Rep.3
Gr.	101b	74	65	87	59.3	53.7	68.9
	109	87	88	94	68.9	69.7	75.8
Ba.	101b	98	93	97	81.9	74.7	80.0
	109	95	96	97	77.1	78.5	80.0

Source	D.F.	M.S.	F.	5%	1%
Replicates	2	50.34	3.22	5.79	
Locations	1	480.06	30.75**	6.61	16.26
Samples	1	82.68	5.30		
Samp. x loc.	1	93.52	5.99		
Error	5	15.61			
Total	10				

Means:

Locations		Samples	
Gr.	= 66.0	101b	= 69.7
Ba.	= 78.7	109	= 75.0

Table 57

Portulaca oleracea, 1949.

Location	Sample	Observed data		
		Rep.1	Rep.2	Rep.3
Gr.	114a	45	30	24
	114b	45	55	20
Ba.	114a	71	53	44
	114b	59	58	54

Table 58

Brassica arvensis, 1949.

Locations	Replic.	Observed 110	Observed 111	Transformed 110	Transformed 111
Gr.	1	92	78	73.6	62.0
	2	76	96	60.7	78.5
	3	78	81	62.0	64.2
Ba.	1	82	86[1]	64.9	68.0
	2	83	80	65.6	63.4
	3	84	86	66.4	68.0

Source	D.F.	M.S.
Replicates	2	5.01
Samples	1	9.90
Locations	1	1.84
Sampl. x Loc.	1	2.90
Error	5	53.33
Total	10	

Means:

Locations	Samples
Gr. = 66.8	110 = 65.5
Ba. = 66.0	111 = 67.3

1) Missing plot. See footnote in App. Table No.54.

Table 59

Plantago lanceolata, 1949.

Locations	Samples	Observed Rep.1	Rep.2	Rep.3	Transformed Rep.1	Rep.2	Rep.3
Gr.	102b	71	74	75	57.4	59.5	60.0
	102c	73	75	74	58.7	60.0	59.3
	106	78	71	80	62.0	57.4	63.4
Ba.	102b	90	89	96	71.6	70.6	78.5
	102c	95	91	87	74.7	72.5	68.9
	106	90	86	91	71.6	68.0	72.5

Source	D.F.	M.S.	F.	5%	1%
Replicates	2	9.16	1.28	4.10	
Samples	2	0.50			
Locations	1	689.44	96.69**	4.96	10.04
Sampl. x loc.	2	9.12	1.27		
Error	10	7.13			
Total	17				

Means:

Locations	Samples
Gr. = 59.7	102b = 66.2
Ba. = 72.1	102c = 65.6
	106 = 65.8

Table 60

Ambrosia artemisiifolia, 1949.

Locations	Samples	Observed Rep.1	Rep.2	Rep.3	Transformed Rep.1	Rep.2	Rep.3
Gr.	115	77	65	75	61.3	53.7	60.0
	116	71	63	74	57.4	52.5	59.3
Ba.	115	89	65	84	70.6	53.7	66.4
	116	76	73	78	60.7	58.7	62.0

Source	D.F.	M.S.	F.	5%	1%
Replicates	2	76.58	7.08**	5.14	10.92
Samples	1	19.00	1.75	5.99	13.74
Locations	1	64.86	6.00*		
Sampl. x loc.	1	1.02			
Error	6	10.81			
Total	11				

Means:

Locations		Samples	
Gr.	= 57.3	115	= 60.9
Ba.	= 62.0	116	= 58.4

Table 61

Chrysanthemum leucanthemum, 1949.

Location	Sample	Observed data		
		Rep.1	Rep.2	Rep.3
Gr.	103	9	4	30
	108	55	7	68
Ba.	103	78	43	61
	108	80	74	63

Tables 62-69

Applying to the Chapter VII

Germination of dry stored seed in the soil.

Table 62

Setaria glauca, 1949.

A.

Replic.	Soils	Depths	Observed 112-B	112-G	113-B	113-G	Transformed 112-B	112-G	113-B	113-G
1	Sand	¼ in	52	41	42	67	46.1	39.8	40.4	54.9
		½ "	47	26	35	31	43.3	30.7	36.3	33.8
		1 "	42	33	33	24	40.4	35.1	35.1	29.3
	Mixt.	¼ "	49	60	58	61	44.4	50.8	49.6	51.4
		½ "	70	53	71	57	56.8	46.7	57.4	49.0
		1 "	78	80	78	70	62.0	63.4	62.0	56.8
	Soil	¼ "	71	64	62	57	57.4	53.1	51.9	49.0
		½ "	74	63	70	62	59.3	52.5	56.8	51.9
		1 "	75	77	82	64	60.0	61.3	64.9	53.1
2	Sand	¼ "	41	24	45	42	39.8	29.3	42.1	40.4
		½ "	50	33	69	82	45.0	35.1	56.2	64.9
		1 "	55	48	49	64	47.9	43.9	44.4	53.1
	Mixt.	¼ "	62	62	71	64	51.9	51.9	57.4	53.1
		½ "	65	48	52	60	53.7	43.9	46.1	50.8
		1 "	65	70	71	55	53.7	56.8	57.4	47.9
	Soil	¼ "	53	45	61	56	46.7	42.1	51.4	48.4
		½ "	56	43	65	61	48.4	41.0	53.7	51.4
		1 "	82	73	69	66	64.9	58.7	56.2	54.3

B.

Source	D.F.	S.S.	C.M.[1]	M.S.	F.	5%	1%
Between Main Plots	7	408.54	(1)				
Replicates	1	0.11	(2)	0.11			
Samples	3	264.04	(3)	88.01	1.83	9.28	
Mature vs Imm.	1	172.36	(4)	172.36	3.58	10.13	
Mature	1	0.16	(5)	0.16			
Immature	1	91.52	(6)	91.52	1.90		
Error (a)	3	144.22	(7)	48.07			
Between Sub-plots	16	2,855.97	(8)				
Soils	2	2,094.57	(9)	1,047.28	16.89**	4.46	8.65
Soils x Samples	6	265.44	(10)	44.24			
Error (b)	8	495.96	(11)	61.99			
Within Sub-plots	48	2,189.20	(12)				
Depths	2	337.15	(13)	168.57	4.86*	3.26	5.25
Depths x samples	6	314.84	(14)	52.47	1.51	2.36	
Depths x soils	4	289.11	(15)	72.28	2.08	2.63	
Error (c)	36	1,248.10	(16)	34.66			
Total	71	5,453.54	(17)				

1) Calculation methods.

Table 62 (continued)

Calculation methods of sums of squares.

(1) = total sum of squares (= S.S.) for table C,

(2) = from table C,

(3) = " " C,

(4) = " " C, mature (112-B & 113-B) vs imm. (112-G & 113-G),

(5) = " " C, 112-B vs 113-B,

(6) = " " C, 112-G vs 113-G,

(7) = (1) - [(2) + (3)] ,

(8) = total S.S. for table C subtracted from total S.S. for table D,

(9) = from table E,

(10) = [(3) + (9)] subtracted from total S.S. for table E,

(11) = (8) - [(9) + (10)] ,

(12) = total S.S. for table D subtracted from (17)

(13) = from table F,

(14) = [(3) + (13)] subtracted from total S.S. for table F,

(15) = [(9) + (13)] subtracted from total S.S. for table G,

(16) = (12) - [(13) + (14) + (15)] ,

(17) = total S.S. for table A (transformed data).

Subsidiary tables:

C.

	112-B	112-G	113-B	113-G	Totals
Rep.1	469.7	433.4	454.4	429.2	1,786.7
Rep.2	452.0	402.7	464.9	464.3	1,783.9
Totals	921.7	836.1	919.3	893.5	3,570.9

Table 62 (continued)

D.

	Rep. 1			Rep. 2			
	Sand	Mixt.	Soil	Sand	Mixt.	Soil	Totals
112-B	129.8	163.2	176.7	152.7	159.3	160.0	921.7
112-G	105.6	160.9	166.9	108.3	152.6	141.8	836.1
113-B	111.8	169.0	175.6	142.7	160.9	161.3	919.3
113-G	118.0	157.2	154.0	158.4	151.8	154.1	893.5
Totals	465.2	650.3	671.2	542.1	624.6	617.2	3570.6

E.

	112-B	112-G	113-B	113-G	Totals
Sand	262.5	213.9	254.5	276.4	1,007.3
Mixt.	322.5	313.5	329.9	309.0	1,274.9
Soil	336.7	308.7	334.9	308.1	1,288.4
Totals	921.7	836.1	919.3	893.5	3,570.6

F.

	112-B	112-G	113-B	113-G	Totals
¼ in.	286.3	267.0	292.8	297.2	1,143.3
½ "	306.5	249.9	306.5	301.8	1,164.7
1 "	328.9	319.2	320.0	294.5	1,262.6
Totals	921.7	836.1	919.3	893.5	3,570.6

G.

	¼ in.	½ in.	1 in.	Totals
Sand	332.8	345.3	329.2	1,007.3
Mixt.	410.5	404.4	460.0	1,274.9
Soil	400.0	415.0	473.4	1,288.4
Totals	1,143.3	1164.7	1262.6	3,570.6

Table 62 (concluded)

Means (in transformed data):

Depths		Samples		Soils	
¼ in.	= 47.6	112-B	= 51.2	Sand	= 42.0
½ "	= 48.5	112-G	= 46.4	Mixt.	= 53.1
1 "	= 52.6	113-B	= 51.1	Soil	= 55.7
		113-G	= 49.6		

Necessary Differences (= N.D.) for significance:

Soils.

$$\text{S.E. diff.} = \sqrt{\frac{61.99}{24} \times 2} = 2.27$$

N.D.(.05) = S.E.diff. x t (at .05; D.F.= 8) = 2.27 x 2.31 = 5.24

N.D.(.01) = S.E.diff. x t (at .01; D.F.= 8) = 2.27 x 3.36 = 7.63

Depths.

$$\text{S.E. diff.} = \sqrt{\frac{34.66}{24} \times 2} = 1.70$$

N.D.(.05) = S.E.diff. x t (at .05; D.F.= 36) = 1.70 x 2.03 = 3.45

N.D.(.01) = S.E.diff. x t (at .01; D.F.= 36) = 1.70 x 2.72 = 4.62

Table 63

Rumex acetosella, 1949.

Soils	Depths	Observed						Transformed					
		Rep.1			Rep.2			Rep.1			Rep.2		
		104	105	107	104	105	107	104	105	107	104	105	107
Sand	¼ in.	11	15	23	4	9	12	19.4	22.8	28.7	11.5	17.5	20.5
	½ "	21	32	25	6	39	19	27.3	34.4	30.0	14.2	38.6	25.8
	1 "	2	8	2	3	2	2	8.1	16.4	8.1	10.0	8.1	8.1
Mixt.	¼ in.	61	55	80	47	53	82	51.4	46.7	63.4	43.3	46.7	64.9
	½ "	3	32	21	2	30	19	10.0	34.4	27.3	8.1	33.2	25.8
	1 "	3	25	7	1	15	5	10.0	30.0	15.3	5.7	22.8	12.9
Soil	¼ "	17	39	33	27	35	34	24.4	38.6	35.1	31.3	36.3	35.7
	½ "	2	30	20	11	22	9	8.1	33.2	26.6	19.4	28.0	17.5
	1 "	3	7	5	4	22	5	10.0	15.3	12.9	11.5	28.0	12.9

Source	D.F.	M.S.	F.	5%	1%
Replicates	1	45.92	22.96x	18.51	98.49
Samples	2	632.62	316.31xx	19.00	99.01
Error (a)	2	2.00			
Soils	2	582.42	19.40xx	5.14	10.92
Soi. x samp.	4	40.56	1.35		
Error (b)	6	30.02			
Depths	2	2,133.13	105.75xx	3.37	5.53
Dep. x soi.	4	587.01	29.10xx	2.74	4.14
Dep. x samp.	4	151.39	7.50xx		
Error (c)	26	20.17			
Total	53				

Means and N.D.

Depths	Soils	Samples
¼ in. = 35.4	Sand = 19.4	104 = 18.0
½ " = 24.5	Mixt = 30.6	105 = 29.5
1 " = 13.7	Soil = 23.6	107 = 26.2
N.D.(.05) = 3.07	N.D.(.05) = 4.41	N.D.(.05) = 2.84
(.01) = 4.14	(.01) = 6.67	(.01) = 6.55

Table 64

Silene noctiflora, 1949.

Soils	Depths	Observed Rep.1 101b	Observed Rep.1 109	Observed Rep.2 101b	Observed Rep.2 109	Transformed Rep.1 101b	Transformed Rep.1 109	Transformed Rep.2 101b	Transformed Rep.2 109
Sand	¼ in.	98	97	95	96	81.9	80.0	77.1	78.5
	½ "	96	99	100	100	78.5	84.3	87.4	87.4
	1 "	99	96	99	99	84.3	78.5	84.3	84.3
Mixt.	¼ "	97	92	99	99	80.0	73.6	84.3	84.3
	½ "	99	100	99	99	84.3	87.4	84.3	84.3
	1 "	99	100	99	99	84.3	87.4	84.3	84.3
Soil	¼ "	97	99	98	97	80.0	84.3	81.9	80.0
	½ "	98	99	96	96	81.9	84.3	78.5	78.5
	1 "	88	96	96	100	69.7	78.5	78.5	87.4

Source	D.F.	M.S.	F.	5%	1%
Replicates	1	19.36	28.05	161	
Samples	1	13.20	19.13		
Error (a)	1	0.69			
Soils	2	32.49	17.46**	6.94	18.00
Samples x soils	2	14.50	7.79**		
Error (b)	4	1.86			
Depths	2	25.96	1.43	3.63	
Depths x sampl.	2	8.55			
Depths x soils	4	18.88	1.04	3.01	
Error (c)	16	18.04			
Total	35				

Means and N.D.

Depths		Soils		Samples	
¼ in	= 80.5	sand	= 82.2	101b	= 81.4
½ in	= 84.5	mixt.	= 83.5	109	= 82.6
1 "	= 82.2	soil	= 80.3		
N.D. (.05)	= 3.67	N.D. (.05)	= 1.53		
(.01)	= 5.05	(.01)	= 2.53		

Table 65

Portulaca oleracea, 1949.

Soils	Depths	Observed Rep.1 114a	Observed Rep.1 114b	Observed Rep.2 114a	Observed Rep.2 114b	Transformed Rep.1 114a	Transformed Rep.1 114b	Transformed Rep.2 114a	Transformed Rep.2 114b
Sand	¼ in.	37	15	27	31	37.5	22.8	31.3	33.8
	½ "	10	31	14	7	18.4	33.8	22.0	15.3
	1 "	0	0	0	0	2.6	2.6	2.6	2.6
Mixt.	¼ "	37	65	47	81	37.5	53.7	43.3	64.2
	½ "	24	24	24	42	29.3	29.7	29.3	40.4
	1 "	0	12	2	7	2.6	20.3	8.1	15.3
Soil	¼ "	19	16	34	46	25.8	23.6	35.7	42.7
	½ "	10	8	15	16	18.4	16.4	22.8	23.6
	1 "	0	1	4	5	2.6	5.7	11.5	12.9

Source	D.F.	M.S.	F.	5%	1%
Replicates	1	154.17	48.48	161	
Samples	1	167.70	52.73		
Error (a)	1	3.18			
Soils	2	548.49	11.13**	6.94	18.00
Soil x samp.	2	142.04	2.88		
Error (b)	4	49.28			
Depths	2	2,759.95	82.50**	3.63	6.23
Dep. x soils	4	62.61	1.87		
Dep. x samp.	2	3.33			
Error (c)	16	33.45			
Total	35				

Means and N.D.

Depths		Soils		Samples	
¼ in.	= 37.6	Sand	= 18.8	114a	= 21.2
½ "	= 24.9	Mixt.	= 31.1	114b	= 25.5
1 "	= 7.5	Soil	= 20.1		
N.D. (.05)	= 5.00	N.D. (.05)	= 7.95		
(.01)	= 6.89	(.01)	= 13.16		

Table 66

Brassica arvensis, 1949.

Soils	Depths	Observed Rep. 1 110	Observed Rep. 1 111	Observed Rep. 2 110	Observed Rep. 2 111	Transformed Rep.1 110	Transformed Rep.1 111	Transformed Rep.2 110	Transformed Rep.2 111
Sand	¼ in.	87	85	85	78	68.9	67.2	67.2	62.0
	½ "	81	82	83	78	64.2	64.9	65.6	62.0
	1 "	85	81	79	76	67.2	64.2	62.7	60.7
Mixt.	¼ "	86	93	83	84	68.0	74.7	65.6	66.4
	½ "	65	85	64	85	53.7	65.6	53.1	67.2
	1 "	49	78	47	61	44.4	62.0	43.3	51.4
Soil	¼ "	80	99	64	87	63.4	84.3	53.1	68.9
	½ "	72	82	47	77	58.1	64.9	43.3	61.3
	1 "	59	70	13	53	50.2	56.8	21.1	46.7

Source	D.F.	M.S.	F.	5%	1%
Replicates	1	402.67	432.97**	161	4052
Samples	1	535.15	575.43**		
Error (a)	1	0.93			
Soils	2	233.89	3.08	6.94	
Soils x samp.	2	252.55	3.32		
Error (b)	4	75.87			
Depths	2	673.06	43.17**	3.63	6.23
Depths x soils	4	119.99	7.69**	3.01	4.77
Depths x samp.	2	4.79			
Error (c)	16	15.59			
Total	35				

Means and N.D.

Depths		Soils		Samples	
¼ in.	= 67.5	Sand	= 64.8	110	= 56.3
½ "	= 60.3	Mixt.	= 59.6	111	= 64.0
1 "	= 52.6	Soil	= 56.0		
N.D. (.05)	= 3.41	N.D. (.05)	= 9.87		
(.01)	= 4.70	(.01)	= 16.33		

Table 67

Plantago lanceolata, 1949.

Soils	Depths	Observed Rep.1 102b	102c	106	Rep.2 102b	102c	106	Transformed Rep.1 102b	102c	106	Rep.2 102b	102c	106
Sand	¼ in	74	71	73	56	72	48	59.5	57.4	58.7	48.4	58.1	43.9
	½ "	82	79	69	71	91	56	64.9	62.7	56.2	57.4	72.5	48.4
	1 "	80	61	66	80	77	56	63.4	51.4	54.5	63.4	61.3	48.4
Mixt.	¼ in	68	64	80	90	97	78	55.6	53.1	63.4	71.6	80.0	62.0
	½ "	72	62	79	67	90	80	58.1	51.9	62.7	54.9	71.6	63.4
	1 "	69	66	83	59	84	85	56.2	54.5	65.6	50.2	66.4	65.6
Soil	¼ in	52	46	68	56	92	84	46.1	42.7	55.6	48.4	73.6	66.4
	½ "	50	55	72	56	75	76	45.0	47.9	58.1	36.9	60.0	60.7
	1 "	12	14	41	53	79	63	20.3	22.0	39.8	46.7	62.7	52.5

Source	D.F.	M.S.	F.	5%	1%
Replicates	1	527.03	1.10	18.51	
Samples	2	160.78			
Error (a)	2	475.21			
Soils	2	701.11	5.86*	5.14	10.92
Soils x samp.	4	201.58	1.68	4.53	
Error (b)	6	119.61			
Depths	2	161.35	4.05*	3.37	5.53
Dep. x soils	4	138.07	3.46*	2.74	4.14
Dep. x samp.	4	13.29			
Error (c)	26	39.81			
Total	53				

Means and N.D.

Depths

¼ in. = 58.0
½ " = 57.4
1 " = 52.5

N.D.(.05)= 4.53
(.01)= 5.84

Soils

sand = 57.2
mixt.= 61.5
soil = 49.2

N.D.(.05)= 8.92
(.01)= 13.50

Samples

102b = 52.7
102c = 58.3
106 = 57.0

N.D.(.05)=31.22

Table 68

Ambrosia artemisiifolia, 1949.

Soils	Depths	Observed Rep.1 115	Observed Rep.1 116	Observed Rep.2 115	Observed Rep.2 116	Transformed Rep.1 115	Transformed Rep.1 116	Transformed Rep.2 115	Transformed Rep.2 116
Sand	¼ in.	15	12	10	22	22.8	20.5	18.4	28.0
	½ "	22	28	11	15	28.0	31.9	19.4	22.8
	1 "	2	9	7	12	8.1	17.5	15.3	20.3
Mixt.	¼ "	5	7	5	10	12.9	15.3	19.2	18.4
	½ "	11	9	8	13	19.4	17.5	16.4	21.1
	1 "	19	16	14	22	25.8	23.6	22.0	28.0
Soil	¼ "	7	9	9	6	15.3	17.5	17.5	14.2
	½ "	10	7	9	6	18.4	15.3	17.5	14.2
	1 "	1	1	3	1	5.7	5.7	10.0	5.7

Source	D.F.	M.S.	F.	5%	1%
Replicates	1	0.08			
Samples	1	27.56	6.35	161	
Error (a)	1	6.33			
Soils	2	213.60	23.60**	6.94	18.00
Samp. x soils	2	35.34	3.90		
Error (b)	4	9.05			
Depths	2	61.25	5.91*	3.63	6.23
Depths x soils	4	134.75	13.00**	3.01	4.77
Depths x sampl.	2	2.89			
Error (c)	16	10.36			
Total	35				

Means and N.D.

Depths

¼ in. = 17.8
½ " = 20.1
1 " = 15.6

N.D.(.05) = 2.78
(.01) = 3.82

Soils

Sand = 31.1
Mixt.= 19.4
Soil = 13.4

N.D.(.05)= 3.39
(.01)= 5.61

Samples

115 = 17.0
116 = 18.7

Table 69

Chrysanthemum leucanthemum, 1949.

Soils	Depths	Observed Rep.1 103	Observed Rep.1 108	Observed Rep.2 103	Observed Rep.2 108	Transformed Rep.1 103	Transformed Rep.1 108	Transformed Rep.2 103	Transformed Rep.2 108
Sand	¼ in	22	78	52	47	22.0	62.0	46.1	43.3
	½ "	24	55	12	32	29.3	46.7	20.3	34.4
	1 "	0	2	0	0	2.6	8.1	2.6	2.6
Mixt.	¼ "	48	91	60	85	43.9	72.5	50.8	67.2
	½ "	35	70	31	58	36.3	56.8	33.8	58.1
	1 "	1	13	3	1	5.7	21.1	10.0	5.7
Soil	¼ "	31	97	40	45	33.8	80.0	39.2	42.1
	½ "	0	46	17	54	2.6	42.7	24.4	47.3
	1 "	0	1	4	22	2.6	5.7	11.5	28.0

Source	D.F.	M.S.	F.	5%	1%
Replicates	1	30.25			
Samples	1	2,190.24	3.97	161	
Error (a)	1	550.68			
Soils	2	295.92	7.23*	6.94	18.00
Soils x sampl.	2	94.08	2.29		
Error (b)	4	40.91			
Depths	2	5,349.22	173.28**	3.63	6.23
Dep. x soils	4	2.82			
Dep. x samp.	2	206.67	6.69**		
Error (c)	16	30.87			
Total	35				

Means and N.D.

Depths	Soils	Samples
¼ in. = 50.7	Sand - 27.0	103 - 23.5
½ " = 34.3	Mixt - 36.8	108 = 39.1
1 " = 8.8	Soil - 30.0	
N.D.(.05)= 4.79	N.D.(.05)= 7.25	
(.01)= 6.60	(.01)=12.01	

Tables 70-77

Applying to the Chapter VIII

Share of the seed coats in delaying germination.

A. The effect of hulling on the germination of *Setaria glauca* seed. Tables 70 and 71.

Table 70

Setaria glauca, 1949.

Hulling and germination date	Samples	Observed Intact		Observed Hulled		Transformed Intact		Transformed Hulled	
Aug.22, 1949	112-B	0	0	21	16	2.6	2.6	27.5	23.6
	112-G	0	0	7	4	2.6	2.6	15.5	11.5
	113-B	0	0	17	16	2.6	2.6	24.4	23.6
	113-G	0	0	11	22	2.6	2.6	19.4	28.0
Nov.29, 1949	112-B	49	61	93	96	44.4	51.4	74.7	78.5
	112-G	14	17	69	60	22.0	24.4	56.2	50.8
	113-B	39	53	90	90	38.6	46.7	71.6	71.6
	113-G	35	20	84	87	36.3	26.6	66.4	68.9
Mar.12, 1950	112-B	60	67	94	94	50.8	54.9	75.8	75.8
	112-G	66	63	79	75	54.3	52.5	62.7	58.7
	113-B	63	63	96	99	52.5	52.5	78.5	84.5
	113-G	48	35	100	98	43.9	36.5	87.4	81.9

Source	D.F.	M.S.	F.	5%	1%
Samples	3	578.96	4.56x	3.29	5.42
Hulling	1	7,701.55	88.79xx	4.54	8.68
Germin. dates	2	11,333.01	130.67xx	3.68	6.36
Hull. x germ. dat.	2	145.05	1.67		
Error	15	86.73			
Duplicates	24	10.93			
Total	47				

Means and N.D.

Germin. dates.

Aug. 22, 1949 = 12.1
Nov. 29 " = 51.8
Mar. 12, 1950 = 62.6

Hulling

Intact = 29.5
Hulled = 54.8

N.D.(.05) = 7.01
(.01) = 9.70

Table 71

Setaria glauca, 1950.

Hulling and germination date	Samples	Observed Intact		Observed Hulled		Transformed Intact		Transformed Hulled	
Aug.16, 1950	127-B	0	0	7	8	2.6	2.6	15.3	16.4
	127-G	0	0	5	9	2.6	2.6	12.9	17.5
	128-B	0	0	2	6	2.6	2.6	5.7	14.2
	128-G	0	0	0	1	2.6	2.6	2.6	5.7
Oct.16, 1950	127-B	0	0	80	78	2.6	2.6	63.4	62.0
	127-G	2	0	21	1	8.1	2.6	27.3	5.7
	128-B	9	8	73	73	17.5	16.4	60.0	58.7
	128-G	0	0	5	8	2.6	2.6	12.9	16.4
Dec.15, 1950	127-B	25	27	99	100	30.0	31.3	84.3	87.4
	127-G	34	41	67	75	35.7	39.8	54.9	60.0
	128-B	85	78	100	99	67.2	62.0	87.4	84.3
	128-G	50	62	67	71	45.0	51.9	54.9	57.4

Source	D.F.	M.S.	F.	5%	1%
Samples	3	948.31	2.99	3.29	5.42
Hulling	1	5,821.20	18.35xx	4.54	8.65
Germ. dates	2	11,107.19	35.02xx	3.68	6.36
Hull. x germ.d.	2	563.51	1.77		
Error	15	317.14			
Duplicates	24	15.89			
Total	47				

Means and N.D.

Germination dates

Aug.16, 1950 = 6.9
Oct.16 " = 22.6
Dec.15 " = 58.3

N.D.(.05) = 13.42
(.01) = 18.58

Hulling

Intact = 18.3
Hulled = 40.3

B. The effect of scarification. Tables 72-77.

Table 72

Rumex acetosella, 1949.

Scarific. date	Scarific. minutes	Observed data 104		105		107	
Dec.10, 1949	0	3	13	25	13	24	8
	1	63	62	51	48	73	69
	2	61	68	58	67	82	83
	4	75	72	54	46	79	75
	8	69	71	49	53	82	79
Sep.21, 1950	0	18	23	31	37	31	48
	1	49	36	58	48	79	72
	2	56	52	54	59	75	68
	4	66	54	45	51	78	72
	8	64	57	45	44	73	74
		Transformed data					
Dec.10, 1949	0	10.0	21.1	30.0	21.1	29.5	16.4
	1	52.5	51.9	45.6	43.9	58.7	56.2
	2	51.4	55.6	49.6	54.9	64.9	65.6
	4	60.0	58.1	47.3	42.7	62.7	60.0
	8	56.2	57.4	44.4	46.7	64.9	62.7
Sep.21, 1950.	0	25.1	28.7	33.8	37.5	33.8	43.9
	1	44.4	36.9	49.6	43.9	62.7	58.1
	2	48.4	46.1	47.3	50.2	58.7	55.6
	4	54.3	47.3	42.1	45.6	62.0	58.1
	8	53.1	49.0	42.1	41.6	58.7	59.3

Source	D.F.	M.S.	F.	5%	1%
Samples	2	753.56	15.85XX	3.55	6.01
Scarific. periods	4	1,538.69	32.36XX	2.93	4.58
Scarific. dates	1	9.60			
Sc.treat.x sc.dat.	4	171.12	3.60X		
Error	18	47.54			
Duplicates	30	13.73			
Total	59				

Means and N.D.

Scarific. minutes

0 = 27.5
1 = 50.3
2 = 54.0
4 = 53.3
8 = 53.0
N.D.(.05) = 5.90
(.01) = 8.09

Scarific. dates

Dec. 10, 1949 = 48.0
Sep. 21, 1950 = 47.2

Table 75

Rumex acetosella, 1950.

Scarific. date	Scarific. minutes	Observed data: 20°C, dark 123		20°C, dark 124		20-30°C, light 123		20-30°C, light 124	
Jul.25,1950	0	0	0	0	0	0	0	0	0
	1	1	1	0	0	3	1	0	0
	2	2	4	0	1	13	17	6	3
	4	38	38	13	10	48	52	28	34
	8	6	5	5	4	5	2	3	2
Sep.25,1950	0	1	1	0	0	3	0	0	1
	1	17	16	0	0	34	28	0	2
	2	38	45	1	1	59	51	35	24
	4	81	78	49	33	80	88	76	73
	8	68	72	40	38	82	76	56	45
		Transformed data							
Jul.25,1950	0	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
	1	5.7	5.7	2.6	2.6	10.0	5.7	2.6	2.6
	2	8.1	11.5	2.6	5.7	21.1	24.4	14.2	10.0
	4	38.1	38.1	21.1	18.4	43.9	46.1	31.9	35.7
	8	14.2	10.0	12.9	11.5	12.9	8.1	10.0	8.1
Sep.25,1950	0	5.7	5.7	2.6	2.6	10.0	2.6	2.6	5.7
	1	24.4	23.6	2.6	2.6	35.7	31.9	2.6	8.1
	2	38.1	42.1	5.7	5.7	50.2	45.6	36.3	29.3
	4	64.2	62.0	44.4	35.1	63.4	69.7	60.7	58.7
	8	55.6	58.1	39.2	38.1	64.9	60.7	48.4	41.0

Table 73 (concluded)

Source	D.F.	M.S.	F.	5%	1%
Samples	1	5,580.32	61.96**	4.28	7.88
Scarif. treatm.	4	4,429.35	81.20**	2.80	4.26
Scarif. dates	1	7,397.78	135.31**		
Temperatures	1	771.90	14.15**		
Sc.treat. x sc.dat.	4	787.54	14.43**		
Sc.treat. x temp.	4	141.64	2.59		
Sc.dat. x temp.	1	104.65	1.92		
Error	23	54.55			
Duplicates	40	6.89			
Total	79				

Means and N.D.

Scarif. treatm.		Scarif. dates		Temperatures	
0	= 3.6	Jul.25, 1950	= 12.9	20°C, dark	= 19.4
1	= 10.5	Sep.25 "	= 32.1	20-30°C, light	= 25.6
2	= 21.9				
4	= 45.7				
8	= 50.8				
N.D. (.05)	= 5.42				
(.01)	= 7.36				

Table 74

Portulaca oleracea, 1950.

Scarific. dates	Scarif. minutes	Observed 129		130		Transformed 129		130	
Sep.8,1950	0	0	5	7	1	2.6	12.9	15.5	5.7
	1	34	7	28	5	35.7	15.5	31.9	12.9
	3	8	25	51	28	16.4	30.0	45.6	31.9
Dec.10,1950	0	5	2	3	0	10.0	8.1	10.0	2.6
	1	45	91	87	46	42.1	72.5	68.9	42.7
	3	64	75	67	65	53.1	60.0	54.9	53.7

Source	D.F.	M.S.	F.	5%	1%
Samples	1	12.61			
Scarif. treatm.	2	2,978.89	57.01XX	5.79	13.27
Scarif. dates	1	2,060.90	39.44XX	6.61	16.26
Sc.tr. x sc.dat.	2	632.21	12.10X		
Error	5	52.25			
Duplicates	12	127.75			
Total	23				

Means and N.D.

Scarif. treatments

0 = 8.4
1 = 40.2
3 = 43.2
N.D.(.05) = 9.28
(.01) = 14.55

Scarif. dates

Sep.8, 1950 = 21.3
Dec.10 " = 39.9

Table 75

Portulaca oleracea, 1949.

Effect of scarification with conc. sulphuric acid on germination of seeds which remained not sprouted after a germination test.

(germination test was given on May 1-8th,1950; seeds were scarified 28 days later).

			Routine tests, Germination %		Additional germin.% after scarif.(1 min.)	
Not stratified	114a	20°C, dark	14	10	26	27
		30°C "	41	42	25	26
		20°C, light	24	27	30	39
		20-30°C "	70	77	9	1
	114b	20°C, dark	5	4	8	16
		30°C "	65	59	19	19
		20°C, light	33	35	21	19
		20-30°C "	80	84	10	12
Strat. Loc. Gr.	114a	20°C, dark	6	5	28	19
		30°C "	46	30	54	70
		20°C, light	20	13	15	39
		20-30°C "	67	73	5	0
	114b	20°C, dark	6	4	27	34
		30°C "	46	68	32	22
		20°C, light	18	31	12	13
		20-30°C "	85	86	0	6
Strat. Loc. Ba.	114a	20°C, dark	5	5	34	31
		30°C "	55	52	13	17
		20°C, light	20	14	17	21
		20-30°C "	69	61	0	5
	114b	20°C, dark	5	5	34	28
		30°C "	57	77	24	17
		20°C, light	21	22	13	12
		20-30°C "	79	83	7	6
Means		20°C, dark	5.8		36.0	
		30°C "	53.0		21.2	
		20°C, light	25.2		20.7	
		20-30°C "	76.2		5.1	

Table 76

Brassica arvensis, 1949.

Scarif. minutes	Observed 110		111		Transformed 110		111	
0	8	13	16	14	16.4	21.1	23.6	22.0
1	31	43	55	46	33.8	41.0	47.9	42.7
2	36	43	60	71	36.9	41.0	50.8	57.4
4	37	42	69	73	37.5	40.4	56.2	58.7

Source	D.F.	M.S.	F.	5%	1%
Samples	1	519.84	11.92**	10.13	34.12
Scarif. treatm.	3	638.34	14.64**	9.28	29.46
Error	3	43.58			
Duplicates	8	11.16			
Total	15				

Means and N.D.

Scarif. treatments

0 = 20.8
1 = 41.3
2 = 46.5
4 = 48.2
N.D. (.05) = 11.23
(.01) = 18.58

Table 77

Brassica arvensis, 1950.

Scarif. minutes	Observed 125		126		Transformed 125		126	
0	2	0	1	1	8.1	2.6	5.7	5.7
1	7	7	10	8	15.3	15.3	18.4	16.4
2	12	8	14	11	20.5	16.4	22.0	19.4
4	31	27	37	27	33.8	31.3	37.5	31.3
6	37	40	50	44	37.5	39.2	45.0	41.6
8	51	61	66	69	45.6	51.4	54.3	56.2
10	59	65	71	75	50.2	53.7	57.4	60.0

Source	D.F.	M.S.	F.	5%	1%
Samples	1	90.00	13.80	5.99	13.74
Scarif. treatm.	6	1,413.62	216.81**	4.28	8.47
Error	6	6.52			
Duplicates	14	6.13			
Total	27				

Means and N.D.

Scarific. treatments

0 = 5.5
1 = 16.3
2 = 19.5
4 = 33.5
6 = 40.8
8 = 51.9
10 = 55.3
N.D. (.05) = 3.37
(.01) = 5.00