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A Study of Factors Influencing Floral Initiation and Seedstalk Development in the Onion, Allium Cepa Linn

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Statement of the Problem

Since the onion is a biennial and seed production depends upon 1. the development of a bulb during the first year and 2. carrying the bulb through to produuction of seed the second year, problems arise which do not occur in production of seed from annual crops.

Methods of producing onion seed vary with the locality in which it is grown. Fall planting during late September or early October is common, especially for the so-called hardy varieties which are able to withstand moderate winter temperatures. Bulb planting in spring is also common and may be preferable if winters are too severe to assure survival of bulbs in the field. Another modification of seed production is referred to as "seed to seed" which involves leaving the bulbs in the field where grown, without any transplanting. This latter method necessitates use of extra land during the first year and does not permit any sorting or selection of "stock" bulbs.

Since it is feasible to plant some varieties in the fall, it is important to determine the best planting time for greatest survival of the bulbs. If, on the other hand, spring planting is indicated, the storage problem becomes important.

Because floral initiation and floral development are forerunners of all seed production, any fundamental studies of seed production must be based on those factors that influence the floral morphology of the plant from its earliest stages. The studies here reported include all phases of the problem mentioned above.

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Literature Review

Morphology and Development of the Onion

According to Jones and Boswell (1), the flower primordia of fall planted onions were differentiated in early spring under conditions at College Park, Maryland. When similar bulbs were planted in the spring no appreciable difference in time of development of the floral organs was noted. Actual appearance of the flower stalk in spring-planted bulbs, these authors state, is governed wholly by the time the bulbs are put in the field, and those bulbs which were planted in the fall and had made "a luxuriant foliage development" prior to primordia differentiation produced heavier and taller seedstalks.

Temperature

Boswell (1), Thompson and Smith (7), Jones (3), and Jones and Emsweller (4) have studied, among other factors, storage temperature as well as growing temperature and their influence upon seedstalk development and seed production in the onion. Boswell, in summarizing his work on onion maturity and storage in relation to vegetative and reproductive development, states that "flower primordium differentiation was materialy inhibited, although not entirely prevented by storing the bulbs at 32° F. for 8 months." He states further that the inhibitory effect is increased with low storage temperatures and with duration of the exposure. Thompson and Smith used sets of Ebenezer, Yellow Globe Danvers, Southport Yellow Globe and Red Wethersfield. These ranged in size from 3/8 inch to 1 1/8 inches in diameter. Storage was at 30°, 32°, 40°, 50°, and common storage at 60° to 70° F. Storage temperatures favoring seedstalk formation were not suitable for commercial sets. Sets stored at 30° and 32° F. gave greatest bulb yields, while most of the seeding was from sets stored at 40° and 50° F. Higher temperatures cause shrinkage of sets in storage.

Jones (3), working with Ebenezer onions in California, stored mother bulbs at 3.5°, 7.5°, 11°-12°, 16°-22°, and 30° C. (common storage) from August 4 to December 6, at which time they were removed and planted. All sprouted bulbs were discarded. Onions at 7.5° C. and 11°-12° C. produced the earliest blooms. Seed produced at these temperatures was 50 to 60 per cent in excess of that from bulbs kept at 30° C. Many vegetative shoots developed from bulbs kept at the high and low temperatures.

Jones and Emsweller (4), who used mature mother bulbs, got results similar to those of Thompson and Smith. These were stored at 38.5°, 53.5°, 46.5°, 86° F. and cellar storage from 61° to 71.5° F. upon maturity in late July or early August and were planted in the field in early December. Greatest seed yields were obtained from those lots held at 53.5° F.: the difference, however, between this yield and that obtained from the 46.5° F. lot not being significant. Those kept 86° F. were entirely unsatisfactory for seed use.

For the most part, temperature and storage studies cited and discussed in this section have been made independently; that is, only a few studies of an interrelation between growing temperatures, temperature effects and effects of other environmental factors, notably light, have been made. Information of this latter type is extremely important and more recent studies have clearly established that it is difficult, if not actually fallacious, to attribute reproductive behavior of a plant to a single factor. For the sake of clarity in this review, factors will be discussed separately where it is possible without distortion of the facts.

Light

McClellan (5) studied a wide variety of economic plants in relation to their behavior under different day lengths. Among the crops investigated were onions, sweet potatoes and potatoes.

Of the four varieties of onions: Prizetaker, Bermuda White, Yellow Globe Danvers and Silver King, only Bermuda bulbed satisfactorily under normal daylight conditions (approximately 13 hours) in Puerto Rico. At the maximum photoperiod used (15 hours) all varieties developed normal bulbs. These results with onions closely parallel those of Magruder (6) who investigated effects of different day lengths on bulb formation in 18 American onion varieties and 8 commonly grown in Europe. Day lengths were from 10 to 18 hours in addition to the normal day of 12.4 to 14.9 hours. In these experiments Yellow Bermuda was the only variety to produce bulbs in the 10-hour day. Most of the American varieties bulbed at a photoperiod between 12 to 14 hours, while a longer photoperiod (16 hours) was required for bulb formation in the varieties from Northern Europe. Neither Mecruder nor McClelland studied the effect of the photoperiod upon flower or seedstalk formation.

Temperature and Light

Bulb formation in the onion depends upon an interaction between temperature and light. Thompson and Smith (7) used a 15-hour day and temperatures at 50°-60°, 60°-70°, 70°-80° F. They found that bulbing took place at 60°-70° and 70°-80°, but not at 50°-60° F.; the higher the temperature, the greater the effect upon bulbing at this length of day. With normal day length of winter and early spring, bulbing did not take place in any of the treatments.

Other Factors

Dormancy and rest periods of the onion have been studied by Boswell (1). In attempt to control dormancy and prolong keeping quality of Yellow Globe Danvers onions, he first studied time of maturity. While he found that those bulbs maturing early were slower in starting growth than the others, there was no appreciable difference in the length of the rest period in the two lots. However, later work by this author does not bear this out. In attempting to break the rest period, Boswell resorted to wounding, freezing, etherization and greening. By making transverse cuts through the bulb, removing from ⅓ to ⅔ of the bulb, he was able to hasten growth; the more of the bulb removed, the greater was the growth. Much less growth response was observed when similar bulbs were cut longitudinally.

The effects of etherization were not of sufficient magnitude nor consistency to be recognized. Greening, by exposing to the sun's rays, resulted in less growth than was observed in the check bulbs. In the freezing experiments bulbs were exposed to 22° F. for periods of from 2 to 72 hours. Death of some of the bulbs resulted, while those surviving showed no benefits as a result of the treatment. Later work along the same line, but in which temperatures just above the freezing point were used, resulted in an apparently earlier cessation of the rest period when the bulbs were removed to a temperature of 50° F.

Materials and Methods

Experiment I

Bulbs used in these experiments were produced from seed of good strains of Sweet Spanish and Ebenezer. These bulbs were grown at the University of Idaho Branch Experiment Station at Parma. The seed bulbs were received at Ithaca, New York, September 27, 1941. This is as early as mature onions may be obtained from this section. The bulbs were fairly uniform in size, the Ebenezer variety averaging slightly more than 2 ounces each, or six to seven bulbs per pound. The Sweet Spanish bulbs were from 5 ounces to 6 ounces in weight. Bulbs of both varieties were 2 inches to 3 inches in diameter, the Ebenezer being slightly smaller in diameter than the Sweet Spanish. This represents the upper limit of the type of planting stock most commonly used for seed purposes in Idaho. Given the proper environment, all of these onions should produce seed.

Immediately upon receipt of this material, 120 bulbs of each variety were placed in storage at 50° F. and at 35° F. All remaining bulbs were kept at about 70° F. until moved as indicated later. Exactly 4 weeks after placing the bulbs in storage, as mentioned above, similar lots were placed at the two storage temperatures. The third lots were put in the storage rooms 6 weeks after the first lots had been so treated. By November 22, therefore, bulbs of each variety had been stored for periods of 8, 4, and 2 weeks at temperatures of 50° and 35° F. Bulbs for check purposes were kept at 70° F. throughout this period of 8 weeks.

All experimental bulbs were planted November 22. They were placed, 20 to the flat, in a composted soil consisting of a sandy loam mixed with sufficient barnyard manure to make a satisfactory soil for potting purposes. Flats were of a size and depth to make possible complete coverage of the bulbs. There was more space between the Ebenezer bulbs than those of the larger Sweet Spanish which were less deeply covered than the Ebenezer because of the increased size.

After the bulbs were planted in the flats they were removed to the greenhouses, maintained at 50° to 60°, 60° to 70°, and 70° to 80° F. One of each variety from each of the two storage treatments and one from the 70° F. storage were subjected to the normal day length. Another flat in each category was given supplementary light to make a 15-hour day. This was made possible through the use of 100-watt Mazda lamps suspended at a height of about 18 inches from the surface of the flats. No lights were used until December, 11, approximately 2 weeks after the bulbs had been placed in the greenhouse. Little top growth had been made prior to that time.

A summary outline of the experiment is as follows: 2 varieties, Ebenezer and Sweet Spanish; three storage temperatures, 50°, 35°, and 70° F.: two photoperiods, normal day and 15-hour day: three lengths of storage, 2, 4, and 8 weeks: and three greenhouse temperatures, 50° to 60°, 60° to 70°, and 70° to 80° F. This would make a total of 108 treatments. However, it should be pointed out here that there were but two (one for each variety) 70° F. storage treatments for each photoperiod in the three greenhouses, reducing the total number by 24, making 28 treatments in each house. More flats of this same treatment would have merely necessitated replications with identical material, for in order to make all plantings at the same time and yet have different periods of storage at the lower temperature, all bulbs had to be kept at room temperature until otherwise treated.

Examination of samples from the 84 treatments was made periodically, two bulbs from each treatment being taken at 2-week intervals beginning January 12 and ending March 8. Bulbs were also examined for flower primordia previous to planting. For purposes of determining presence of floral primordia a lower-power binocular was used. The bulb was first cut transversely on a plane below the center. At a glance, the number and location of the growing points were determined. Each piece containing a shoot or growing point was reduced to a block of tissue about 5 mm. square and 10 mm. long, care being taken to preserve a section of the stem plate in each piece. By means of a scalpel it was then possible to slice from this block of tissue a median section about 1 mm. thick containing the growing point. This section was then placed under the binocular where, by making use of dissecting needles, the portions of leaf bases were removed from the stem plate, exposing the growing point. After a certain amount of practice it becomes relatively easy to dissect the points down to the youngest leaf, or the flower primordium, as the case might be. This method has the same degree of accuracy as can be obtained from prepared sections, without the accompanying work. A further advantage is that the floral primordia may be examined in all dimensions by this method. Some of the tissue was preserved, however, in formal-acetic acid, cleared by butyl-alcohol, stained with saffranin and fast-green, and sectioned for detailed examination and for photographing.

Experiment II

This experiment was conducted to determine the effect of high temperature (70° to 80° F.) upon flower stalk development after floral initiation at lower temperature levels.

Six flats each (20 bulbs per flat) of Ebenezer and Sweet Spanish were planted October 18, and placed in a cold frame out of doors. These flats were later covered with a layer of leaves to protect them from cold injury. On December 19, all of the above material was moved into the greenhouse and maintained at a temperature of from 40° to 50° F. Throughout the winter, at intervals of approximately 4 weeks, some of these were transferred to the 70° to 80° F. house. On December 31, three flats of each variety were transferred from the 40° to 50° house to the 70° to 80° house. One flat each of the two varieties were moved from the cold house to the warm house on January 28 and February 24. This left one flat of each variety remaining in the 40° to 50° house. Bulbs from these flats were sampled simultaneously with those in Experiment I. It is not likely that any primordia had been initiated by December 31, the time that the first flats were moved into the 70° to 80° house. However as early as January 21 primordia had been found in bulbs kept in the 40° to 50° house. Any subsequent treatment, therefore, would have to do with the development of the floral axes rather than with their initiation.

On March 26, one flat of Ebenezer and one flat of Sweet Spanish bulbs were transferred from the 70° to 80° house to a greenhouse where the temperature was maintained between 60° and 70° F. Data from these bulbs included counts of the number of seedstalks produced.

Analysis of the Data

Fisher's analysis of variance method was used in analysis of the data. Variance beyond that contained in third order interactions was included in the error variance. It is possible by this method to determine significance, if present, in any of the interactions. Some of the more important of these are described under Experimental Results.

Experimental Results

Flower and Leaf Primordia in Onion Bulbs, and Development of the Floral Axis

Samples from bulbs which were planted in November were examined at that time for floral primordia. There was no evidence of any floral development when the bulbs were planted. The data which follow will show the rate and course of floral initiation in the various treatments. First primordia developed during early January and were present January 17 when all the treatments were sampled for the first time.

The figures shown here are photographs of floral and leaf primordia. Figure 1 is a typical floral axis in its early stage. Leaves have been removed. At this time the primordium of the floral head is easily recognized; the internode, which develops into the peduncle, has started to elongate. The involucral bract, which covers the florets after they have developed, is conspicuous. The somewhat fluted appearance of this structure is a characteristic by which floral primordia may be distinguished from leaf primordia. There is some variation in shape and general conformation of these floral axes in the earliest stages.

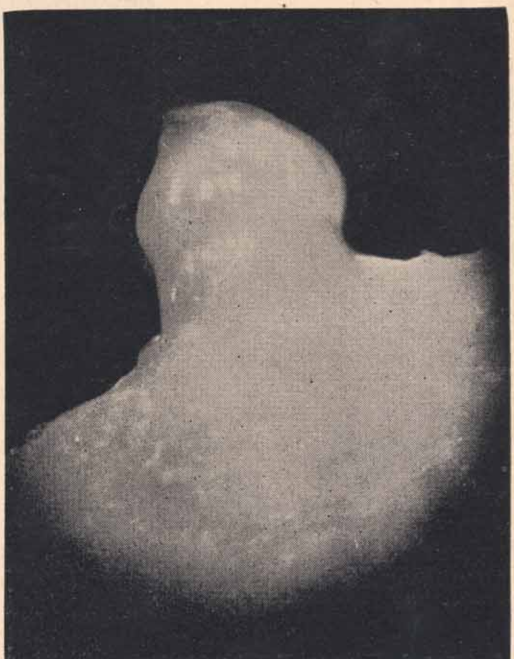

Figure 1.—Floral axis primordium at the time when the peduncle is beginning to elongate. About 15x.

Figure 2, on the other hand, shows a typical leaf primordium. The wedge-shaped appearance, when viewed from the side, is an important character. However, it should be pointed out that complete dissection of the growing point is necessary before final determination can be made. Since the primordial floral axis lies underneath the last leaf structure, it is possible to overlook the floral axis by incomplete dissection.

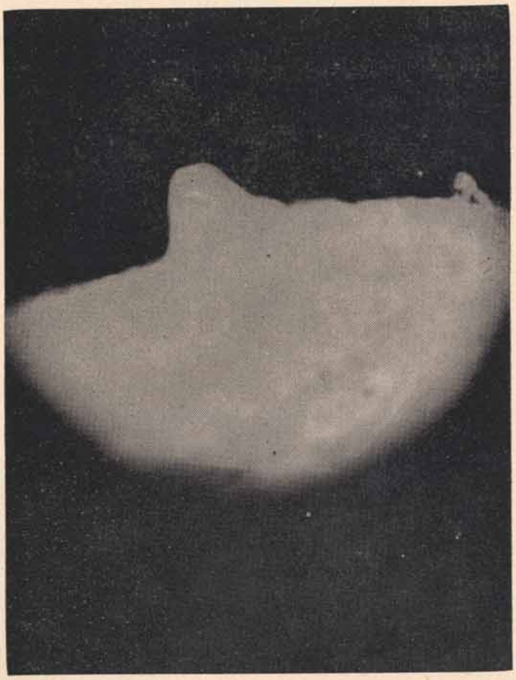

Figure 2.—Leaf primordium, side view, characterized by wedge-shaped appearance. About 15x.

The anatomical structure of the floral primordium is shown in Figure 3. This shows also the bases of the last two leaves and the alternate arrangement of the leaves on the stem plate. The dark areas are regions of small cells whose nuclei are deeply stained with saffranin. That part of the peduncle which has already developed shows these darkened nuclei in great numbers. These cells, which show darkest in the photomicrograph, are rapidly dividing. According to Hoffman (Hayward*), "in the earliest stage of development the entire leaf is meristematic; at a later date, only the sheath and base of the blade; and still later, only the base of the sheath."

*Hayward, Herman E. **The Structure of Economic Plants,** McMillan Co. 1938.

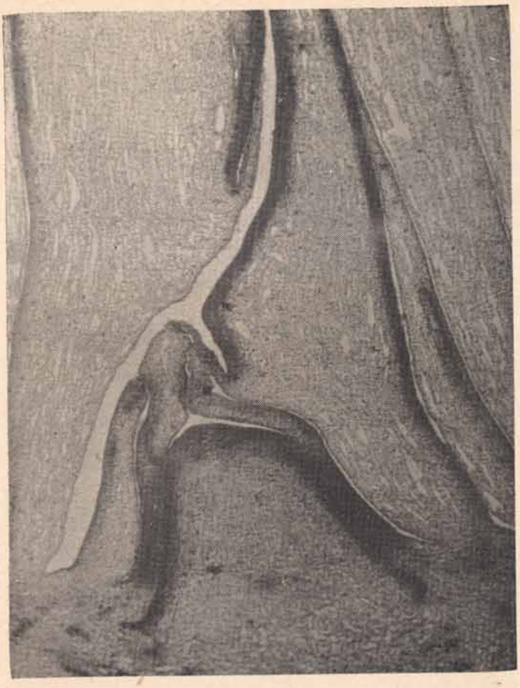

Figure 3.—Photomicrograph of longitudinal section through floral axis and enclosing leaves. About 20x.

It often happens that a leaf primordium and flower primordium are found together under the last leaf. Figure 4 shows such a condition. The leaf primordium here is in about the same stage of development as the lone leaf primordium shown in Figure 2. When these leaf primordia are present, growth is resumed; new bulbs are formed which will produce another crop of seed during the ensuing season. If no leaf primordium is formed here at the base of the primordial floral axis, growth is terminated in the floral axis in that particular shoot.

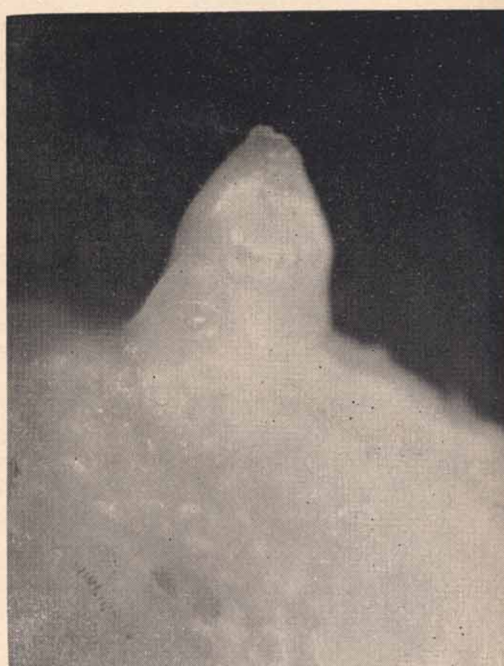

Figure 4.—Flower and leaf primordia arising from one shoot. About 15x.

Effect of Light, Greenhouse Temperature, Storage Temperature and Length of Storage on Floral Initiation in Sweet Spanish and Ebenezer Onions

A complete analysis was made of all the data taken in Experiment I. As far as possible statistical methods of analysis were used on data collected in Experiment II. In the discussion of these results, particularly in Experiment I, it seems best to divide the sources of variation into (1) Main Effects, and (2) Interactions. The main effects in this experiment were light, greenhouse temperature, storage temperature, length of storage, variety and sampling date. Interactions may be between any two, three or four of the main effects. No attempt will be made to interpret interactions between four main effects. A discussion of the more significant interactions involving two or three main effects will be presented under the heading Interactions. In a few instances, in order to clarify the data, some mention will be made of first-order interactions in the discussion of the main effects. The figures used are made up from data which, according to results of the statistical analysis, show significances with odds of 19:1 or greater against the differences being due to chance.

Main Effects

Influence of Light on Floral Initiation in Sweet Spanish and Ebenezer Onions

In view of the fact that primordia are laid down within the bulb while it is still in an apparently dormant condition, and while the bulb is either in storage or in the ground, it is not expected that light differences should greatly alter primordium formation.

Experiment I. Analysis of these data show a significant difference between the number of primordia initiated under normal-day conditions and those initiated when supplemental light was given. From the total number of primordia, 308 were formed under conditions of the normal day, while with a 15-hour day 366 primordia were formed. Equal lots of bulbs were examined in both instances.

Table I shows data relative to the influence of light on primordium initiation during the 8-week sampling period.

Table I. Primordia formed in onion bulbs exposed to two different photoperiods and examined over an 8-week period.

Photoperiod	No. of bulbs in each sample	Date of Sample Jan. 17	Jan. 30	Feb. 9	Feb. 25	Mar. 11
Normal Day	108	10	43	78	74	103
16-hour Day	108	28	37	67	115	119

A glance at the figures in the table show that light seemed to influence floral initiation during the latter half of the sampling period more than it did in bulbs examined earlier. At this point it might be well to explain that some trouble was encountered in getting Sweet Spanish bulbs to grow under the high greenhouse temperatures. Bulbs rotted unless water was carefully controlled. This condition was more prevalent in those plots where no supplementary light was given. Probably the first impression would be that additional heat from the light would reduce the moisture content of the soil, thus reducing the incidence of decay. It is not likely that this occurred, for in this and in similar experiments conducted with the use of these lights, no apparent temperature difference existed between the normal-day treatment and the supplementary light treatment.

Influence of Greenhouse Temperature Upon Floral Initiation in Sweet Spanish and Ebenezer Onions

Greenhouse temperature, or growing temperature, appears to be one of the most important environmental factors in its effect upon floral initiation. Growth is more rapid at the higher temperatures — 60°-70° and 70°-80° F. — than it is at 50°-60° F. However, growth alone, that is, development of leaves and roots, was not found to be an index to primordial development. Perfectly dormant bulbs, taken from the cellar during February, were found to have initiated primordia, although no growth was present.

Experiment I. By referring to Figure 5 it can be seen that where bulbs were exposed to a greenhouse temperature from 50°-60° F. floral initiation greatly exceeded that at either of the higher levels.

The differences between floral initiation at the three greenhouse temperatures were not as great during the earlier part of the sampling period as they were at the end of the 8-week period. Throughout the 8 weeks there was no change in the course of initiation at 70°-80° F. Appreciable increase of flower primordia was noted in plants grown at 60°-70° F., while at 50°-60° the increase in floral initiation through the five sampling dates resembled a rather typical growth curve, leveling off as the period of initiation was terminated.

The Influence of Storage Temperature Upon Initiation of Floral Primordia In Onion Bulbs

Studies of storage temperatures were made on bulbs grown in the field as well as on those grown in the greenhouse. In the Parma, Idaho, experiments, however, only two temperatures were used — 35° and 70° F., while at Ithaca an additional storage temperature, 50° F., was used. Four varieties of onions were used in the field experiments at Parma, while only two were used in the greenhouse.

Experiment I. Table II shows the effects of storage temperature upon floral initiation, as studied under greenhouse conditions. According to the analysis of variance, differences between these figures are significant at odds well beyond 999:1.

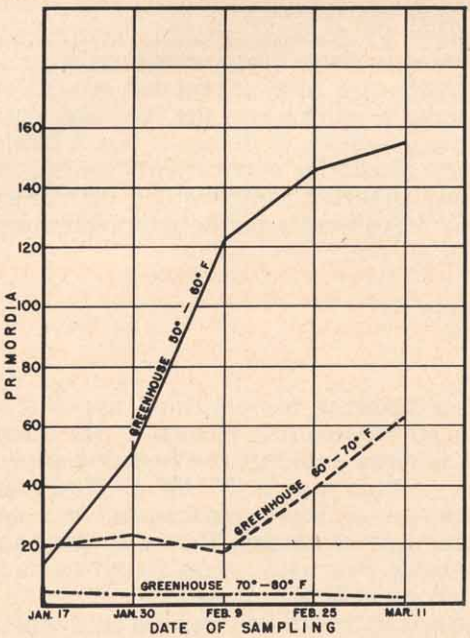

Figure 5—The effect of greenhouse temperature upon floral initiation in onion bulbs over a period of 8 weeks.

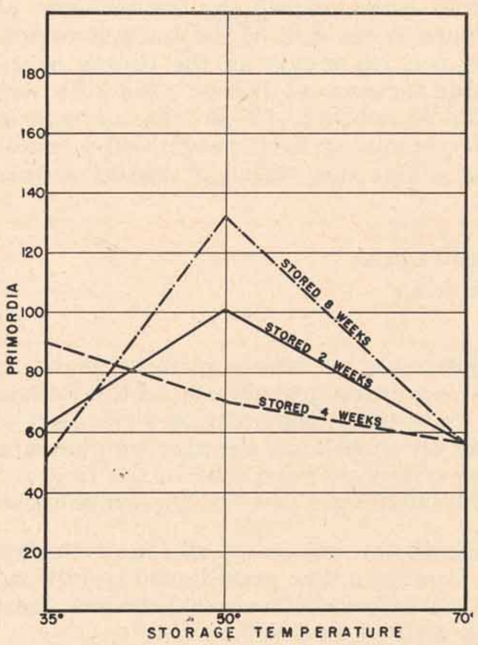

Figure 6.—Influence of storage temperature and length of storage on floral initiation in onion bulbs.

Table II. Primordia formed in 3 lots of onion bulbs previously kept at different storage temperatures.

Storage temperature	No. bulbs examined	No. primordia
35° F.	360	203
50° F.	360	303
70° F.	360	168

From these data it is apparent that a storage temperature of 50° F. is significantly superior to either 35° F. or 70° F. from the standpoint of subsequent floral initiation.

The data showing primordium development from bulbs stored 2, 4 and 8 weeks at 35°, 50°, and 70° F., and which are set forth in Figure 6, show that 50° storage is generally better than 70° or 35° storage. The single exception is in the case of those bulbs stored for 4 weeks; 35° storage for 4 weeks seems better than storage for the same period at either 50° or 70° F.

Only one lot of bulbs was stored at 70° F. It has been previously mentioned that, in order to be able to plant all of the bulbs at the same time, it was not possible to differentiate 2, 4 and 8 week lengths of storage at 70° F., or room temperature. Data taken from the single lot have been repeated for all three of the different storage periods.

Influence of Length of Storage Period on Floral Initiation in Onion Bulbs

If a so-called "rest period" is desirable in order to insure floral development in the onion, the length of this rest period is important equally as well as the temperature under which this rest period goes on. Two, 4, and 8 week periods were used in the greenhouse experiments.

Experiment I. Length of storage appears to have no significant effect upon development of the floral axis in onion bulbs. The data are set forth in Table III.

Table III. Primordia formed in bulbs previously store for 2, 4 and 8 week periods.

Length of storage	No. bulbs examined	No. Primordia
2 weeks	360	219
4 weeks	360	216
8 weeks	360	239

Length of storage in relation to storage temperatures has been discussed under the previous heading, data for which have been given in Figure 6, page 14.

Influence of Variety on Floral Initiation in Onion Bulbs

Yields of seed from different varieties of onions are not the same, other things being equal. Seed yield depends upon (1) number of flower primordia which develop into seed stalks, and (2) general size and vigor of the flowering head. Ebenezer and Sweet Spanish present two extremes as regards bulb characteristics. Excellent yields are obtained from both varieties under favorable conditions.

These two varieties showed marked differences in behavior in the greenhouse.

Experiment I. There is a great difference between these two varieties from the standpoint of floral initiation. One obvious reason for this is the fact that there are more shoots in the Sweet Spanish bulbs than in the Ebenezer bulbs. This, however, does not account for all of the difference, for of 2161 shoots of Sweet Spanish which were examined, 480, or 22.2 per cent, showed floral primordia, while Ebenezer, with 1586 shoots, bore only 194 primordia, or 12.2 percent. Figure 7 shows the relationship between floral initiation and time of sampling in the two varieties.

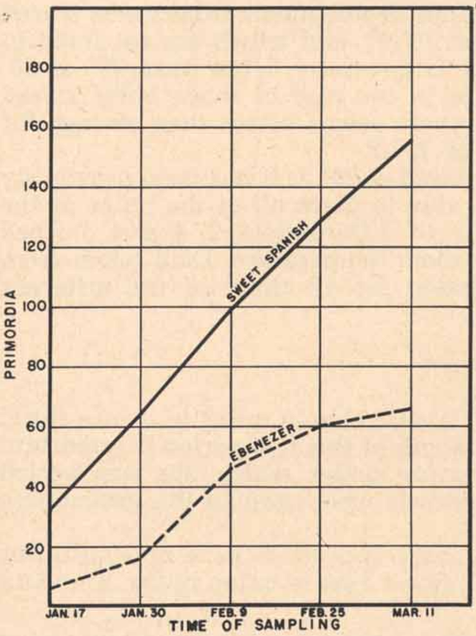

Figure 7.—The development of floral primordia in Sweet Spanish and Ebenezer onions, as shown on five consecutive sampling dates.

The curve for floral initiation shows, in the Sweet Spanish variety, a uniform increase with each date of sampling. The course of primordium development in Ebenezer, however, differs from that in Sweet Spanish. At the end of the 8-week period samples of Ebenezer bulbs showed only slightly more primordia than a similar lot of bulbs had shown 2 weeks earlier.

Primordium Initiation Over the Period of Sampling, January 17 to March 11

Experiment I. Initiation of floral primordia in these onion bulbs began about January 17, almost 2 months after the bulbs were planted in the greenhouse. The first samples of bulbs which were examined exhibited primordia in only a few instances, as is shown in Table IV. From then on there was a rapid increase in the number of primordia present at each succeeding sampling date. These figures, plotted against time, give a somewhat typical growth curve.

Table IV. Initiation of floral primordia in samples taken at 2-week intervals over a period of 8 weeks.

Date of Sampling	No. bulbs examined	No. primordia
Jan. 17	216	38
Jan. 30	216	80
Fab. 9	216	145
Feb. 25	216	189
Mar. 11	216	222

Interactions

The analysis of variance method of measuring significance between any two means in a given series has the advantage, besides showing significance between main effects, of making it possible to show accurately significant interactions. If two factors such as light and variety are involved in an interaction, it is termed a first-order interaction; if three are included, it becomes a second-order interaction, etc. If an interaction such as the one mentioned above is found to be significant, the indication is that the two varieties do not respond similarly to changes in light. Beyond first-order interactions, interpretation becomes increasingly difficult. However, any of these interactions may be expressed graphically, using abscissa and ordinates for two of the variables and as many series of curves as are necessary to represent the others.

Following is a discussion, supplemented by graphs, of some of the more important significant interactions as found in Experiment I. First-order interactions which could not have been conveniently omitted in the discussion of main effects have already been presented.

The Influence of Greenhouse Temperature on Floral Initiation in Sweet Spanish and Ebenezer Onions Over a Sampling Period of 8 Weeks

Bulbs grown at 50°-60° F. showed practically the same response in both varieties, as shown in Figure 8. Sweet Spanish grown at 60°-70° F. showed a marked increase in floral development from January 17 to March 11. In Ebenezer, at the same temperature, there were few primordia found at any time. Thus, greenhouse temperature did not influence the two varieties in the same manner over a definite period. It seems likely that most of the variability in this interaction is here between these two varieties grown at 60°-70° F. At 70° to 80° F. the course of floral development is about the same in both varieties. No primordia were found in some of the Sweet Spanish samples and the number found in Ebenezer was not great enough to be important.

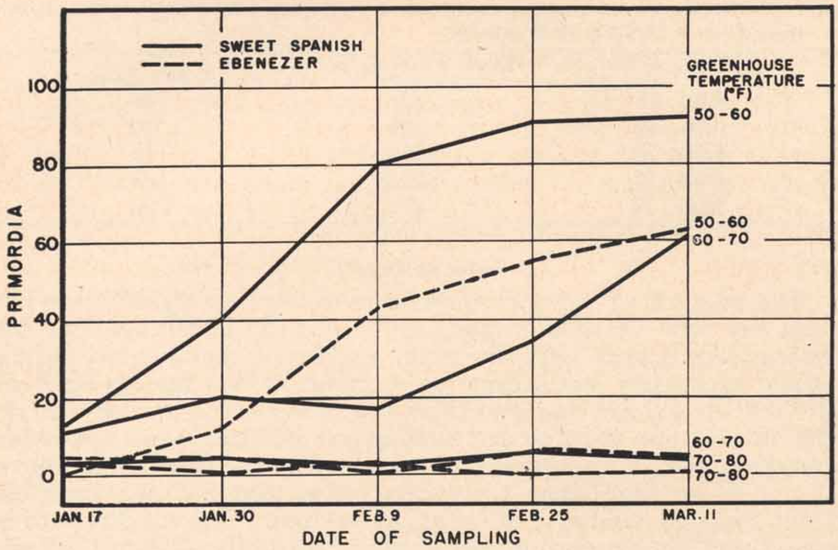

Figure 8.—The influence of greenhouse temperature on floral initiation in Sweet Spanish and Ebenezer onions as shown on five consecutive sampling dates. Each point on the curves represents 36 bulbs examined.

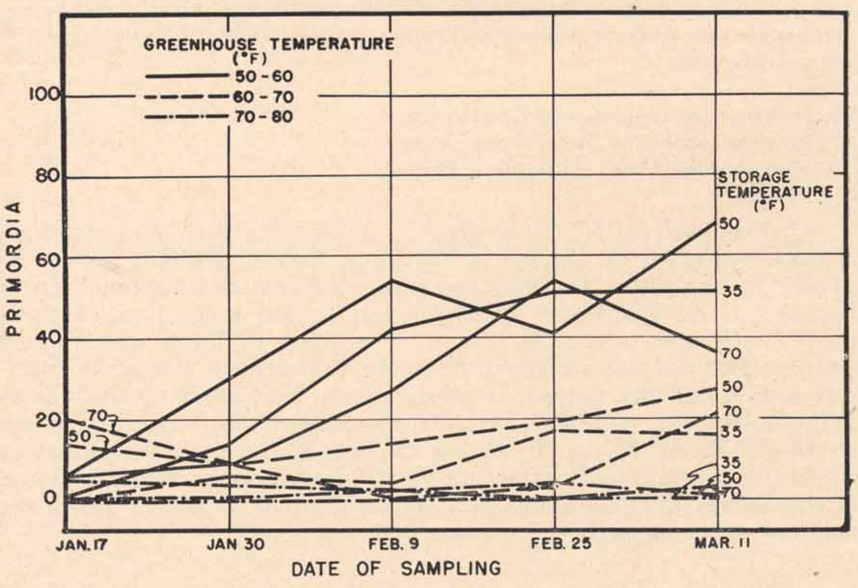

Figure 9.—The influence of greenhouse temperature and storage temperature on floral initiation. Each point on the curves represents 24 bulbs examined.

The Influence of Greenhouse Temperature on Floral Initiation in Bulbs Stored at 35°, 50° and 70° F. Over an 8-Week Period

The general trend of primordium development within bulbs grown at the same temperature is about the same in all three cases. There is, however, one exception to this which is hard to explain. By studying Figure 9 it will be seen that bulbs grown at 60° to 70° F. which had been stored at 70° F. showed no floral primordia in samples taken February 9, while 20 primordia were found in the first samples from this lot, and 21 were found in the sample taken March 11. Those bulbs stored at 35° and 50° F. and grown at 60° to 70° F. showed a general upward trend in primordium initiation during the sampling period.

In the 70°-80° greenhouse temperature slowed down primordium initiation to the extent that previous storage temperatures had no effect.

The Influence of Greenhouse Temperature on Floral Initiation in Sweet Spanish and Ebenezer Onions Grown at Two Different Photoperiods

Figure 10 shows the development of primordia in the two varieties when exposed to different photoperiods. There are two points of importance brought out in this figure: (1) Ebenezer growing at 60° to 70° F. produced no more primordia than when growing at 70° to 80° F. Sweet Spanish, however, produced considerably more primordia at 60° to 70° F. than at 70° to 80° F.; (2) light influences primordium development rather markedly in Sweet Spanish at 60° to 70° F., and has little influence upon Ebenezer at any temperatures.

A basic cause for the increased development of floral primordia in Sweet Spanish at 60° to 70° F., compared with primordium development in Ebenezer at the same temperature, is

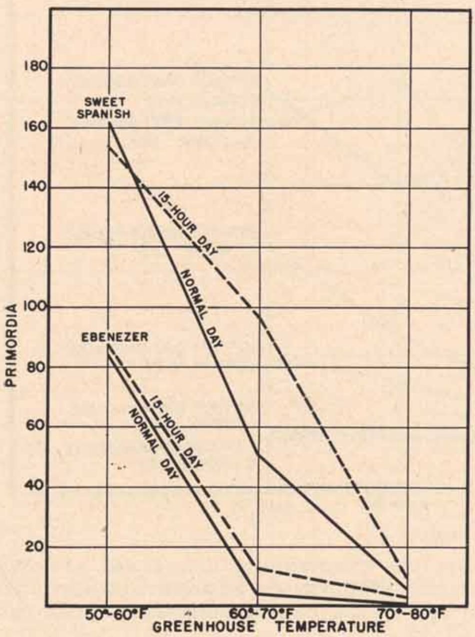

Figure 10.—The influence of greenhouse temperature on floral initiation in Sweet Spanish and Ebenezer bulbs at two different photoperiods. Each point on the curves represents 90 bulbs examined.

difficult to explain. It is evident that, at the higher temperature (70°-80° F.), the deleterious effects of this additional heat are of sufficient magnitude to mask any influence that any other environmental factor, such as light, might have. At 50° to 60° F. there is an opportunity for some factor to be limiting. If this is the case, then additional light will not increase floral initiation. Light alone may limit development at 60° to 70° F., thus the difference as indicated in the figure.

Influence of Greenhouse Temperature on Floral Initiation Over a Period of 8 Weeks in Onion Bulbs Grown at Two Different Photoperiods

The data for the two varieties are not separated. Light treatments, therefore, include data from both varieties. Differences which contribute toward making this interaction, between light, time of sampling and greenhouse temperature, are to be found in Figure 11. The first thing to be noted is the general course of development of primordia in bulbs grown at the three different greenhouse temperatures. At 50° to 60° F. the trend is upward from start to finish, with but two variations from the trend. The increase in number of floral primordia in bulbs grown at 60° to 70° F. is found during the last 4 weeks of the sampling period. At 70° to 80° F. very few primordia were formed.

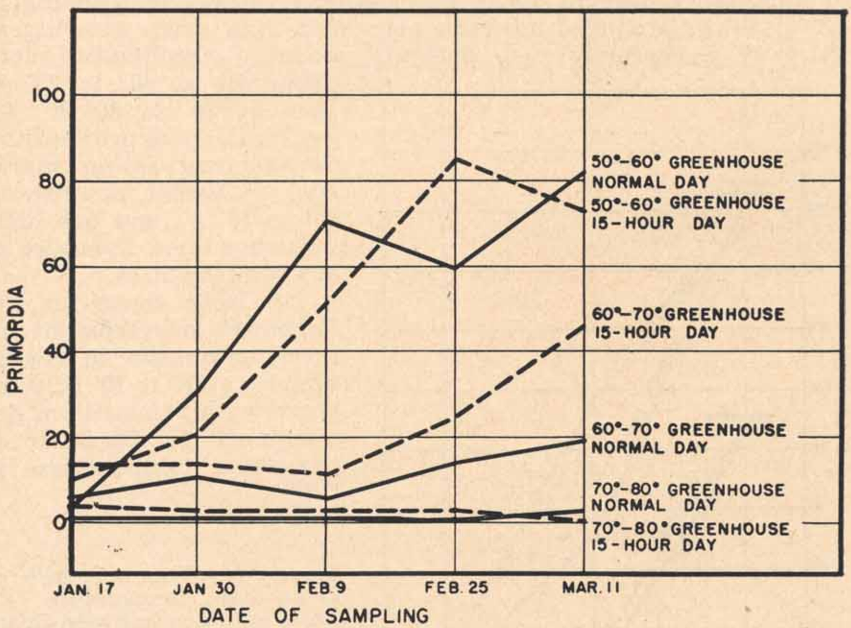

Figure 11.—The influence on greenhouse temperature upon floral initiation in onion bulbs grown at two different photoperiods as shown on five consecutive sampling dates. Each point on the curves represents bulbs examined.

Another source of significance is in the difference between bulbs grown at the three different growing temperatures in their response to light. At 50° to 60° F. the influence of light changes over the 8-week period. At 60° to 70° F. additional light increases the number of primordia formed as against those formed at the shorter photoperiod. There being so few floral primordia initiated at 70° to 80° F., it is not to be expected that light would be able to exert any influence.

The Influence of Storage Temperature on Floral Initiation in Sweet Spanish and Ebenezer Onions Grown at Two Different Photoperiods

The most striking point observed in these data, which are graphically shown in Figure 12, is the response of those Sweet Spanish bulbs stored at 35° and those stored at 50°, in comparison to the difference in primordium initiation of Ebenezer bulbs stored at these two temperatures. In other words, about the same number of primordia were formed in Ebenezer bulbs stored at 35° F. as were formed in those stored at 50° F. In Sweet Spanish considerably more primordia were formed in bulbs stored at 50° F. than in those stored at 35° F. A second source of significance will be seen

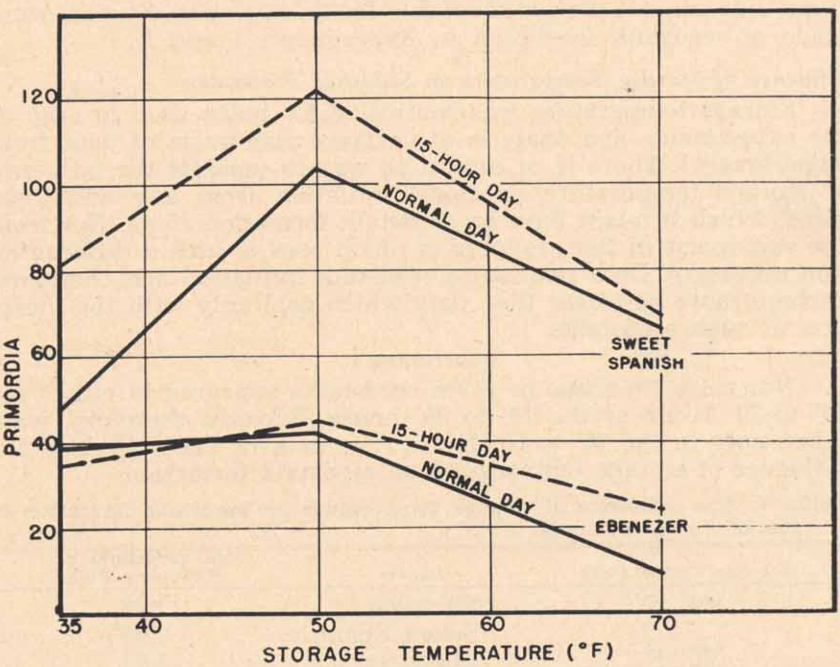

Figure 12.—The influence of storage temperature on Sweet Spanish and Ebenezer onions when grown at two different photoperiods. Each point on the curves represents 90 bulbs examined.

when the influence of the 35° and 70° F. storages is considered. In Sweet Spanish slightly more primordia were formed in bulbs held in the 70° storage than in those held in the 35° storage. However, in Ebenezer bulbs, 33 primordia were formed in bulbs from the 70° storage and 74 were formed in bulbs from the 35° storage. Light does not seem to alter the significance of this interaction a great deal. The only difference between the two varieties, in their response to light, is in those bulbs stored at 35° F.

Effects of Storage Temperature, Length of Storage, Greenhouse Temperature and Light Upon Flower Stalk Development

Following initiation of the floral primordium, if environmental conditions are satisfactory, the central axis begins to elongate and growth takes place rapidly. The primordia which develop into florets to form the flower head begin to differentiate below the involucral bract. These individual florets are subtended by secondary bracts which become rather conspicuous shortly after elongation of the axis begins. Conditions which favor initiation of the floral axis may also be suitable for its subsequent development. On the other hand, conditions which support elongation and growth of the floral axis are not always favorable for its initiation. Studies were made of seedstalk formation in Experiments I and II.

Influence of Storage Temperature on Seedstalk Formation

Storage temperature was controlled for bulbs used in each of the experiments and analysis of variance was made of data from Experiment I. There is, of course, no way to separate the influence of storage temperature on floral initiation from any additional effect which it might have on seedstalk formation alone. Nor from the standpoint of the producer of onion seed is such a differentiation necessary. Data relative to seedstalk formation are, therefore, perhaps more pertinent than data which deal only with the inception of such seedstalks.

Experiment I.

Not more than two or three seedstalks appeared in either the 60° to 70° house or the 70° to 80° house. Records, therefore, were taken only in the 50° to 60° house. The data in Table V show the influence of storage temperature on seedstalk formation.

Table V. The influence of storage temperature on seedstalk formation in the 50° to 60° F. house.

Storage Temperature	Variety	No. Seedstalks per Flowering Bulb
35° F.	Ebenezer	1.86
	Sweet Spanish	1.58
50° F.	Ebenezer	1.71
	Sweet Spanish	1.80
70° F.	Ebenezer	*
	Sweet Spanish	1.50

*No data.

An analysis of these data gives no indication of significance between the storage temperature treatments.

The Influence of Light on Seedstalk Development in Onion Bulbs

Light was controlled only in Experiment I. Significant differences were found between the length of the seedstalks in bulbs grown at the two photoperiods. As can be seen in Table VI, these differences are great enough to be noticed immediately in the growing plants.

Table VI. The effects of light on growth of seedstalks in bulbs grown at 50° to 60° F.

Photoperiod	Average length of seedstalks
Normal Day	60.7 cm.
15-hr. day	123.1 cm.

The analysis of these data gives odds against this difference being due to chance as being greater than 99:1. It is difficult to predict as to the importance of this increased growth resulting from additional light. Experiments in which seed yields are recorded would be necessary in order to measure the ultimate efficacy of a lengthened photoperiod.

As might be expected, the longer photoperiod had no significant effect upon the number of seedstalks developed.

The Influence of Greenhouse Temperature on Seedstalk Development

In one series of plantings in Experiment II bulbs were planted in flats and placed in the cold frame on October 18. On December 19 these flats were removed to a cold greenhouse (40° to 50° F.). At intervals these flats were placed in the 70° to 80° greenhouse. Flats of Ebenezer and Sweet Spanish were later taken to a greenhouse maintained between 60° to 70° F.

The last observations were made on these bulbs May 16. A few bulbs, about one in each flat, produced seedstalks, but these were not in sufficient number to be recorded. The same conditions prevailed when the flats had been removed from the 70° to 80° house to one where the temperature was maintained at 60° to 70° F.

The important point to be brought out from this phase of the work is that while samples taken from these flats through January and February showed that flower primordia had been initiated (at the time they were in the 40° to 50° greenhouse), almost no development of flower stalks took place under the higher temperature conditions. That this inhibition of flower stalk development at 70° to 80° F. was of permanent nature is substantiated by the fact that a later transfer from 70° to 80° F. to 60° to 70° F. did not remedy the situation. Examination of these bulbs showed that the floral primordia had been damaged during their early stages of development within the bulb. This damage amounted to a shrinking and withering of the new-formed floral axis. These parts turned brown in the later stages.

Effect of Length of Storage on Seedstalk Development

In Experiment I different lengths of storage were used. Bulbs from the first experiment were all planted at the same time. Because length of storage and time of planting must be correlated, the two will be discussed together.

No significant differences were discovered between the response of bulbs stored for 2, 4 and 8 weeks. As previously mentioned, storage treatments, at most, probably influence seedstalk formation only indirectly as they affect primordium initiation.

Summary and Discussion

The experiments discussed were conducted for the purpose of determining the influence of several different factors upon (1) floral initiation in onion bulbs, and (2) development of the seedstalk or inflorescence. The factors in the study were (1) greenhouse temperature, (2) storage temperatuure, (3) photoperiod, (4) length of storage.

Studies were made of the influence of each of the above factors. A study of the significant interactions between the effects of these various factors was also included.

In greenhouse experiments with Ebenezer and Sweet Spanish bulbs, samples were taken from each of the various plots and examined for evidence of floral initiation. Sampling began January 17 and was repeated at approximately 2-week intervals until March 11, a period of about 8 weeks.

A few flower primordia were found in the first samples examined, indicating that floral development had its beginning during early January. Rapid progress in the development of these primordia took place over the 8-week period, with a greater rate of initiation in Sweek Spanish than in Ebenezer.

It should be borne in mind that this experiment did not simulate actual conditions under which onion seed is grown. Under greenhouse conditions, development of primordia might take place earlier than under field conditions. Field work conducted at Parma, Idaho, not reported in this paper, indicates that late February or early March is about the time when primordia may first be found. On the other hand, if bulbs were planted in the greenhouse immediately after harvest in September or late August, there might be reason to suspect earlier initiation of flowers.

Bulbs grown at a 15-hour photoperiod produced a significantly greater number of primordia than did similar bulbs growing under normal day conditions of approximately ten hours. Part of this difference is attributed to the fact that light seemed to be important in helping to prevent rotting of bulbs, particularly Sweet Spanish, in the warm greenhouse.

Bulbs grown at 50° to 60° F. produced the greatest number of primordia. Almost no primordia were initiated in bulbs growing at

70° to 80° F. Floral initiation in bulbs growing at 60° to 70° F. was much less than that obtained at 50° to 60° F.

The most effective storage temperature in inducing floral initiation was 50° F. Almost twice as many primordia were formed in bulbs stored at 50° F. than were formed in bulbs at 70° F. Significantly fewer primordia were formed in bulbs stored at 35° F. than were formed in those from the 50° storage, yet this lower temperature (35° F.) seems noticeably better than 70° F. in effecting floral initiation. From these findings one might be led to believe that, in the production of onion seed, a sudden change from desirable storage or "pre-field" conditions would reduce the possibility of floral initiation and subsequent seeding. However, such a situation is unlikely in actual practice. Bulbs are planted either in the fall or in early spring. If planted in the fall, conditions will parallel, in part at least, those which have been shown to be best in the foregoing experiments, and a sudden rise in temperature before primordium initiation would be a rare exception. Spring planted bulbs, we may assume, will have been stored under favorable conditions and in some cases primordia will be present at planting time. Again, in this case as well as with fall planted bulbs, there will be a gradual change in temperature during which time practically all of the floral parts will have been initiated.

The length of the storage period had no effect upon floral initiation under the conditions of the greenhouse experiment. Previous experimental work (8) done under field conditions supports the findings in the greenhouse. If bulbs are planted in the fall, little attention is given to storage since the interval between harvest and re-planting is short and since day and night temperatures a this time of year are conducive to keeping bulbs in good condition. Where spring planting is resorted to, bulbs are stored in cellars or sheds where temperatures are not too low to damage the bulbs. In the seed-growing areas these temperatures will vary, and while temperatures not much below freezing are the rule, it sometimes happens, during the colder winters, that seed bulbs will freeze almost solid during the storage period. While such bulbs are apparently uninjured by this freezing treatment, cases are on record where some "blindness" or failure to produce seed heads occurs. This condition has never been directly attributed to storage conditions, nor is such an assumption an easy one to make. While it has been shown (3) (7) and in the present work storage temperatures around 50° F. are most favorable for subsequent floral initiation, periods at which temperatures may fall below this figure are not uncommon in successful seed growing. This is certainly true whether bulbs are planted in the fall or in the spring.

The fact remains that some time in the life cycle of the onion, conditions must be favorable for floral initiation and subsequent seed production. Thus, even though a range of temperature exists while the bulb is either in the ground or in storage, somewhere within the range is an optimal temperature. "Induction" probably will take place at temperatures lower than, and possibly at higher

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