TREATMENTS FOR INCREASING THE GERMINATION OF GLADIOLUS CORMELS

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THE 1940 GLADIOLUS INVESTIGATION FIELD PLOTS

on the Oregon State College Experiment Station

Connected With

A Study of Treatments for Increasing the Germination

of Gladiolus Cormels

TREATMENTS FOR INCREASING THE
GERMINATION OF GLADIOLUS CORMELS

INTRODUCTION

The production of gladiolus corms and flowers in Oregon has developed in recent years to a point where it is one of the more important speciality crops in a rapidly developing nursery stock industry. In 1939, over 635 acres of gladiolus were produced in the state of Oregon, with a cash farm income value of $326,000. This phenomenal growth in the gladiolus industry in Oregon has been due mainly to the natural adaptation of this flower to Oregon's climate, and to the development of certain localities favorable to its intensive production.

Although flower production and marketing serve as an added source of income to these producers, the principal return from the plantings is in the form of the vegetative corms used for propagation purposes. One of the chief outlets for Oregon grown gladiolus is the Florida market, where the corms are grown only for the flower spike, which is shipped into the populated areas of the east as a cut flower. This practice has popularized the flower of the gladiolus to the extent that it has become one of the most widely used flowers in the trade. Its inherent keeping qualities as a cut flower, coupled with the wide diversity of colors and types developed by systematic breeding, has given it a wide variety of uses in floral decoration.

Closely following the development of any intensive agricultural enterprise are the problems relating to disease and cultural methods. Although considerable work has been done along both of these lines in the eastern gladiolus sections, there has been very little work done in Oregon in the way of systematic research. Considerable attention has been given to the disease problems by the Oregon Experiment Station, but cultural methods have been more or less left up to the individual growers, who have worked out their present methods more or less by trial and error. This paper is to deal with some of the preliminary work which has been started by the Oregon Experiment Station along the line of these cultural problems.

Scope of the Investigation

A review of the literature on the subject of gladiolus culture reveals much interest in the investigation of methods for propagating this flower from the small vegetative cormels. These small cormels are planted in much the same way as seed is sown in the production of certain farm crops. The commercial growers depend on the small cormel stock for increasing their supply of salable corms. It has been realized for some time that the germination, particularly in some varieties, is unsatisfactory under present commercial conditions. This has presented a problem not only of practical importance but also of scientific interest.

A number of treatments have been devised by various investigators endeavoring to increase the germination of these cormels. Most of these treatments, however, would not be practical on a commercial scale or have not been applied under field conditions.

The present study was undertaken, therefore, to compare the effectiveness of the existing treatments, and at the same time to endeavor to establish new treatments which might have commercial possibilities in the future.

HISTORICAL REVIEW

It was realized early by fanciers of the gladiolus flower that the small cormels used for increasing their planting stock had a naturally hard shell, inherited from its distant ancestor from Africa. They observed also that the various varieties differed in this respect, that some had a more impervious covering than others--which apparently affected germination. The early treatments for increasing the germination of these vegetative bodies centered around means for breaking down this impervious coat and thereby increasing the germination.

Work during the last decade has shown conclusively, that there are factors other than mere seed coat structure that influence the germination of these cormels. That these cormels go through a rest period of varying length is well established. Of late another interest in cormel treatments is that of the effect of fungicial dip treatments on the viability of the cormel afterward. Little work has been done as yet on this latter problem, but indications are that it may prove of decided importance in the selection of materials to be used in controlling gladiolus diseases.

Influence of the Cormel Coat

C. E. Gersdorff (11) in 1920, reports results obtained from peeling gladiolus cormels to increase germination. He peeled 59 varieties of cormels, and observed a wide range in germination between the varieties and within the varieties. Dr. Spencley (26) increased the germination of hard shelled cormels by use of a warm water bath for short periods, followed by a 24-hour soak in Semesan. He recommended that the heat treatment be not prolonged, and that planting immediately after treatment be practiced to avoid rotting of the cormels.

Post (24) at Michigan State College in 1930, reported a number of treatments to aid cormel germination. His results showed a great advantage in a 3-day soak in water. The number of cormels to germinate in each variety was considerably more, excepting the variety, Mrs. F. Pendleton, where a 5-day treatment produced greater germination. The use of sulfuric acid ranked high, while a hot water treatment, he found, did not appear desirable since it materially reduced germination.

H. E. Jones (16) devised a simple method for increasing bulblet germination. His treatment consisted of soaking the cormels for 72 hours under warm conditions, then transferring them to moist germinating cloths placed in a box at 85 to 90 degrees F.. J. B. Maple (21), also, confirms Jones' method of attacking the problem by using the shucked "rag-doll" method.

Starrett (27) reported a different method of attack, that of fall planting of the cormels. He found that fall planting of the cormels resulted in better germination, due to the action of the weather on the hard husks. Little work has been done since to confirm these observations.

The use of sulfuric acid to break down the impervious hard coat of the cormel has been reported from time to time. Laurie (18) reports results obtained from its use. By dipping the cormels in commercial strength sulfuric acid (75% pure) for 10 minutes, he found that he could increase germination from 25 to 50 per cent. Similar results have been reported by other workers using acid on seeds having hard coverings.

Some of the more recent work on cormel treatments for increasing germination has been carried out by Shoemaker and Adamson (25) at the University of Alberta. They conducted experiments to determine the effect of two pre-planting treatments, namely, scarification and soaking in water. Scarification was effected by breaking the husk between the fingers. With naturally rapid germinating varieties, soaking proved the best treatment, while in the case of cormels having comparatively tough seed coats (hence, germinating rather slowly) scarification produced the best results. They found a correlation between ability to germinate readily and ease in propagation, and that the best index of the ability of a cormel to germinate readily is undoubtedly the appearance of the cormel coat.

Influence of the Rest Period

The small cormels used in propagating the gladiolus are very dormant in the autumn and early winter, some varieties even retaining this condition into the growing season. The slowness of germination and low percentage of germinations obtained from many varieties have been a source of annoyance and financial loss to the growers. For this reason, much of the work on cormel germination treatments have centered around the matter of rest period breaking. A number of workers have endeavored to overcome this factor both by chemical and by storage treatments prior to planting.

Chemical treatments. Among the chemical treatments used in breaking the rest period in gladiolus, and thereby indirectly increasing total germination, has been the use of ethylene chlorhydrin. Apparently, the first reported results obtained from this chemical are those of Haber (14) in 1926. Using 1 to 2cc of ethylene chlorhydrin per liter of water, he found that soaking for 2 hours gave good results in stimulating the bulbs into earlier growth, provided the bulbs were planted immediately afterward. He concluded from his results that there is a close delicate balance between stimulation and toxicity in using these materials, and it becomes necessary, therefore, to work out particular concentrations for each particular type of bulb.

The work of Haber was followed in 1928 with a paper prepared by Miller (22), in which he reports the results obtained from treatments of gladiolus using various gases, namely, ethylene, propylene, and ethylene chlorhydrin. He found upon reuniting corms, which had been cut into halves, (one half being treated, the other used as a control) that the ethylene and acetylene gases greatly hastened germination or sprouting of the bulbs. Propylene and ethylene chlorhydrin, as well as water soaking, gave negative results. The gladioli responded to heavy doses of the gases only; while potatoes failed to stand these heavy concentrations.

Denny (1) in 1928, tried various chemicals including ethylene, acetylene, acetaldehyde, chloroform, ethyl iodide, furfurcel, thiourea, sodium nitrate, and ethylene chlorhydrin for increasing the speed of germination and total germination of gladiolus cormels. He found that ethylene chlorhydrin was the only chemical of this group that would effect the desired results.

After their experiments in breaking the rest period of corms and bulbs, Loomis and Evans (20) suggest that vegetative organs containing stored starch will have their rest period shortened by ethylene, ethylene chlorhydrin, ether, and similar compounds; while organs such as bulbs containing little or no starch will not show the same response. This theory has survived in the work done by these men with tulips, narcissus, and onion bulbs, gladiolus and crocus corms, Irish potato tubers, and apple twigs.

Using ethylene chlorhydrin for breaking the rest period, Denny (2) found that results varied with the variety and with the stage of dormancy at which the treatment was applied. Certain varieties responded to treatments applied within a short time after harvest, while others did not respond satisfactorily to treatments with this chemical until relatively long periods after harvest. One variety was not affected at any stage of its rest period. Of the other treatments tried, exposure to ethylene gas and warm temperature storage were not effective in breaking the rest period of freshly harvested corms, but they showed a favorable effect by increasing germination if applied at a later stage of the rest period.

Weinard and Decker (28), in experiments in forcing gladioli, found that corms may be forced into early growth with certain chemicals such as ethylene dichloride, or ethylene chlorhydrin, but found that such treatments were not easily standardized and might be ineffective or even injurious to the corms.

The direct effect of these gases, particularly ethylene chlorhydrin, on the physiological activity of the gladiolus corm is reported by Guthrie, Denny, and Miller (13). They found that treatments with ethylene chlorhydrin produced an increase in the peroxidase, catalase, and sulphydryl content and in the pH value in both the dormant and non-dormant corms of gladiolus.

Denny (3) determined the most pronounced effect of ethylene chlorhydrin vapors upon the chemical composition of the corm was with respect to the reducing sugars; the treatments in some cases causing a decrease in this element almost to nothing. Sucrose, however, was higher in the treated than in the control series. The treatments caused increases in the soluble and decreases in the insoluble nitrogen content.

The interesting point in these results is the fact that the responses are not the same as those found when treating potato and lilac. The chemical composition of the latter was changed in some cases in the opposite direction from that of gladiolus, making it impossible to establish any general biological explanation for the stimulating effects on germination.

More recent work by Denny and Miller (8) has shown that not only the large corms but also the small dormant cormels may be hastened in germinating by vapors of ethylene chlorhydrin. With some varieties a gain of from 60 to 90 days was noted in the time required to reach a certain stage in germination. Still other varieties showed gains of from 100 to 180 days. The amount of gain was largest, not in tests made immediately after harvest, but in those made at somewhat later periods. The lower values for days gained in the earlier treatments was attributed to the greater dormancy of the cormels and in the later periods to their lack of dormancy.

Continued trials by Denny (5) in 1937 further substantiated the earlier investigations and, at the same time, call attention to the importance of storage temperatures when treating cormels with ethylene chlorhydrin. Some varieties showed large increases by treatment after storage under either cold or normal room temperatures while others responded to the treatments only after cold storage. That the large corms respond in a similar manner as the cormels is shown by the results which Denny obtained (6) in 1937 and (7) 1936 in a retrial of the above work using the large stock.

Of the investigations made by various workers on the rest-period-breaking qualities of ethyl chlorhydrin, few have failed to observe at least some degree of stimulation from this particular chemical. Gilbert and Pembler (12), however, in attempts to hasten germination of winter forcing stock by exposure to ethylene chlorhydrin fumes, obtained negative results from such treatments. Whether this was due to improper concentrations is not reported. It might be stated here that, of all the results of treatments presented in this paper, none show more promise than those resulting from the use of ethylene chlorhydrin. This is especially true when one considers the possibilities for practical application.

Results obtained from the use of chemicals for breaking the rest period of gladiolus have been reported by Harvey (15) in 1927. For 6 days before planting he treated the corms with air, ethyl ether, chloroform, and ethylene;

which gave germinations of 5, 100, 80, and 80 per cent respectively 32 days following planting in soil. Six days was found sufficient to give the desired stimulation.

Moore (23), in studies relative to breaking the dormancy in tulip bulbs, failed to secure any positive results from use of sulfuric ether fumes, hydrogen peroxide, potassium chlorate, Javelle water, or potassium nitrate. Attempts at breaking the rest period by immersing the bulbs in warm water were also fruitless, unless the bulbs had previously been exposed to low temperatures.

Influence of Storage Conditions

Means other than chemical treatments have been resorted to in attempting to break the rest period and increasing the germination of bulb-like structures. Moore (23) found that, when Pride of Harrlem tulip bulbs were exposed to cold storage temperatures, a shortening of the rest period resulted. Bulbs which were never exposed to temperatures below 25 degrees C. appeared incapable of normal development. Catalase activity was greatest in bulbs stored at from 1 to 6 degrees C., and was least in those held at high temperatures without previous exposure to cold. Low temperatures increased the sugar content of the bulbs, at the same time decreasing that of starch.

Early germination in gladiolus corms was obtained by

Loomis (19), after heat treatments in storage. This was obtained by temperatures from 25 to 40 degrees C., depending on the length of the storage period. The milder temperatures with longer storage was recommended to avoid possible injury to the corms. Sucrose was found to increase in these treatments using high storage temperatures. This result was not the case where cormels were tried for forcing.

Denny and Miller (9) report low temperatures, 3 to 10 degrees C. for 60 to 90 days, as effective in shortening the rest period of gladiolus cormels, and were distinctly more favorable than higher temperatures such as room temperatures, 29 degrees C. to 35 degrees C. Storage at 35 degrees C. gave germinations earlier than at room temperatures only in the later stages of the rest period.

The above results are further substantiated by the results obtained by Denny (4) in later investigations. Even 3 weeks storage at low temperatures hastened the germination of most varieties of gladiolus corms used.

The latest cormel germination experiments that have been reported are those of Klein and Laver (17) during 1940. In two successive years, cormels of several varieties of gladiolus were subjected to direct sunlight for different periods, with total darkness as the control. In both years the speed of germination was hastened by sunlight exposure prior to planting. A 2-hour period gave the best results, with 5 hours almost as beneficial. In one variety, Pasteur, a naturally poor germinator, germination was increased by exposures up to 15 hours, the longest light treatment given. With most varieties, long exposure decreased germination. These investigations may explain the beneficial results obtained by certain Oregon growers, who found that by putting their cormels out in the sun previous to planting, they could increase the percentage of germination.

Using the work of other investigators as a background, it was hoped by the following investigations both to check previous work done and also to establish possible new treatments which might be of practical value to the gladiolus growers of the state. The work was to act also as a check on possible fungidical treatments for the control of disease and the relation possible between treatments of this type and cormel germination.

METHODS OF PROCEDURE

One of the weaknesses noted in results obtained by previous workers was the great variations in germination, that were obtained with gladiolus cormels. It was thought necessary therefore, in the cormel germination work to have sufficient replications of each treatment to care for some of the chance errors in such determinations. Analysis of variance calculations were applied also to each set of results in order to determine the significance of the treatments.

A set method was used for each series of treatments, which made it possible to use printed forms for recording the results. This also facilitated the planting of the cormels, so that there might be the least possible variation from one series to another.

Each treatment within the series was made up of 100 cormels, which were divided upon planting into 10 replications of 10 cormels each. The cormels were sized by passing them over screens made of galvanized wire of varying sizes. The cormels were graded into three sizes, namely, 1's, 2's, and 3's; these sizes depending upon whether they would pass through number 3, 4, and 5 mesh screens respectively. The size 2 cormels were used in most treatments, since it was found that this size was most representative of normal field plantings.

All cormels used in any one series of treatments were collected from one grower's stock to eliminate the variations due to handling and storage conditions. In all cases the stocks used came from the same lots in the storage houses, to further control any differences that might exist there.

The treated cormels were planted in ordinary greenhouse flats in a uniformly mixed soil. Each flat was marked with a specially made marker to give 13 rows to the flat with 10 places marked off in each row for individual cormels. (See Figure 2) This made it possible to plant one replication of the 13 treatments to each flat. The cormels were placed in the depression left by the marker and a measured layer of fine sand was sprinkled to a uniform depth over the cormels.

The rows were marked with a painted label, to show the position of each replication in the flat. (See Figure 3) To facilitate note taking, the number on the label corresponded to the number of the treatment. A systematic system of replication was used in order that records of a large number of treatments could be taken rapidly. This systematic method of rotating the replications in each flat resulted in a distribution of the replications in practically every possible position in the flats.

The plantings were watered as uniformly as possible, even though there were sufficient replications to take care of any possible variation due to moisture conditions.

Germination records were taken at varying intervals during the two months that the series were run. The germination counts were tabulated on specially prepared forms which were designed to make statistical analysis of the data as easy as possible. By using a uniform set of tables for each series of treatments, much of the chance error was removed.

Figure 2. A section of flats used in the germination studies, showing method of arranging treatment replications and flats.

Figure 3. Close-up view of flats showing arrangement of row treatments with germinating cormels.

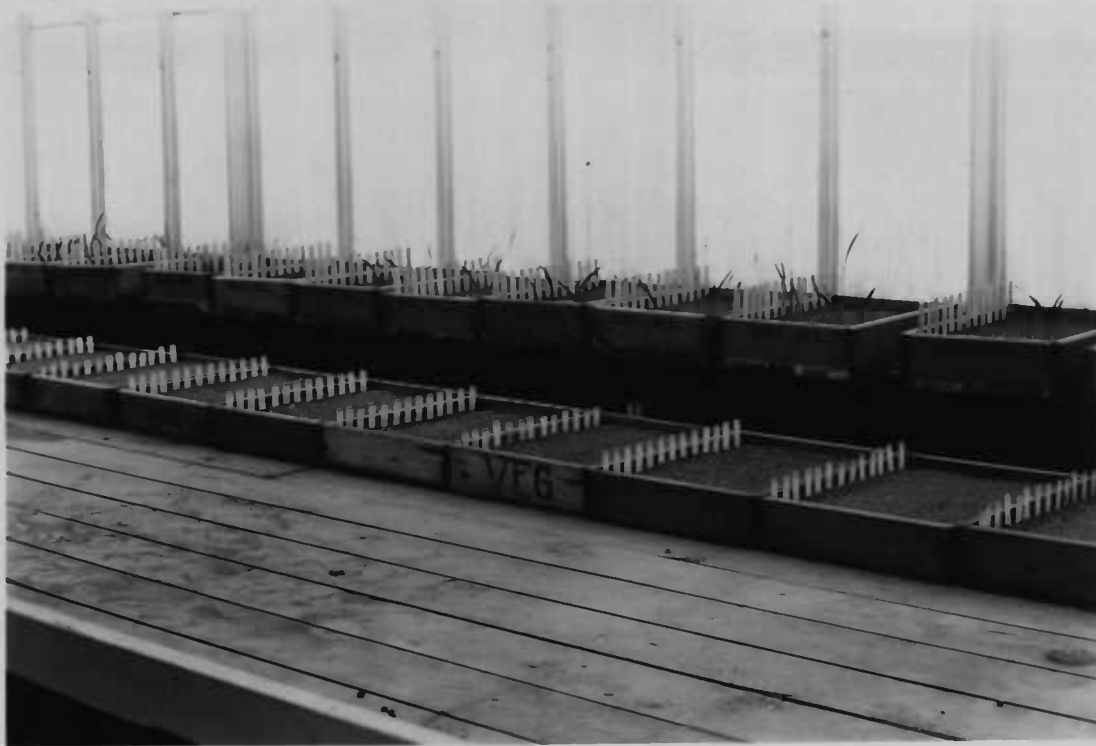

Figure 2

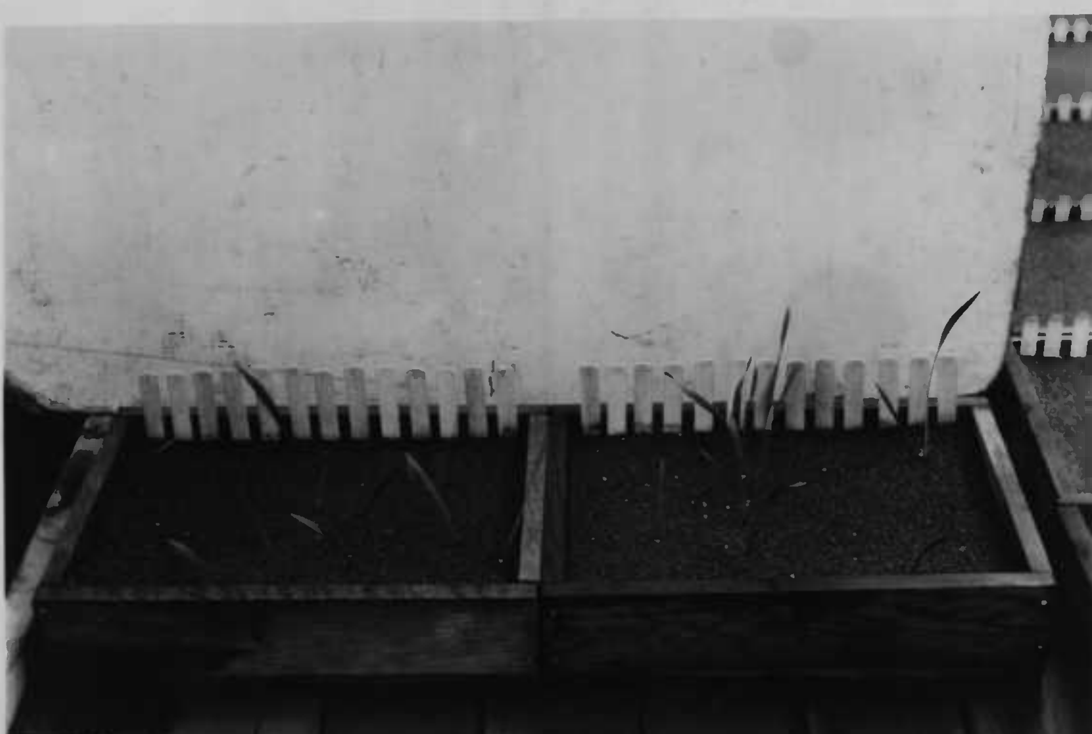

Figure 3

Controls

In each series of treatments, a number of checks were used to determine the normal germination when no treatment was given. Two types of controls were used, one being given a 24 hour soak in water called a wet check, and another to which no treatment was given, designated as a dry check. It was thought, that this would provide a means for checking treatments in which water solutions were used.

EXPERIMENTAL DISCUSSION

Normal Cormel Germination

It has been observed for some time that field germination of gladiolus cormels was quite varied, depending upon the variety in question. In order to approach some estimate as to the normal or average germination of some of the well known varieties, a number of untreated lots of these were planted to obtain this data. It was hoped in this way to establish normal germination figures for conditions under which the treated cormels were to be grown. These resultant figures impress one more fully of the necessity for treatments to increase the germination of certain varieties, while others apparently have quite satisfactory germinations without treatments.

The results of this study are shown in Table 1, where the varieties are listed in order of total percentage germination, both for cormels from bulb stock and for bulblet or cormel stock. The cormels from bulb stock are those from large corms when harvested, while cormels from bulblet stock are those from small cormels on harvesting. The difference, of course, is in the age of the stock from which they came.

A study of Table 1, shows a great variation in the germination of various varieties, with such varieties as Veilchenblau, Bill Sawden, Milford, and others being quite low as compared with high germinating varieties such as Golden Cup, Gate of Heaven, and others. No varieties, however, show anywhere near perfect natural germination, further strengthening the argument in favor of treatments for increasing cormel germination. The normal stages in gladiolus cormel germination are pictured in the photograph in Figure 4.

An interesting observation, in passing, is the difference between the germination of the Minuet cormels from two season's crops. Those harvested in 1938 and held over a year without planting show a substantial gain in germination over those of the 1939 crop, not given the extra year of rest.

The other outstanding fact shown by this study is the

Figure 4. Normal cormel germination, showing development of fibrous roots, shoot, and later formation of large succulent taproot.

Figure 6. Enlarged cormel from Figure 5 (second from left) with husk removed, showing blighted shoot section with development of an adventitious shoot at the point of normal root origin.

Figure 5. Husked Dr. Bennett cormels after third week of the germination period, showing one of the gladiolus diseases destroying the cormel. (One of the causes of poor germination and plant development)

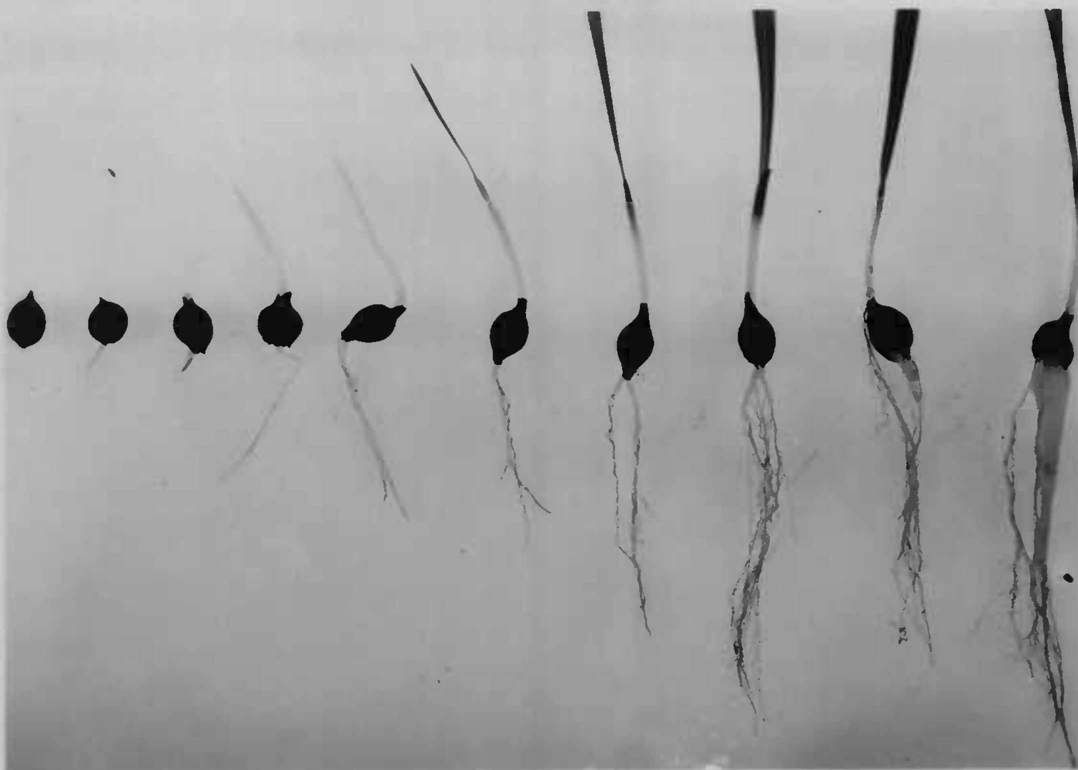

Figure 4

Figure 6

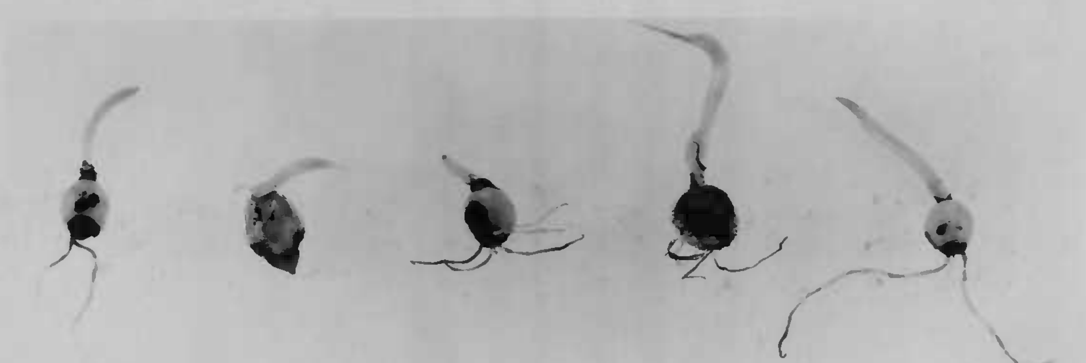

Figure 5

difference in speed of germination found between the cormels from bulb and bulblet stock. Those from cormel stock, although apparently not resulting in any higher total germination, germinated more rapidly than the average of the cormels from bulbs or older stock. This difference has also been reported by growers, who have observed a difference in total germination in favor of those cormels from bulb stock, although they were a little later in germinating. This is probably a matter of difference in thickness of cormel coat and amount of stored food material; one, in favor of the bulblet stock in one case, and the other in favor of the bulb stock.

From the data obtained and recorded in Table 1, it was thought desirable to use cormels of Veilchenblau, Bill Sawden, and other varieties normally low in germination. It was considered that these would probably show greater response to any beneficial treatment.

Preliminary Treatments

In order to obtain some idea as to the effectiveness of treatments already recommended by previous workers as well as new and untried treatments, a series of treatments was run with this in mind. Since, fungidical dips are more or less standardized as to concentration etc., these were included in this series of treatments to systematically check the desirability of using the various ones as to their effect on germination.

The treatments were made in January using cormels of the Dr. Bennett variety. Records on germination were taken at intervals during a period of two months. The results obtained from the various treatments are recorded in Table 2, showing the trend of germination and the final total germination. The replications are totaled together to give this total germination figure in the table. The analysis of variance results are given at the end of each table to show treatments resulting in germinations significantly greater or smaller than the check or control series. This method is used throughout this paper in presenting the results.

Husked cormels. From a study of Table 2, the effect of the cormel husk on germinating ability of the cormel is readily seen. As compared with the highest control of 38 per cent germination, the shucked lot was 61 per cent. This was later found to be the case in all treatments. The mechanical barrier formed by the husk against the processes of germination is illustrated by the enlarged cormels pictured in the photograph in Figure 8. The 3X enlargement shows small rootlets unable to penetrate the impervious husk, and are therefore pressed into small ribbons of tissue by the pressure developed. This question of the influence of the husk in the processes of germination will be taken up in more detail in later discussions.

Fungicidal dips. The data presented in Table 2, definitely shows bi-chloride of mercury to be an undesirable treatment for gladiolus diseases, since it retards and lowers the total germination of the cormels. Statistical analysis verifies this statement. Lye and cresol treatments, while not showing as high germination as the dry checks, cannot be proved statistically detrimental to germination from the amount of data presented. Further work should be carried on with these materials however, since, there is a possibility they may prove to have harmful effects on germination. Figures 5 and 6 show the necessity for these or similar treatments in controlling disease and indirectly favoring better germination.

Temperature treatments. Preliminary treatments using fluctuations in temperatures did not produce any positive results, but did present negative or detrimental results in the case of a 2 weeks treatment at 85 degrees F.

In the case of temperature treatments in which the cormels were subjected to fluctuating temperatures by storing for short periods under different temperature conditions, it appears that the treatment of cormels at 85 degrees F. for 1 week followed by a cold treatment for 1 week at 30 degrees F. is not as satisfactory as are other treatments in the series. Although, statistically, not significantly lower in germinating ability, the treatment does show a tendency toward less total germination than do the treatments in which the cold storage was given prior to the heated storage, or where cold storage alone was given.

The results from these preliminary trials were enough to suggest the possibilities of fluctuating temperatures in influencing the germination of gladiolus cormels, whether it be detrimental or stimulating in its effect. For this reason a series of treatments were outlined to more closely check the factor of storage temperature as it is related to subsequent cormel germination.

Hot water treatment. Included in these preliminary treatments was a series of cormels soaked in water brought to the boiling point. The cormels were added to the boiling water, which was allowed to cool naturally, immediately upon adding the cormels. The cormels were allowed to remain in the water for 16 hours, similar to the ordinary water soaked controls.

A survey of the results in Table 2, will show this particular treatment to be unsatisfactory. An examination of the cormels, after a period of time, showed severe killing and subsequent rotting as a result of the treatment.

Preliminary chemical treatments. Previous investigators have reported beneficial results, in both hastening and increasing total germination, by using a concentrated solution of sulfuric acid to corrode and otherwise break down the impervious cormel coat. A preliminary treatment was included, using a 10 minute soak in 75 per cent sulfuric acid, which was reported as successful by Laurie (16). The cormels were immersed in the solution for the allotted time and were then immediately removed and washed in running water to prevent further action of the acid.

The results from this treatment, as recorded in Table 2, show no increased total germination, but it is interesting to note that in the earlier stages of the germination period, there was a tendency for those that did germinate to do so earlier. It was felt that this treatment deserved further trial using a wider range of concentrations and time limits.

Ethyl alcohol and sodium thiocynate were included also in these preliminary trials but proved of no consequence within the safe range of concentrations used. Sodium thiocynate has been reported as effective in hastening the sprouting of dormant potato tubers. These chemicals as well as others may have possibilities in hastening the germination of gladiolus cormels, but the scope of these investigations was such that it was impossible to include all of them.

Other chemicals, including ethylene chlorhydrin, were included in this series of treatments, but were not effective at the particular concentrations used. As will be shown later, the reason for the failure of the ethylene chlorhydrin was the concentration of the solution. There proved to be a narrow margin between toxicity and stimulation. The outstanding results obtained by Denny, made it desirable to follow up his work with possible applications to large scale use.

Sulfuric Acid Treatments for Hastening and Increasing Total Germination

The use of sulfuric acid for increasing the germination of various seeds and seed-like parts of plants has been going on for some time. In the review of literature on cormel treatments, it was recorded as being used on gladiolus cormels as well. For this reason it was believed desirable to make a more complete study of this type of treatment and determine, if possible, how it might compare with other less severe treatments. The use of such strong concentrations of acid might be questionable, when it comes to applying such treatments on a commercial scale.

The first series of sulfuric acid treatments was made using one concentration of acid for various lengths of time, to determine how long the cormels would stand these high concentrations of acid. Using 70 per cent sulfuric acid, different lots of cormels were immersed for 30 minutes, 1 hour, 2 hours, and 3 hours respectively. After the acid soak, the cormels were washed thoroughly in running water to remove the excess acid and stop its action on the cormel.

The results of these treatments as compared with water soaked and dry controls are recorded in Table 3. It is apparent from these figures, that even a 3-hour soak in 70 per cent sulfuric acid did not have any detrimental effects, nor was it apparently increasing the total percentage germination of the cormels. However, the 2 and 3-hour treatments resulted in significantly higher germinations than did the average of the wet and dry checks. This is not the case, however, when only the three dry checks are taken into consideration; since, each of the dry checks resulted in germinations as high or higher than the two acid treatments.

It is of interest, to note at this time the difference between the germination percentages of the wet and dry checks in favor of the dry controls. This consistent tendency for more of the dry check cormels to germinate than the water-soaked lots in the same period of time will be discussed later in the paper. It is needless to say that this is rather remarkable, since usually water-soaking is considered to be an advantage in increasing the percentage germination of most seeds with hard coats.

The second series of acid treatments was designed to increase both the concentration and time of treatment in the acid, since it was apparent in the foregoing series that the possible limits of safety had not been reached. In this series two concentrations of acid were used, namely, 70 per cent and 95 per cent sulfuric acid. The cormels were treated from 5 to 30 minutes in the case of the higher concentration, and for periods of from 3 to 12 hours in the weaker concentration.

The results from these various treatments are found in Table 9. The cormels used were of the Veilchenblau variety rather than Dr. Bennetts, since, it was found during the interval between the two series of treatments, the germination of the Veilchenblau variety was even a greater problem than was the germination of the cormels of the Dr. Bennett variety. It must be realized also, that it is impossible in any of these treatments, even though the same variety be used in both series, to compare two series as far as percentage germination is concerned. The difference in dates of planting has a marked effect on germination, due to the rest period or other factors. This problem of rest period in gladiolus cormels will be discussed further under treatments influencing it.

From the data recorded in Table 9, it would seem that treatments of 30 minutes in 95 per cent sulfuric acid are as effective in increasing germination, as is a treatment of 8 hours in 70 per cent sulfuric acid. Both of these treatments as well as a 12-hour soak in 70 per cent sulfuric acid are effective in materially increasing the germination of the Veilchenblau cormels. It would appear that the 12-hour treatment might be too long, since it shows significantly poorer germination than the 8-hour treatment.

The effect of these sulfuric acid treatments, undoubtedly, is that of breaking down the more or less impervious cormel coat, thereby allowing oxygen and moisture to come in contact with the cormel embryo. That there is possible toxic effect, also, from the acid is shown by the fact that the shucked check lot in the series resulted in significantly better germination than any of the acid treatments.

The fact, that the more concentrated acid is more effective in a shorter time of treatment leads to the possibility of longer treatments at those concentrations. It seems reasonable to suppose that it is necessary in using acid for removing the husk, to use concentrations that will quickly remove the husk without long soaking periods, which invite acid injury, due to long contact.

Variety responses to acid treatment. In order to determine the variety difference as related to sulfuric acid treatments, a number of varieties were treated with a uniform treatment of sulfuric acid. Since a check was being made at the time as to normal cormel germination of a number of varieties reported earlier in this paper, these acid treatments were made at the same time in order to have controls against which to check the effects of the treatment. A 3-hour treatment in 70 per cent sulfuric acid was used, since this particular treatment at the time was thought to be safe enough. It is well to mention, however, that when the previous treatments were made using this concentration and exposure, the cormels were not dried out as much possibly, and few cracks existed in the husks.

The results obtained from these tests are found in Table 1, with the data on normal cormel germinations. One glance at the figures in this table suffice to show the complications which must be faced in trying to establish a standard treatment for gladiolus cormels. Out of the 10 varieties treated with 70 per cent sulfuric acid for 3 hours, only two failed to show definite harm from the treatment. These two varieties, Veilchenblau and Picardy, show some indications of being benefited.

The outstanding indication shown by this data is the apparent positive correlation between the normal germination of these varieties and the amount of acid injury shown from such a treatment. It would seem that the higher the normal germination of the variety, the more apt it is to be injured by prolonged acid treatments. This is due possibly to the fact that the higher germinating varieties have a thinner, more or less broken husk which both facilitates quicker, higher germination and also allows acid injury by contact of the acid with the embryo. Veilchenblau, Picardy, Milford, and others have far heavier husks with fewer openings than the higher germinating, acid-tender varieties, such as Berty Snow, Golden Cup, and Gate of Heaven.

It would seem that the low germinations in the case of thin, more or less broken-husked varieties are not a result of the husk factor alone, and the cormels are less likely to respond favorably to acid treatments for breaking down this husk, but are more apt to show severe injury to germinating ability. However, data presented in Table 9, conclusively shows the benefits of sulfuric acid treatments to the hard, well-sealed husks of varieties such as Veilchenblau.

The use of acid, therefore, as a treatment for hastening or increasing the total germination of gladiolus cormels, is limited to certain varieties or to concentrations adapted to each. It is a question whether the use of acid would be practical on a commercial scale, since it apparently has these obvious limitations. From data presented, it seems that the husk factor alone is not responsible for the low germinations of certain varieties of gladiolus cormels, but also that other factors have their effect. This is shown by the fact that husked cormels used as controls, although showing considerably higher and more rapid germinations, do not approach perfect germination. That acid treatments for correcting this husk factor are far from effective is shown by comparing the germinations of husked controls with those of acid treatments. The acid treated lots do not approach the husked lots in the percentage germinating.

Further work should be done with higher concentrations of sulfuric acid for shorter durations, since indications are that it is best to make the acid treatments short, and thus avoid soaking of the acid into vital parts of the cormel.

Influence of Cormel Size on Germinating Ability

The very nature of the cormel's development results in a wide variety of cormel sizes being produced. The cormels are formed around the base of the newly developing corm, and new ones continue to develop throughout the growing season, which results in cormels in all stages of size and development at harvest time. It has been a question whether these cormels which are harvested at various sizes have the same germinating ability, since it is apparent that some have a larger food reserve than others and possibly more nearly approach maturity. The thickness of the husk is also a factor to be considered.

Going into the problem purely from the standpoint of germinating ability of the various cormel sizes, the writer endeavored to determine if the larger cormels really show a higher total germination and result in larger more vigorous seedling plants. Figure 4 shows a photograph of the stages in the development of a normal gladiolus cormel of average size.

The cormels used in the trial were of the Dr. Bennett variety and, since the results were so obvious, the test was not continued with other varieties. To substantiate any recommendations, further trials should be made using a number of varieties, but greenhouse space would limit the number of trials that could be made in these preliminary studies. The cormels were graded into three sizes using galvanized wire screens. The sizes were designated as 1's, 2's, and 3's; the number 1's being the largest size. The very minute cormels passed through even the smallest screen and were therefore discarded as of no practical importance. The cormels were planted in replications identical to the

Figure 7. Influence of cormel size on germinating ability. Dr. Bennett cormels two months after planting. Rows from left to right--large cormels (No. 1's), medium sized cormels (No. 2's), and small cormels (No. 3's).

Figure 8. Cormels after being in the germination media for one month, with husks removed to show the effect of the hard, impervious husk on rootlet structure and development. Husk has prevented the emergence of the roots and the pressure has cuased them to be flattened into ribbons which are apparently still functioning.

Figure 7. (Above) Figure 8. (Below)

methods used throughout the investigations.

Table 4b, and Figure 7, give the results obtained in both record and picture form. A study of the data in this table clearly substantiates a popular belief among gladiolus growers that cormels should be drastically graded as to size. The large cormels are apparently not only quicker to germinate, but possess higher total germination ability than do the smaller sized cormels, to say nothing of the vigor of the resulting seedlings as shown in Figure 7. It appears from this small amount of data, that there is little difference in the germinating ability of the smaller sizes after the step down from the number 1 size, although the trend seems to be toward less satisfactory germination as the size decreases.

These figures point the way to possible returns from proper sizing and grading of the cormels which are the grower's increase-stock. It will be noticed, however, that even the number 1 cormels, with 72 per cent germination, are still considerable below a desirable germination percentage. It cannot be said, therefore, that cormel size is the answer to the problem of gladiolus cormel germination.

Ethylene Chlorhydrin Treatments

In these preliminary studies of treatments for increasing cormel germination, no chemical treatment showed more promise than did the use of ethylene chlorhydrin. Denny's results were so outstanding, with ethylene chlorhydrin, that it was thought that this chemical might have practical value under Oregon conditions. Unlike sulfuric acid, ethylene chlorhydrin vapors can be used without any of the complications that are associated with the use of concentrated acid solutions.

The first series of treatments made using ethylene chlorhydrin were made following Denny's reported concentrations and time treatments. These treatments proved to be a failure, since in all cases they were toxic to the cormels. It became apparent to the writer, that there was a narrow margin between toxicity and stimulating effect from use of this chemical. The work, therefore, became centered around tests of concentrations.

The first series of concentrations that showed any indication of being near the desired strength are shown in Table 4a. These consisted of treatments using 3cc of 40 per cent ethylene chlorhydrin per liter of air space for 1, 2, and 3 days respectively. Only the 100-cormel sample was added to each liter of air space of the container. The toxicity of the vapors for long periods is readily seen on studying the figures in this table.

There was apparently some stimulating effect over the control series from the ethylene chlorhydrin in a 1-day treatment.

The second series of treatments was set up, using both liquid and vapor treatments of ethylene chlorhydrin, in order to establish necessary concentrations and to check the relative effectiveness of the two forms. In the case of both solution and gas or vapor treatments, several concentrations and exposure combinations were used on Veilchenblau cormels.

A 40 per cent solution of anhydrous ethylene chlorhydrin was used in providing the vaporized form in the closed containers. One series of cormels was treated for 1 day with 3cc of this 40 per cent solution per liter of air space, another with 1cc for 1 day and still another with 1cc for 3 days. It was believed that, by decreasing the amount of the chemical used and extending the time of exposure, the narrow margin between stimulus and toxicity might be reduced. The results seem to substantiate this theory.

In the case of ethylene chlorhydrin solution treatments, the concentrated, commercial form was diluted to the desired strength with distilled water. Two concentrations were used, namely, one part of the chemical to 100 and to 1000 parts of water respectively. For each concentration a separate lot of cormels were soaked in the solution for 1, 3, and 5 days respectively. The results from this series of treatments are recorded in Table 9.

The outstanding treatment of the series is apparently the 3-day exposure to 1cc of 40 per cent ethylene chlorhydrin per liter of air space. Not only is this particular treatment far above the highest control in total germination, but is better than any other type of treatment made at that time, outside of the shucked check. It is significant, that the ethylene chlorhydrin treated lot approaches the germination record of the shucked lot. This might suggest the possibility either that the husk is not as important a factor as supposed, or that the effect of the chlorhydrin is partially directed at the husk. The earliness of the germination of the chlorhydrin treated lot is significant, also.

It would seem desirable to go further with this particular concentration (1cc per liter of 40 per cent ethylene chlorhydrin) and give longer exposures than 3 days, since the outstanding results obtained were at this particular time limit, which was the longest period in the series. It is possible that stimulation might be more pronounced at longer exposures. This possibility will be checked in future studies.

Although the treatment of the cormels with water solutions of the chemical did not seem as effective as the gas or vapors, the results recorded in Table 9, show some interesting trends. In the case of the 1-100 concentration of chlorhydrin, there is apparently a negative correlation between the number of days exposure and the resulting percentage germination. It would seem that the concentration was a little on the toxic side, or at least there was no decided stimulus to germination of the cormels.

The concentration 1-1000, however, presents a different picture. Apparently a positive correlation existed between the length of exposure in days and the total percentage germination. With this concentration, the 5-day treatment resulted in germination which was significantly greater than the average of the six checks (both wet and dry). Since, this was the longest exposure in the series, it would seem logical to suppose that longer treatments at this particular treatment hold promise.

The advantages of using ethylene chlorhydrin over sulfuric acid are quite obvious, when one considers the severity of the two treatments, and the greater response in germination obtained from the ethylene chlorhydrin. Some means of standardizing the treatments as to concentration, exposure and size of lot to be treated per unit of space of gas or liquid must be worked out. This will necessarily, have to be determined before any possible practical commercial value can be placed on such a treatment. It might be said though, that this comes the nearest to being a practical method of increasing cormel germination, since the handling operations are comparitively simple.

Effects of Moisture and Temperature Conditions on Germination

In this preliminary study of factors influencing the germination of gladiolus cormels, some interesting observations were made as to the effects of temperature and moisture conditions on germination. The indication that moisture conditions might be an important factor in cormel germination was the outstanding difference noticed between germinations of dry and of water-soaked controls, in favor of the dry checks. This is rather contrary to the usual response of seed-like structures to water-soaking, which ordinarily results in more rapid and higher percentage germinations. Cormels also showed responses to various temperature treatments as well as varying degrees of drying. A treatment of this type which would show substantial increases in germination would be quite desirable on a large scale, since it would not be necessary to use severe chemical treatments.

Dry controls versus water-soak checks. Throughout the various series of treatments, it was noted that the dry checks resulted in consistently higher germinations than did the water-soaked controls. These results may be checked by examining the control lot figures of the various treatments. A complete record of these results, however, is given in Table 5.

These results were so consistent and so contrary to what might have been expected that it was believed worth while to repeat them in order to determine if possible the reason behind them. A series of treatments were set up to check the effects of longer moisture treatments as well as treatments in the opposite direction, namely, treatments having a drying or warming effect. These two types of treatments were obtained by holding in moist sand at room temperatures for 1, 2, 3, 5, and 7 days, certain lots of cormels, and holding others at 35 degrees C. under controlled conditions for the same time limits. A series of controls were also planted with these two series to check the effects of the treatments. The results from these treatments are recorded in Table 6.

That heat treatments of short duration have a stimulating effect on germination is shown by these results. It is also apparent, that prolonged water-soaking under these conditions does not benefit germination, but may materially reduce it. Although the difference in germination between any two treatments does not show much significance when subjected to analysis of variance, there is, apparently, a negative correlation in this table between the moisture treatments and the percentage germination. With one exception, it appears there is a positive correlation between the length of the heat treatments and the number of cormels germinating but this might not be the case if the treatments were run for longer periods.

At this point it is well to point out that, as the season progressed, during which the cormel treatments were being made, the tendency for the dry checks to germinate more readily than the water-soaked checks declined. A point was reached in the late spring and summer months, when prolonged water-soaking definitely hastened germination. In no case can it be said, however, that water-soaking increased the final total germination of cormels. The discussion that follows, on further treatments made along these lines, does not give the reason for these results of dry treatments over water-soaking. A possibility, which has not as yet been investigated, is that of a toxic material in the cormel husk which may be released by water-soaking.

Drying or temperature factor? In order to determine whether the heat treatments were increasing germination, by drying-out the cormel to a certain degree or by merely increasing respiration through increased temperatures, a series of treatments was set up with this in mind. Certain lots of cormels were held under controlled conditions at 35 degrees C., which is considerably above normal room temperatures, for from 1 to 4 weeks. Another series of cormels were held in a closed container over sulfuric acid to obtain approximately the same amount of drying effect (later proved to be the case by weighing samples) for the same periods of time. This procedure was followed with two varieties of cormels, namely, Veilchenblau and W. H. Phipps. The two varieties represent both extremes in respect to normal germination; the Veilchenblau being a very poor germinator, while the W. H. Phipps is a comparatively good germinator.

The husk factor also was taken into consideration in these treatments. This was done by running a duplicate series of cormels, whose husks had been removed, for each series of treatments. It was hoped in this way to determine the influence of the husk on such treatments.

The results are recorded in Tables 7 and 8. The germination record for the Veilchenblau cormels being in Table 7, and those for the W. H. Phipps in Table 8.

<u>Phipps cormels</u>. In the case of the W. H. Phipps cormels, which have relatively thin, open husks as compared with Veilchenblau, the response to warm storage for short

periods is apparently due to increases in respiration, rather than in drying. This seems reasonable to assume, since the cormels dried over acid at room temperatures did not show any significant increase in germination over the checks, while the cormels held in the oven at 10 degrees C. higher temperatures responded with significantly higher total germinations. The responses to these increases in temperature, however, resulted only when the cormels were warmed for a period of at least 2 weeks and not more than 3 weeks. Longer periods apparently caused drying and oxidation of vital parts of the cormels.

As was observed in previous studies removal of the hard husk, in the case of the Phipps cormels, greatly increased germination. Holding these husked cormels under warm conditions for any length of time resulted in decreased germinations, as is shown in Table 8.

Veilchenblau cormels. The Veilchenblau cormels with their hard, well-sealed husks failed to respond to the heat treatments. There was no response of these cormels to varying exposures to warm temperatures, and only an indication that they might respond to drying over acid at lower temperatures.

The removal of the husk by hand caused substantial increases in germination, as was observed in a previous series. Treatment of these husked cormels with higher temperatures only resulted in lower germinations, probably due to oxidation of the exposed tissues.

It would seem from these limited trials using drying and heat treatments, that neither treatment is the answer to the problem of increasing cormel germinations. There is a slight response of cormels to heat treatments in increasing total germination, brought about by increased respiration and other physiological processes, which are partially responsible for satisfactory germinations. The use of heat treatments in increasing the germination of gladiolus cormels would seem to be less promising than do other treatments used in these studies.

Cold Storage Treatments for Hastening and Increasing Total Germination

Of all the treatments used in these preliminary trials none shows more promise in a practical sense than the use of cold storage. Literature on the subject of germination of seed and seed-like organs continually mentions the stimulating effect of varying exposures to cold on the germination of these materials. The effect is apparently one of breaking the rest period that is associated with the seeds of many species. It may have some effect in hastening the after-ripening processes that also are mentioned as necessary in the case of some seeds. Whether both of these conditions are one and the same or are different stages of a prolonged process is yet to be determined and clarified. It remains, however, that many seeds and in this instance seed-like bodies such as cormels, respond to cold storage with increased percentages of germination or sprouting.

The treatments in cold storage were made near the end of the investigations, so are not given as a complete picture of the effects of cold storage treatments on cormel germination, but merely to show the possibilities which such treatments might have if further investigations were made. It is quite possible that such treatments might prove of commercial value, since the treatments could be made with a minimum of care and expense.

In this series of treatments the two varieties, Veilchenblau and W. H. Phipps, were employed. The cormel lots were stored in a controlled cabinet at 35 degrees F. for 1, 2, 3, and 4-week periods. At the end of this time all lots were removed and planted together in flats, as outlined previously for another series.

The data from these treatments are recorded in Tables 7 and 8. The results are most promising and interesting, when one takes into account the type of cormels used and their normal germinations. In the case of the Veilchenblau cormels, apparently a 2 to 3-week treatment is necessary to stimulate germination, while only a 1-week treatment increases substantially the germination of Phipps cormels. The trend seems to be for decreased germinations with increased time exposures over 3 weeks, at this particular temperature.

There is a possibility that slightly higher temperatures for longer periods of time might prove more beneficial to germination than this relatively low temperature. It has been shown by other workers in stratifying seeds that temperatures of around 40 degrees F. are far more effective than temperatures nearer the freezing point.

General Discussion and Conclusions Concerning Cormel Treatment Investigations

Since these investigations were preliminary in nature, with the object in mind of determining what types of treatments might have possibilities for application in a practical and commercial sense, it might be well to summarize the work and determine how near the objective was reached. Any one type of treatment used here, although it might have proved statistically to be outstandingly advantageous for increasing the germination of gladiolus cormels, would have to be extensively tried using various combinations on many varieties before it could be recommended for wide use. This will take far more investigational work than was possible to include in these preliminary trials.

It would seem, however, from these studies that certain treatments have definite promise for further consideration. Additional work should be done with acid treatments at higher concentrations in order to check the possibilities of reducing injury due to prolonged exposures. It is quite possible that secondary treatments might be worked out to counteract the acid, after it has done its job of husk removal. Such elaborate chemical treatments are limited in their application to large scale operations. Treatments less severe and more easily handled might be more applicable and desirable.

Ethyl chlorhydrin has very definite possibilities for increasing the yields of gladiolus cormels. It only remains necessary to work out a practical method of application, using concentrations that have the desired effect over a wide range of variety types and conditions.

The narrow margin between stimulation and toxicity of ethylene chlorhydrin may possibly limit its use, unless careful handling methods are used. It is reasonable to suppose, however, that treatments may be worked out that will be very practical and far more easily applied than the more severe treatments such as sulfuric acid.

The possibilities of cold storage treatments already discussed in this paper need no further discussion. The outstanding results obtained from these beginning trials are enough to warrant their further consideration.

The results obtained in these studies from sizing cormels are enough to recommend this practise to growers, who wish to obtain better stands of more vigorous plants.

Interesting is the fact that higher germination percentages were obtained from dry treatments than from solution treatments. The fact that this did not continue to be the case later in the season suggests further interesting possibilities. The importance of these may influence the form of material used for combating insects and disease such as cormel dips. The time that such dips were applied might also be of material importance.

It might be concluded, therefore, that the treatment of gladiolus cormels to increase germination is not only an interesting scientific problem but also a problem of much practical importance.

TABLES

Table 1

Variety Germination Record of Cormels Planted Without Any Previous Treatment

Variety	Germination Record by Weeks 1st %	2nd %	3rd %	4th %	5th %	7th %	Total Germination %
Cormels from Bulb Stock:							
Golden Cup	0	10	16	34	16	10	86
Minuet 1938 Crop	0	0	7	41	17	10	75
Gate of Heaven	0	6	13	49	3	0	71
Berty Snow	1	3	6	38	6	12	66
Picardy	0	0	3	36	12	14	65
Albatross	1	11	20	25	0	3	60
Dr. Bennett	0	2	7	39	11	1	60
Minuet 1939 Crop	0	0	0	5	12	34	51
Milford	2	8	7	19	2	0	38
Bill Sawden	0	5	6	10	3	5	29
Veilchenblau	0	0	0	2	0	3	5
Cormels from Bulblet Stock:							
King Arthur	2	13	8	32	4	5	64
Selback Orchid	1	7	16	32	2	2	60
Sonatine	11	20	13	10	1	1	56
Debonaire	12	13	11	8	1	0	45

Table 1 Continued

Variety	Germination Record by Weeks 1st %	2nd %	3rd %	4th %	5th %	7th %	Total Germination %	
Cormels from Bulb Stock, Treated with 70% Sulfuric Acid 3 Hours:								
Golden Cup	0	0	1	8	4	2	15	
Minuet 1939 Crop	0	0	0	7	8	14	29	
Gate of Heaven	0	0	6	3	0	0	9	
Berty Snow	0	0	2	11	2	2	17	
Picardy	0	0	3	62	5	3	73	*
Albatross	0	1	9	11	5	2	28	
Dr. Bennett	0	0	3	35	9	0	47	
Milford	0	2	6	11	5	2	26	
Bill Sawden	0	2	0	9	3	5	19	
Veilchenblau	0	0	0	0	1	8	9	*

* Those not showing injury, but possibly some benefit.

Table 2

General Preliminary Treatments of Dr. Bennett Cormels at the Beginning of the Investigations, From 1/12/40 to 3/12/40

Treatment	Germination Record by Weeks 2nd %	3rd %	4th %	5th %	6th %	8th %	Total Germination %	
Fungicidal Dips:								
Cresol 16 hours	2	8	11	6	3	2	32	
Lye 16 hours	4	10	8	1	1	1	25	
Bi-chloride 16 hrs	1	4	3	5	0	2	15	-
Controls:								
Wet Check 1	5	7	8	3	1	1	25	
Dry Check 1	5	11	8	6	3	3	36	
Wet Check 2	7	12	5	3	2	0	29	
Dry Check 2	6	13	11	5	2	1	38	
Wet Check 3	5	4	4	2	1	3	19	-
Dry Check 3	5	13	14	5	1	0	38	
Shucked Check	16	25	10	5	1	4	61	*
Temperature Treatments:								
85° F. 2 Weeks	1	5	6	0	0	1	13	-
30° F. 2 Weeks	0	9	12	7	4	5	37	
65° F. 1 Week 30° F. 1 Week	1	7	7	5	2	1	23	
30° F. 1 Week 85° F. 1 Week	3	14	10	3	2	1	33	

Table 2 Continued

Treatment	Germination Record by Weeks 2nd %	3rd %	4th %	5th %	6th %	8th %	Total Germination %	
Hot Water Soak:	0	0	0	2	0	0	2	-
Chemical Treatments:								
75% Sulfuric Acid 10 Minutes	10	17	6	1	3	0	37	
95% Ethyl Alcohol 1 Minute	7	15	14	0	1	1	38	
Sodium Thiocynate	3	12	4	1	3	1	24	
Vatsol 1-200	0	6	13	2	3	4	28	
Potassium Permanganate 1-500	7	11	6	2	1	3	30	
Ethylene Chlorhydrin Vapors 16 hours	0	0	0	0	0	0	0	-

Difference between total germinations necessary for significance as determined by analysis of variance 12.8

* Significantly higher than highest check.

\- Significantly lower than average of checks.

Table 3

Dr. Bennett Cormels. Chemical Treatments

Treatment	Germination Record by Weeks 2wks %	3rd %	4th %	5th %	7th %	8th %	Total Germination %	
70% Sulfuric Acid:								
30 minutes	7	7	18	4	4	0	40	
1 hour	2	14	12	5	4	0	36	
2 hours	6	11	18	10	1	1	47	-
3 hours	4	9	20	8	5	2	46	-
Controls:								
Wet Check 1	1	1	6	2	0	1	11	
Dry Check 1	3	11	26	8	7	2	57	
Wet Check 2	3	0	6	2	1	1	13	
Dry Check 2	2	9	21	8	5	2	47	
Wet Check 3	0	8	6	5	1	0	20	
Dry Check 3	5	4	27	4	7	3	50	
Water-Soak 1 Week at Room Temperature:	1	2	5	5	6	2	21	
Water-Soak at 45° C.:								
2 Days	0	0	3	2	1	2	8	
3 Days	0	0	0	0	0	0	0	#
5 Days	0	0	0	0	0	0	0	#

Table 3 Continued

Treatment	Germination Record by Weeks 2wks %	3rd %	4th %	5th %	7th %	8th %	Total Germination %
3% Hydrogen Peroxide:							
15 minutes under vacuum	1	2	15	6	4	1	29
Water Check 15 minutes under vacuum	2	4	11	8	2	1	28
95% Ethyl Alcohol:							
1 minute	1	1	10	3	5	1	21
5 minutes	0	2	4	10	3	2	21
15 minutes	3	1	4	1	3	0	12
30 minutes	0	2	3	1	6	0	12
Potassium Permanganate: Solution 1-500 + $10^{cc} H_2SO_4$							
95%-24 hours	2	4	11	4	3	2	26
1-500-48 hours no acid	1	2	5	6	1	0	15
1-500-96 hours no acid	0	4	4	4	5	1	18
Auxin:							
#5-24 hours	0	1	5	5	2	0	13
#5-48 hours	1	1	2	3	2	0	9
#5-72 hours	1	0	0	1	3	0	5

Table 3 Continued

Difference between total germinations necessary for significance as determined by analysis of variance 12.2

* Significantly larger than the average of the controls.

Significantly lower than lowest check.

Table 4

Preliminary Treatments of Dr. Bennett Cormels to Show the Influence of Ethylene Chlorhydrin and Size of Cormel on Germination

Treatment	Germination Record by Date					Total Germination
	4/5	4/17	4/30	5/13	Coming	
	%	%	%	%	%	%
a. Ethylene Chlorhydrin:						
40% Solution used: 3cc per liter and air space						
1 day	2	22	17	15	5	61
2 days	0	3	8	3	6	20
3 days	0	0	3	2	2	7
Control:	2	22	8	11	9	52

1.76 difference between means necessary for significance.

Influence of Cormel Size

Treatment	Date Record					Total Germination
	4/5	4/10	4/17	4/30	5/13	
	%	%	%	%	%	%
b. Dr. Bennett Cormels:						
Size 1's	14	17	23	13	5	72
Size 2's	0	3	13	4	8	28
Size 3's	0	1	6	11	4	22

Table 5

Showing the Effect of Water-Soaking for Short Periods (16 hours) in Reducing the Percentage Germination of Gladiolus Cormels. Data Compiled from Checks Used in All Treatment Series

Series		%	Av. %
I	Dr. Bennett Cormels Planted January 12 to March 12		
	Dry Check 1 Total Germination	36	
	Dry Check 2 Total Germination	38	37
	Dry Check 3 Total Germination	38	
	Wet Check 1 Total Germination	25	
	Wet Check 2 Total Germination	30	24
	Wet Check 3 Total Germination	19	
II	Dr. Bennett Cormels Planted February 24 to April 24		
	Dry Check 1 Total Germination	57	
	Dry Check 2 Total Germination	47	51
	Dry Check 3 Total Germination	50	
	Wet Check 1 Total Germination	11	
	Wet Check 2 Total Germination	13	15
	Wet Check 3 Total Germination	20	
III	Veilchenblau Cormels Planted March 20 to May 20		
	Dry Check 1 Total Germination	9	
	Dry Check 2 Total Germination	13	9
	Dry Check 3 Total Germination	6	
	Wet Check 1 Total Germination	2	
	Wet Check 2 Total Germination	9	6
	Wet Check 3 Total Germination	8	
IV	Dr. Bennett Cormels Planted April 4 to June 4		
	Dry Check 1 Total Germination	35	
	Dry Check 2 Total Germination	25	30
	Dry Check 3 Total Germination	31	

Table 5 Continued

Series			%	Av. %
IV	Dr. Bennett Cormels Planted April 4 to June 4			
	Wet Check 1	Total Germination	28	
	Wet Check 2	Total Germination	22	25
	Wet Check 3	Total Germination	26	

<u>Total Mean Average:</u> Dry Controls = 32%
Wet Controls = 17%

Table 6

Dr. Bennett Cormels Subjected to Drying and Water-Soaking to Determine Their Effect on Germination

Treatment	Germination Record by Weeks						Total Germination
	3rd %	4th %	5th %	6th %	7th %	8th %	%
Drying Temperatures: 35° C.							
1 Day	0	5	7	12	4	3	31
2 Days	2	6	9	11	8	4	40
3 Days	3	7	11	15	9	2	47
5 Days	2	3	10	8	3	1	27
7 Days	5	5	21	12	6	3	52
Controls:							
Wet Check 1	10	2	4	8	3	1	28
Dry Check 1	4	5	9	10	3	4	35
Wet Check 2	6	5	2	5	2	2	22
Dry Check 2	4	2	3	8	5	3	25
Wet Check 3	5	4	7	2	5	3	26
Dry Check 3	6	3	2	9	8	3	31
Soaking in Moist Sand at Room Temperature:							
1 Day	3	8	3	1	4	1	20
2 Days	7	3	3	7	3	0	23
3 Days	3	5	7	4	4	1	24

Table 6 Continued

Treatment	Germination Record by Weeks						Total Germination
	3rd	4th	5th	6th	7th	8th	
	%	%	%	%	%	%	%
Soaking in Moist Sand at Room Temperature:							
5 Days	2	3	4	1	1	2	13
7 Days	5	2	1	6	3	4	21

Difference between total germinations necessary for significance as determined by analysis of variance 33.0

Table 7

Veilchenblau Cormels Subjected to Various Temperature Treatments and Drying

Treatment	Germination Record by Weeks 2nd %	3rd %	4th %	6th %	8th %	Total Germination %	
<u>Cormels Not Husked:</u> <u>Controls:</u>							
Dry Check 1	0	0	2	8	2	12	
Wet Check 1	1	2	0	2	5	10	
Dry Check 2	0	0	1	2	2	5	
Wet Check 2	0	0	1	2	2	5	
<u>Holding in Oven at 35° C.</u>							
1 Week	0	3	1	0	1	5	
2 Weeks	0	0	1	2	1	4	
3 Weeks	0	0	0	3	1	4	
4 Weeks	0	0	0	1	1	2	
<u>Holding Over Acid at 20-25° C.</u>							
1 Week	0	1	0	5	3	9	
2 Weeks	0	0	0	7	10	17	
3 Weeks	0	1	0	11	9	21	-
4 Weeks	0	0	0	8	8	16	
<u>Cold Storage 35° F.</u>							
1 Week	0	0	2	5	8	15	
2 Weeks	0	1	4	18	11	34	*
3 Weeks	0	1	4	20	4	29	*

Table 7 Continued

Treatment	Germination Record by Weeks 2nd %	3rd %	4th %	6th %	8th %	Total Germination %
Cold Storage 35° F.						
4 Weeks	0	0	3	9	4	16
Cormels Husked: Controls:						
Husked Dry Check	3	15	19	40	4	81
Husked Wet Check	7	30	21	16	7	81
Holding in Oven at 35° C.						
1 Week	1	25	12	14	2	54
2 Weeks	1	23	20	13	5	62
3 Weeks	1	13	26	14	2	56
4 Weeks	0	14	23	10	3	50
Drying Over Acid at 20-25° C.						
1 Week	5	35	23	18	1	82
2 Weeks	1	35	19	20	1	76
3 Weeks	8	27	18	26	0	79
4 Weeks	0	17	23	27	8	75

Difference between total germinations necessary for significance as determined by analysis of variance 11.2

* Significantly higher than highest check.

\- Significantly higher than average of checks.

Table 8

W. H. Phipps Cormels Subjected to Various Temperature Treatments and Drying

Treatment	Germination Record by Weeks 1st %	2nd %	3rd %	4th %	5th %	6th %	Total Germination %	
<u>Cormels Not Husked:</u> <u>Controls:</u>								
Dry Check 1	0	0	4	10	14	2	30	
Wet Check 1	2	6	26	7	2	8	51	
Dry Check 2	1	0	28	22	13	0	64	
Wet Check 2	1	5	25	9	13	0	53	
<u>Holding in Oven at 35° C.</u>								
1 Week	0	0	25	15	12	2	54	
2 Weeks	0	0	37	15	16	4	72	-
3 Weeks	0	0	20	39	17	3	79	*
4 Weeks	0	0	8	29	21	2	60	
<u>Drying Over Acid at 20-25° C.</u>								
1 Week	0	0	24	13	20	7	64	
2 Weeks	0	1	31	13	18	1	64	
3 Weeks	0	0	22	9	12	3	46	
4 Weeks	0	0	14	14	23	4	55	
<u>Cold Storage 35° F.</u>								
1 Week	0	2	30	18	28	3	81	*
2 Weeks	0	0	16	28	30	4	78	*
3 Weeks	0	0	6	41	25	1	73	-

Table 8 Continued

Treatment	Germination Record by Weeks 1st %	2nd %	3rd %	4th %	6th %	8th %	Total Germination %	
Cold Storage 35° F.								
4 Weeks	0	0	2	36	31	3	72	-
Cormels Husked: Controls:								
Husked Dry Check	0	15	64	5	2	0	86	
Husked Wet Check	23	34	22	7	4	1	91	
Holding in Oven at 35° C.								
1 Week	1	8	48	9	4	1	71	
2 Weeks	0	12	57	14	2	0	85	
3 Weeks	0	1	37	16	2	1	57	
4 Weeks	0	0	22	8	7	0	37	
Drying over Acid at 20-25° C.								
1 Week	0	12	59	21	1	0	93	
2 Weeks	1	27	55	11	3	0	97	
3 Weeks	3	21	49	7	7	1	88	
4 Weeks	1	11	59	17	2	3	93	

Difference between total germinations necessary for significance as determined by analysis of variance 14.64

* Significantly higher than highest check.

\- Significantly higher than average of checks.

Table 9

Chemical Treatments of Veilchenblau Cormels Started 6/7/40 and Ending 8/7/40

Treatment	Germination Record by Weeks (Two Months) 3rd %	4th %	5th %	6th %	7th %	8th %	Total Germination %	
<u>Sulfuric Acid Series:</u>								
<u>Concentration 70%</u>								
1 hour	2	1	2	1	0	6	12	
2 hours	1	3	0	2	1	3	10	
3 hours	0	5	2	3	3	4	17	
3*hours	1	0	3	2	3	5	14	
5 hours	2	2	2	1	2	2	11	
8 hours	4	8	6	6	4	14	42	*
12 hours	2	5	4	6	5	7	29	*
<u>Concentration 95%</u>								
5 minutes	0	3	2	1	1	5	12	
10 minutes	0	0	1	3	4	6	14	
30 minutes	4	5	7	3	5	12	36	*
<u>Controls:</u>								
Wet Check 1	0	3	1	4	2	6	16	
Dry Check 1	0	1	1	1	2	1	6	
Wet Check 2	2	2	0	2	4	5	15	
Dry Check 2	0	2	0	4	1	4	11	
Wet Check 3	0	2	0	0	0	3	5	
Dry Check 3	0	1	0	1	3	4	9	

Table 9 Continued

Treatment	(Two Months) Germination Record by Weeks 3rd %	4th %	5th %	6th %	7th %	8th %	Total Germination %	
Shucked Check	33	27	8	3	4	4	79	*
Ethylene Chlorhydrin Series: 40% Solution in Closed Jar 3cc per liter								
1 day	0	3	3	1	3	6	16	
1cc per liter								
1 day	0	2	0	2	1	5	10	
3 days	2	20	30	10	10	4	59	*
Solution Form Concentration 1-100								
1 day	0	4	0	4	4	4	16	
3 days	2	5	1	1	1	3	13	
5 days	0	3	2	1	0	1	7	
Solution Form Concentration 1-1000								
1 day	0	0	0	0	4	2	6	
3 days	0	1	1	4	6	5	19	
5 days	2	7	1	2	4	5	21	-

Difference between total germinations of treatments necessary for significance as found by analysis of variance was 9.84

* By statistical analysis found to be significantly higher germination than the highest control.

- Significantly greater than the average of the 6 checks.

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