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APPLICATION OF LOW-TEMPERATURE  
VERNALIZATION TO COLUMN  
STOCKS, Matthiola incana

With bibliographies on vernalization  
and on the production of Stocks

Thesis for the Degree of M.S.  
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Joseph Emery Howland  
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THESIS







APPLICATION OF LOW-TEMPERATURE VERNALIZATION

TO COLUMB STOCKS, Matthiola incana

With bibliographies on vernalization

and on the production of Stocks

by

JOSEPH EMERY HOWLAND

A THESIS

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THESIS



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## INTRODUCTION

Annual types of Stocks make profitable winter and spring greenhouse cut-flower crops in northern sections. Demand for cut-flower stock is greatest in the spring, but the crop is readily sold at any time. The large-flowered, column type has rapidly gained great favor. Quality flower stalks average 26 to 30 inches in height, with the upper 9 to 12 inches densely covered with florets.

Cultural requirements of the column Stocks

A 45° to 52° F. night temperature produces a good plant growth. Setting of flower buds occurs even more readily at lower temperatures. Thus a 30° to 40° F. night temperature is conducive to excellent quality in the crop, but plants then require a growing season of 6½ months.

Time of flowering in Stocks is known to be influenced by temperature, but when this influence is most effective is the subject of much dispute. Many florists claim that a temperature above 65° F. for a daily period of as little as 6 hours is likely to inhibit flowering.

Post (1934) claimed that an exposure to low temperature for 14 days was necessary for flower-bud differentiation, and he maintained that the treatment had little or no effect when applied to plants in the very early or very late stages of growth.

Laurie and Poesch (1939) reported that flowering is hastened by exposing the seedlings (4-leaf stage) for 2 weeks to a 40° F. temperature. They claimed to have produced the same effect by exposing the young plants to slight frosts in the coldframe.

Ball (1941) could not substantiate this latter claim. He allowed

September-sown plants of the Ball Lilac-lavender variety to remain unprotected in coldframes until they were bunched in mid-December after the removal of the chrysanthemum crop. The untreated plants flowered simultaneously with the treated plants.

Zorn and Gaertner (1942), Michigan florists, reported that they regularly expose their September 15-sown Stocks seedlings to the usual fall temperatures in unprotected coldframes until early December. No damage is caused by any ordinary Michigan fall weather, and according to Zorn and Gaertner the exposure does seem to increase the earliness of flowering.

Lasveller and Borthwick (1937) found that a 3-day exposure to low temperatures was sufficient to initiate flower-bud differentiation and to cause a subsequent flowering of all treated plants. Ball (1941) reported that Stocks, after the plants are 5 to 6 inches tall, differentiate flower buds at any time the low temperature requirement is supplied.<sup>1</sup> He claimed that exposure of the plants to low temperatures when they are 5 to 6 inches tall produces a short-stemmed crop. To prevent such an occurrence Ball uses a 50° F. minimum until flower-bud differentiation is completed, after which any temperature above freezing is satisfactory, with the growth rate proportional to the temperature. A 45° F. temperature is the usual minimum, but lower temperatures are employed if the crop is developing too rapidly to flower for a certain market occasion.

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In his Grower Talks for July 1942 Ball reports that even June sowings may set flower buds normally, and he concludes that "perhaps...Stocks belong to the short day class of plants and...temperature is not the vital factor in going blind that we thought it was".



Stocks seeds germinate in 6 to 8 days, even in a cool house. In warm weather the seedlings are ready to be benched within 3 or 4 weeks from seeding, but during the cool, short, dull days of fall growth is usually so slow that 6 weeks are required. Any check in the growth of Stocks severely injures them. They must be transplanted promptly after germination, then grown rapidly in the flats until the third or fourth pairs of leaves have developed, at which time they should be benched.

#### Advantages of direct seeding of Stocks

On March 21, 1942 the author inspected in the West Chicago, Ill. range of Geo. J. Ball, Inc. a gravel-grown planting of a September 13 seeding of the Ball Supreme Pink column variety. Plants benched directly from the seed flat 2 weeks after the seeds were sown were just coming into flower. Those which were exposed to the fall temperatures in an unprotected coldframe until they were benched on November 10 evidently would not flower for another week, while those seeded directly in the gravel had already been in flower for a week.

It would seem that each time the seedling Stocks are transplanted they suffer a severe shock - a check which causes a delay in date of flowering. Growth of Stocks is also seriously delayed if the main roots are curled. Careless planting is the usual cause of root-curl, but in the present study the root-curl condition was observed in plants subjected to a vernalization treatment which produced a characteristic root development during the period of storage. Affected plants were observed to grow much more slowly, to flower at a much reduced height,

and to possess stems too weak for the flowers to be classified as quality spikes. The severity of the root-curl seemed to control the severity of the dwarfing effect. It is thus entirely possible that the seedlings transplanted by Ball may have flowered later than the direct-seeded ones because of a dwarfing effect induced by a root-curl condition.

On Dec. 20, 1941 the author direct-seeded two rows of Henderson No. 3753 Colonial Branching Stocks (variety, Priscilla). The plants were not pinched or disbudded. The first flowers were produced on April 22. Within 9 days the crop was in prime condition for cutting. This was a growing season of  $4\frac{1}{2}$  months from seeding, a gain for this type of Stocks of about 1 week over the usual method of benching from a flat. The growing season possibly would have been shortened even more if the plants did not have to compete for light with the taller Stocks of the regular trial.

Some growers regularly grow their Stocks seedlings in 2 $\frac{1}{2}$  inch pots in an effort to avoid the set-back caused by transplanting, but this practice has seldom proved profitable because even a slight drying of the soil causes a detrimental hardening of the plants. Plants so affected are slow to recover, and they are always later-flowering than normal plants.

## THE GENERAL PROBLEM:

The problem is to reduce the length of the growing season required by Stocks, not just to produce an earlier crop of flowers. An earlier date of flowering is easily obtained by merely advancing the date of seeding a corresponding number of days. While Stocks do not require a high growing temperature, they are relatively expensive to produce because of the long growing season required. The use of artificial lighting to increase the length of day has proven very satisfactory for those growers equipped to provide it, but florists in general have been hesitant about investing in lighting equipment.

Stocks normally require about the following lengths of growing season in Michigan:

| Date of<br>seeding | Date of<br>marketing | Approx. time |
|--------------------|----------------------|--------------|
| July 15            | Christmas            | 5 mo.        |
| Aug. 1             | January              | 5-5½ "       |
| Sept. 1            | February             | 5-5½ "       |
| Oct. 1             | March                | 5½-6 "       |
| Nov. 1             | April                | 5½-6 "       |
| Dec. 1             | May                  | 5-5½ "       |
| Jan. 1             | May 20               | 5 "          |
| Feb. 1             | June                 | 4½-5 "       |
| Feb. 15            | June 15              | 4-4½ "       |



## STATEMENT of PRESENT STUDY

The purpose of the present study was to test the hypothesis that a vernalization<sup>1</sup> by a relatively short exposure - probably of from 2 to 4 weeks - at a temperature of 0° to 5° C. produces an accelerated rate of development in columb Stocks, thus providing the commercial florist with a practical method for reducing the length of the growing season.

Time of flowering of plants produced from germinated seeds exposed to temperatures of 1°, 3°, 5°, and 8° C. for periods of time ranging from 1 to 3 weeks was compared with that of plants produced from untreated seeds.

The investigation was limited to the study of these temperature-time relationships. Factors of relative humidity, light intensity, light duration, and seed moisture-content during the periods of treatment were kept as uniform as possible for all groups of seeds.

Underlying the project has been the idea that the method devised for shortening the growing period must be such that it produces an actual commercial advantage in earliness under conditions practical for use by florists.

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Vernalization may be defined as a process in which the growth processes are artificially (usually by refrigeration near 0° C.) kept nearly at a standstill while the developmental processes progress rapidly, thereby enabling the treated plant to proceed to reproduction more rapidly than normally.

## REVIEW of LITERATURE

In March 1933 the Imperial Bureau of Plant Genetics at Aberystwyth and Cambridge published a bulletin (White and Hudson, 1933) on "Vernalization or Lyсенko's Method for the pre-treatment of seed". Until then little was known of this method or theory. The original papers were available only in Russian, and the very few references in papers in other languages had been extremely brief.

"...the present publication...sets out the theories of Lyсенko and of the other schools of thought, it summarizes the results obtained in Russia and elsewhere as well as the practical applications of vernalization so far as it has been tried. It brings all that information as near as possible up to date."<sup>1</sup>

Excellent, more recent reviews of the literature by Terry (1937), White (1937), Baskin and Grossman (1940), and McKinney (1940) supplement 'Bulletin 17' quoted above.

Lyсенko, an admirer of Mitchurin, first presented his conclusions on vernalization at the 1925 Genetics Conference in Leningrad. This new concept of the interrelationship between the plant and its environment states that reproduction is not a phase subsequent to vegetation, and that hastening vegetative growth does not cause a more rapid transition to the reproductive. The growth process is considered to be

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David Chavich, in his foreword to "Vernalization and phasic development of plants" (Bulletin 17 of the Imperial Bureau of Plant Genetics at Aberystwyth and Cambridge), December 1935.

one of quantitative increase, resulting from nutrition; and it is not in any way connected with cell differentiation, the basis of development, according to Lysenko.

He believes that development consists of a series of qualitative changes, each of which must be completed in its serial order before reproduction is possible. Lysenko also believes that each stage requires for its completion a definite set of external conditions of temperature, light, humidity, and aeration. Experiments seem to indicate that two of the stages can be most readily completed if the germinated seeds are subject to vernalization treatments.<sup>1</sup> Temperature assumes predominant importance in the first stage, light in the second; hence they have been named thermo and photo phases, respectively.

The exact method whereby the influence of vernalization treatments of germinated seeds is transmitted to the succeeding cells until the plant differentiates reproductive organs is still the subject of much discussion. As with much of the investigation conducted on vernalization, the discussions to date have often been based more on theoretical consideration and personal interpretation than on scientific proof.

"The problem is to discover for the variety under discussion all the precise conditions required for the rapid completion of the several developmental phases, and the particular set of factors constituting

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<sup>1</sup>

"vernalization treatment", as used in the present study, designates any definite set of environmental conditions which supposedly would produce the accelerated rate of development of the treated plant.

the environmental conditions playing the greatest part in the process of vernalization."<sup>1</sup>

Lysenko has steadfastly contended that vernalization is acquired in definite stages and that the process is irreversible. Both contentions have been contradicted by numerous investigators. The detailed studies of Lojkin (1936) seem to indicate that vernalization is acquired progressively, and that prolonged treatment after the minimum period necessary neither further shortens the vegetative period nor results in any loss of the vernalized condition already acquired. Reversal of vernalization occurred in the Lojkin studies only when the seeds were subsequently dried or held at high temperatures, never under conditions of the vernalization treatments.

Lysenko has concluded that varietal differences in response to vernalization treatments are adaptations, resulting from long-continued natural selection during evolution. Thus thermo and photo adaptation usually are similar, i.e. northern plants are favored by chilling and long days. The actual amount of vernalization treatment required by any one variety is not a fixed quantity but varies both with the temperature and light conditions of the region in which the variety is to be grown and with those in which the seeds were produced.

#### Practical uses of the vernalization process

That vernalization is a process which can be employed successfully on a large scale in commercial crop production by average farmers has been claimed by Lysenko and his fellow agricultural leaders in Russia.

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Bulletin 17



In 1933 they recommended the vernalization of wheat, claiming that vernalized winter wheat outyielded spring wheats and that durum wheats yielded better when vernalized. Folkeev and Vyrov (1934,1935) reported that during the winter of 1934 special courses were held in the central Volga region to train 36,000 wheat farmers in the use of vernalization. The claim is made that virtually the entire planted area of 300,000 ha. in this region was sown with vernalized seed, resulting in seedling production 2 to 4 days earlier than normal, thicker stands, better root development, and fewer plants without ears at harvest time.

#### Results of vernalization treatments applied to various plants

Lysenko was primarily interested in cereal production, and he and his fellow Russians have conducted their investigations almost exclusively on cereal crops. Few investigators in other countries have studied the effects of vernalization on other than the cereals. The early, unfavorable report of the United States Department of Agriculture (McKinney, Sando, Swanson, et al) evidently discouraged the investigation of vernalization by other American workers, even as to its possibilities for crops other than cereals. True, our growing season is sufficiently long for the production of most field crops without resorting to vernalization, but economical greenhouse production of many florist crops is difficult because of the relatively long time the greenhouse bench-space is occupied. Results of vernalization studies on the cereals indicate that the time required from the start of the

treatment until plants flower is approximately the same as that required from the seeding of unvernialized seeds until these plants flower, but it is much more economical for the florist to store seeds in a refrigerator for a few weeks than to have seedlings occupying greenhouse bench space for this length of time.

Pobedimova (1936,1937) claimed successful vernalization of Cyclamen, both during ripening of the seed and immediately after harvest. Turner (1937) was unable to accelerate flowering in Calendulas by using a 0-2° C. vernalization treatment for 12 and 24 days.

Vernalization methods for plants requiring high-temperature treatment have been studied comparatively extensively in various countries, but this type of vernalization is outside the scope of the present study.<sup>1</sup>

#### THEORETICAL POSSIBILITIES of SUCCESSFULLY VERNALIZING STOCKS

Vernalization studies of other investigators have shown that the plants which produced the greatest response to treatment usually have been those which tend to be biennial in habit. Matthiola is a biennial. The "Ten Weeks" type from which the column varieties have been derived actually is a selection from the biennial type.

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<sup>1</sup>

The decrease in the rate of germination, as well as the increase in the number of seedlings too weak to withstand transplanting, as observed in the present study, indicate to the author that it is unlikely that Stocks require a high-temperature vernalization treatment.

Stocks prefer cool weather and long days. Experiments in vernalizing other plants indicate that such a preference is typical of plants which vernalize by exposure to low temperatures. Honie's (1934) studies already have indicated an apparent response by Stocks to a low-temperature vernalization treatment.

Results of vernalization studies of certain cereals by Purvis and Gregory (1937) indicate that, at least for cereals, there is a minimal number of leaves, after the production of which the plant can flower. In winter varieties of cereals the number is reduced to the minimum only after prolonged low-temperature treatment during seed germination, but in the spring varieties the minimal number is not exceeded, regardless of the temperature during germination. When maximal number of leaves has been produced, flower-bud differentiation occurs in the winter varieties, irrespective of the temperature of germination.

Florists occasionally report abnormally early flower-bud differentiation in some crops of Stocks. Accurate records of any difference in the number of leaves produced by these plants are not available, but presumably these plants did not produce the maximal number of leaves for a late-growing, tall crop of Stocks. Florists believe that the increased earliness of flowering is due in such instances to an exposure to low temperature at some early stage of the crop's development. Exposure to cold thus has apparently reduced the amount of vegetative growth required by these Stocks, possibly to a minimum such as Gregory and Purvis found in the cereals.

## MATERIALS and METHODS USED

The plan of the study was to grow both a spring crop and a winter crop. It was thought that the effectiveness of the vernalization treatments might vary with the time of year. In 1941 a late spring crop, designed to follow a winter crop of column Stocks, was sown on February 15. Growth of Stocks is rapid in the spring because of the greatly increased amount of light available. February 15 is about the last practical date for sowing Stocks in Michigan because later sowings are subject to excessive heat. The spring of 1941 was unusually warm in Michigan, and for a time it appeared that the Stocks would be unable to differentiate flower buds. In planning the experiment it was thought that a late spring crop, which so often fails to flower, might produce flowers only on plants from treated seeds, thereby establishing another value for the vernalization treatments.

The second trial, designed to follow the fall chrysanthemum crop, was made on an October 25, 1941 seeding.

Seeds

The seeds used in the present study were harvested as selection No. 227-90A of the Ball No. 1 Lilac-lavender variety in August 1940 in West Chicago, Ill.<sup>1</sup>

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Appreciation is expressed to George K. Ball of Geo. J. Ball, Inc. for assistance in securing these seeds of known conditions of production, and for providing storage facilities for the seed.

The length of the vernalization treatment required by any one variety varies with the temperature and the light conditions of the region where it is to be grown and with those of the region in which the seeds were produced. Investigators have claimed that seeds may be vernalized during the period of maturation if the weather at that time is cool. These claims have been severely criticized, but at present the idea seems to have been sufficiently substantiated to warrant its acceptance.

Data as to the applicability of pre-harvest vernalization to greenhouse-grown crops are lacking. It would seem possible, however, that investigators will prove the importance to the florist of knowing the climatic conditions under which the seeds have been produced. Earlier maturity because of pre-harvest vernalization of the seeds would reduce the cost of crop production.

Inasmuch as the seeds used in the present study were matured during the summer, they could not have been subject to any pre-harvest vernalization influence. Recently Wort (1941) has claimed that such seeds cannot be vernalized in the thermo phase until the pre-thermo phase - which is normally completed in many seed-producing areas by a natural pre-harvest vernalization - has been completed.<sup>1</sup> Wort believes that the shortest pre-thermo phase occurs in those varieties which require the highest temperature for the completion of the thermo phase.

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Wort based this claim on Vasiljev's report (1936) that some seeds do not respond to vernalization treatments, yet the young plants do respond to a low-temperature treatment.



Each lot consisted of 100 seeds, selected at random from the seed package. Much critical discussion has revolved about the possibility of vernalization in excised, partial, and damaged embryos; hence in the present study care was taken to use only uninjured seeds, and care was taken in handling the germinated seeds to prevent damage to the embryo. Unusually small seeds were also removed. These were sown in 1942 as Lot 96. A sample of the remnant of the seed used in 1941 was sown as a check lot in 1942.

The Ball No. 11 Pink (selection No. 120-90A) and the Ball No. 20 Apricot (selection No. 6-100A) presumably were produced in the greenhouse in West Chicago, Ill. No history is known for the other three varieties used in 1942: Stupp & Walters Gardenia, Stupp & Walters Yellow Wonder, and Waller-Franklin Yellow Wonder.

#### Pre-treatment preparation of the seeds to control molds

Previous attempts by Hoxsie (1934) to vernalize seeds of the column Stocks were unsuccessful because molds killed the embryos during the period of treatment. Seeds used in the present study were soaked in a one per cent aqueous mercuric chloride solution for 10 minutes just prior to the start of the regular soaking period in the vernalization treatments. Preliminary studies indicated that this treatment did not reduce the germination rate of the seeds.

#### Regulating growth rate of the embryo during the vernalization treatment

Preliminary studies indicated that germinated seeds of Stocks do not grow excessively during low temperature storage; hence no attempt

was made to regulate moisture-content of the seeds or to use a retarding solution for the period of soaking.

#### Soaking seeds to initiate germination

Preliminary studies indicated that a 12-hour soaking period at room temperature was sufficient to initiate germination in seeds of Stocks. Accordingly all lots were soaked for this period before being refrigerated. For the period of soaking, approximately 50 cc. of sterilized distilled water<sup>1</sup> were used in 150-cc. beakers.<sup>2</sup>

The seeds were transferred after the period of soaking to sterile petri dishes (100 mm. by 15 mm.) for storage in the refrigerators.<sup>3</sup>

#### Germination of Stocks seeds under water

It may be questioned whether the presence of the 5-8 cc. of water used to rinse the seeds into the petri dishes may have reduced germination of the seeds. In a preliminary experiment seeds of Ball No. 1 Lilac-lavender (selection No. 227-90A) held under distilled water at 5° C. germinated in 6 days. Seeds of Ball No. 11 Pink (selection No. 120-90A) germinated in 3 days when held under tap water at room temperature. Under similar conditions seeds of Ball No. 20 Apricot (selection No. 6-100A) exhibited a 30-per cent germination after 3 days.

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1

True (1914) has shown the injurious effects of distilled water on plant growth, but preliminary studies by the present author seemed to indicate no significant difference in the rate of germination of Stocks seeds which had been disinfected and soaked.

2

Various chemicals may be used to decrease the length of period required to vernalize seeds, but in the present study none of these were used.

3

The last 5-8 cc. of the water were used to rinse the seeds into the petri dishes.

### Aeration requirements of germinated seeds during the refrigeration period

Criticism may be made that the use of the petri dishes precluded the possibility of sufficient aeration for continued growth of the embryos. Wort (1940) refrigerated 20-grain samples of seeds in petri dishes, but he considered it necessary to remove the covers daily to aerate the seeds for a few seconds. Eremenko (1953), reporting that vernalization progressed more slowly in closed jars than in open ones, claimed that free excess of air is apparently necessary, not to increase the oxygen content but to remove the carbon dioxide.

The author, however, considers the air volume of the 100 mm. by 15 mm. petri dish as sufficient for the 100-seed samples for the length of treatment used in the present study.

### Growth of plants at temperatures approximating 0° C.

Germinated seeds of Stocks continue to grow at temperatures of 0-1° C. (fig. 1). Growth of plants at 0-1° C. has previously been reported by numerous investigators.<sup>1</sup>

All who have studied the vernalization process agree that one of the most serious problems encountered in vernalization is that of preventing growth of the seedlings during the time of refrigeration. It is not that this growth damages the seedlings but that the difficulty involved in handling seeds with excessively long sprouts makes planting of them commercially impossible.

McKinney et al (1934), however, reported good stands have been

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<sup>1</sup>

This literature has recently been reviewed in a private paper by the author and will not be reviewed here. The most important of these reports have been included in a supplementary bibliography in Appendix E.



Fig. 1. Growth of germinated seeds of Stocks  
at 1° C.

The 100-seed sample of Ball Lilac-lavender, selection No. 227-90A, sown in new, washed, bank sand in the 3 inch pot, was germinated at room temperature for 43 hours and then transferred to the 1° refrigerator. The photograph was made when the pot was removed from the refrigerator 3½ weeks later.

obtained in wheat when the glaucous were  $1/3$  inch long & the roots 1 inch long, even when the seeds were purposely planted with the glaucous inverted. Lojain (1935) has shown that not only is continued growth of the embryo necessary for vernalization treatments to be effective, but that there are indications that vernalization occurs most readily if growth goes on fairly rapidly. The grain, however, is admittedly slight and it is usually overbalanced by the difficulty of handling large-sprouted seeds.

#### Refrigeration temperatures used in present study

It seemed best to employ refrigeration temperatures near  $0^{\circ}$  C. for Stocks. Accordingly the  $0-1^{\circ}$  C. temperature was used as the basis in refrigeration in the present study, although the effects of temperatures of  $3^{\circ}$ ,  $5^{\circ}$ , and  $8^{\circ}$  C. were also studied.<sup>1</sup>

#### Injurious effects of over-chilling

Chilling beyond the minimum necessary to complete the thermo phase has been claimed to cause a reversal of vernalization. It was thought that in the present study the 3-week period of refrigeration might prove to be excessive, but it was expected that the plan of starting the various treatments at weekly intervals would indicate any such occurrence.

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<sup>1</sup>

Since the photo phase of vernalization was not to be considered in this study, efforts were made to keep the time of exposure and the intensity of the incident light low and comparable for all refrigerators.

#### Addition of water during period of refrigeration

A single thickness of blotting paper was used as a moisture pad in the cover of each petri dish. No additional water was used in the 1941 trial. All lots were sufficiently moist at the end of the 3-week period. Drying did occur, however, in the 1942 trial, especially in the lots stored at 5° and 6° C. Consequently sterilized distilled water was added in 5-3 cc. quantities to the petri dish when the seeds appeared to be insufficiently moist.

#### Prevention of reversal of vernalization

The possibility of reversal of vernalization, especially when the seeds are dried before being sown, has been the subject of much critical discussion. To avoid possibility of error through reversal of vernalization, in the present study all seeds were sown immediately after removal from the refrigerators.

#### Seedling production

The 1941 trial was sown in unsterilized 2-year-old compost on Feb. 15 in a 75° F. greenhouse. Within 24 hours many seedlings had pushed up through the soil. All flats were transferred 2 weeks later to a 48° F. greenhouse. After 2 weeks at the lower temperature the seedlings were spotted in flats. An attempt was made to separate by inspection the single-flowering type from the double-flowering type. Seedlings of Lot 1 (3 weeks at 1° C.) were the healthiest appearing at this time. Only one plant in this lot was unusually small.

It was observed that in many of the smaller plants the roots were slightly to severely curled. This condition evidently was a result of



growth while the seedlings were held in storage in the petri dishes.<sup>1</sup>

The 1942 trial was sown on Oct. 25, 1941 in washed sand in a 50° F. greenhouse. Seeding was again done by the careful use of tweezers since no successful method of drying the surfaces of the seeds sufficiently to permit the use of normal methods of seeding has yet been found for Stocks.<sup>2</sup> Flats were watered with warm water immediately and then placed on an east shelf in the greenhouse. Flats containing Lots 36, 43, 50, 57, 60, 61, 67, 74, 79, 84, 89, 91, 92, 93, and 94 were placed on the west shelf of the same greenhouse. Attention was given to make conditions of light, temperature, and moisture comparable. However, it was very noticeable when the seedlings were benching on Dec. 18 that those from the west shelf (predominantly check lots) were entirely normal in growth habit, while those from the east shelf had produced a growth characterized by brittleness, i.e. the leaves were lost very readily. A soil test by the Spurway system<sup>3</sup> made on these sands the following day failed to indicate any abnormal soil condition.<sup>4</sup>

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Attempts were made in the 1942 trial to eliminate the root-curl condition by sowing the seeds immediately after they were disinfected and soaked, but the technique was not sufficiently refined to warrant its use.

2

The use of diatomaceous earth as recommended for tomatoes by Baker (1941) seemed in preliminary trials to leave the rate of germination unaffected in Stocks, but the rate of seeding was not appreciably increased.

3

Spurway, C. H. 1938. Soil testing: a practical system of soil fertility diagnosis. Mich. Agr. Exp. Sta. Tech. Bul. 132 (2nd revision).

4

It is now believed that the brittleness occurred only in the treated lots, and that it was a boron deficiency symptom, with the lack of boron due to the method of storage of the seeds during the vernalization treatments and to a deficiency of boron in the subsequent sand-culture of the seedlings. Discussion of this conclusion is outside the scope of the present paper.

Each flat received 1 quart of a potassium nitrate-mono basic calcium phosphate nutrient solution in each of five weekly feedings. Leaves were lightly rinsed after each feeding. No additional water was given. The last feeding was made on Dec. 15.

#### Benching the seedlings

Plants of the 1941 trial were benched on April 19 in a west-center tiled bench. Roots were matted together in the flats, but they were rather small and non-fibrous. The plants were benched at a 6 inch by 6 inch spacing immediately as removed from the flats. They were lightly shaded for a week, but those near the door wilted severely, necessitating the removal of all lower leaves on them to reduce the danger of foot-rot infection. Foot-rot was already present in check lot B; hence this lot was grown to maturity in the original flat (fig. 2). Check lots C, D, and E were benched on April 26 in the north end of the east bench of the same greenhouse. The soil used for these was a remnant of that used for the main bench. Root systems of these check plants were much more extensive than those on the plants benched on the 19th, and flower buds had already been differentiated in many plants. The soil in the flats was much drier, resulting in less damage in separating the roots.

The 1942 trial plants were benched on Dec. 16, 1941 in the east-center bench of the same greenhouse as used in the 1941 trial. Plants were benched directly from the original flats (figs. 3 & 4). The bench had previously been check-rowsed at 4 inches. Roots were heavy, well-proportioned, and approximately 1-1½ inches long. All plants exhibited



Fig. 2. 1941 trial check lot B

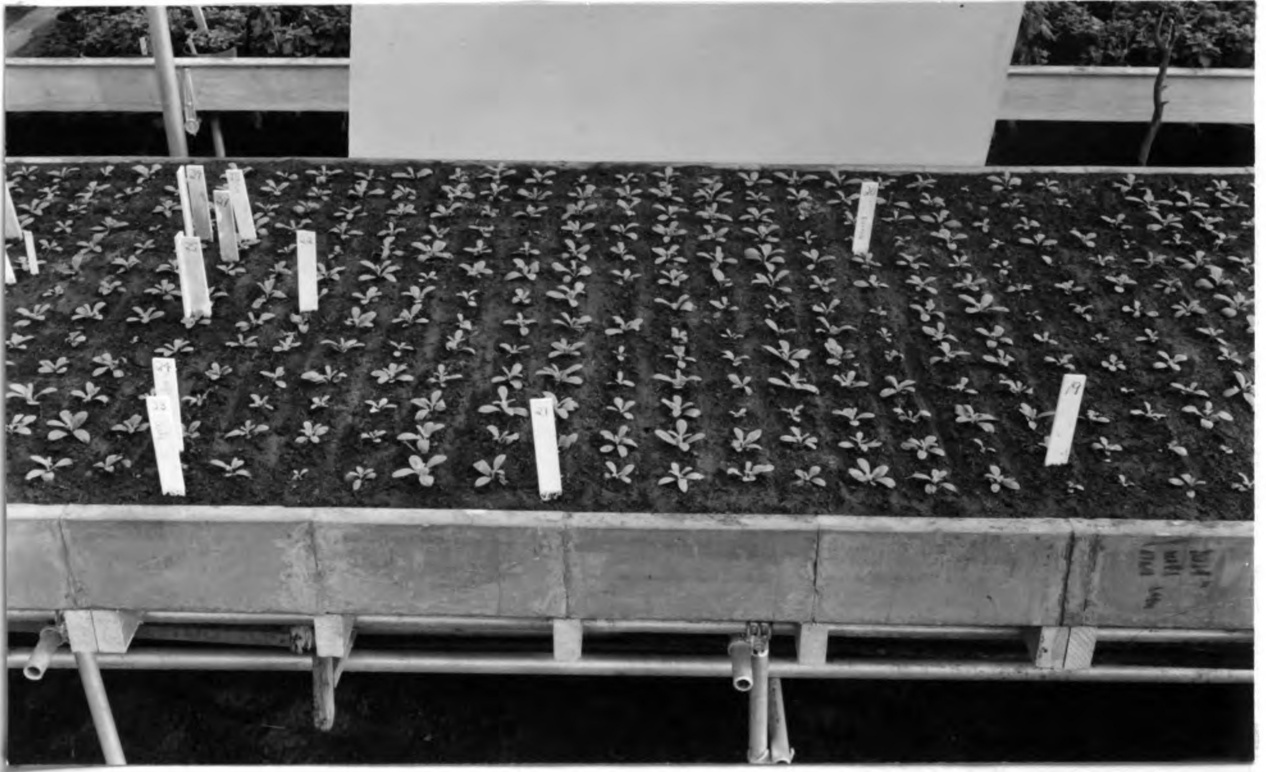


Fig. 3. 1942 check lot seedlings  
at benching time

Benched lots 20 and 21 are  
duplicate check lots 98 and 90.

These seedlings were produced at the standard 50° F. temperature used for Stocks. Florists claim that higher temperatures produce a weakened growth and a greater loss from foot-rot. Improper watering is the real cause of both troubles. It is the author's belief that Stocks should be grown at a 60-65° F. temperature until they are benched, then at 55-60° for the next month, and only then should the temperature be lowered to 50° F. The more rapid rate of growth produced under this system seems to be of considerable value in promoting earliness of flowering. Growth is not weak, and foot-rot is not serious, provided that the soil is new and the watering is done correctly.



Fig. 4. 1942 seedlings at  
benching time

| Bench no. | = | Lot |
|-----------|---|-----|
| 81        |   | 43  |
| 82        |   | 67  |
| 83        |   | 36  |
| 84        |   | 60  |
| 85        |   | 50  |
| 86        |   | 74  |

a slight mildew, the first indication of any disease condition in the 1942 trial.<sup>1</sup>

#### Regulation of greenhouse temperatures

During the 1941 trial an attempt was made to maintain a 45-50° F. night temperature. Day temperatures naturally exceeded on many days the 60° F. maximum desired. Growth of the Stodds, although never excessively soft, was not sufficiently firm to produce stems as straight as desired (fig. 5).

A continuous thermograph record was made throughout the entire life of the 1942 crop from seeding to harvesting. Desired night temperature was 50° F., with 60° satisfactory for day temperatures on sunny days. Plant growth was firm at all times (fig. 6). Given here are monthly and weekly summaries of temperatures for the 1942 trial (tabs. 1 & 2).

Table 1. Monthly summary of greenhouse temperatures  
in 1942 trial

| Month | Days | Hours | Hours at various temperatures |        |        |        |        | Percentage of month at the various temperatures |       |       |       |           |
|-------|------|-------|-------------------------------|--------|--------|--------|--------|-------------------------------------------------|-------|-------|-------|-----------|
|       |      |       | 45-50-                        | 50-60- | 60-70- | 70-80- | 80-90- | 45-49                                           | 50-59 | 60-69 | 70-79 | 80-89° F. |
| Oct.  | 24   | 80    |                               | 56     | 4      |        |        |                                                 | 93.33 | 6.67  |       |           |
| Nov.  | 30   | 720   | 150                           | 419    | 113    | 33     |        | 20.83                                           | 58.19 | 16.39 | 4.59  |           |
| Dec.  | 31   | 744   | 29                            | 529    | 172    | 14     |        | 3.90                                            | 71.10 | 23.11 | 1.89  |           |
| Jan.  | 31   | 744   | 23                            | 559    | 147    | 10     |        | 3.75                                            | 75.13 | 19.76 | 1.35  |           |
| Feb.  | 28   | 672   | 14                            | 445    | 184    | 29     |        | 2.03                                            | 66.22 | 27.38 | 4.32  |           |
| Mar.  | 31   | 744   | 25                            | 510    | 145    | 57     | 7      | 3.36                                            | 66.55 | 19.49 | 7.66  | 0.94      |
| Apr.  | 34   | 80    | 7                             | 42     | 8      | 17     | 6      | 8.75                                            | 52.50 | 10.00 | 21.25 | 7.50      |
|       | 1504 | 3764  | 283                           | 2560   | 776    | 160    | 13     | 6.72                                            | 68.01 | 20.67 | 4.25  | 0.35      |

<sup>1</sup>

On the evening of the 13th the greenhouse had been insufficiently ventilated, resulting in the presence of mildew on all crops.



Fig. 5. Typical weak growth of 1941 trial,  
owing to a combination of over-  
watering and excessive temperatures in later  
periods of development. (Compare with fig. 6).  
Flower spikes typically short and curved.





Fig. 6. Typical firm growth of 1942 trial.  
Soil-moisture and greenhouse temperatures were carefully regulated. Flower spikes were typically elongated, straight, and heavily set with florets.

Table 2. Weekly summaries of deficits and excesses in greenhouse temperatures in 1942 trial

| week | period      | number and duration of temperature variations from<br>desired 59-60° F. |            |           |            |           |           |
|------|-------------|-------------------------------------------------------------------------|------------|-----------|------------|-----------|-----------|
|      |             | 45-49° F.                                                               |            | 70-79° F. |            | 80-89° F. |           |
|      |             | number                                                                  | hours      | number    | hours      | number    | hours     |
| 1    | 10/26-11/1  | 2                                                                       | 12         |           |            |           |           |
| 2    | 11/2-11/8   | 9                                                                       | 61         |           |            |           |           |
| 3    | 11/9-11/15  | 10                                                                      | 47         | 2         | 2          |           |           |
| 4    | 11/16-11/22 | 3                                                                       | 8          | 4         | 21         |           |           |
| 5    | 11/23-11/29 | 4                                                                       | 22         | 2         | 10         |           |           |
| 6    | 11/30-12/6  | 1                                                                       | 3          | 2         | 4          |           |           |
| 7    | 12/7-12/13  | 2                                                                       | 4          | 1         | 1          |           |           |
| 8    | 12/14-12/20 | 3                                                                       | 16         | 2         | 2          |           |           |
| 9    | 12/21-12/27 | 1                                                                       | 3          | 1         | 1          |           |           |
| 10   | 12/28-1/3   | 4                                                                       | 12         | 1         | 6          |           |           |
| 11   | 1/4-1/10    | 6                                                                       | 18         |           |            |           |           |
| 12   | 1/11-1/17   | 1                                                                       | 1          | 3         | 6          |           |           |
| 13   | 1/18-1/24   |                                                                         |            | 1         | 4          |           |           |
| 14   | 1/25-1/31   |                                                                         |            |           |            |           |           |
| 15   | 2/1-2/7     |                                                                         |            | 2         | 3          |           |           |
| 16   | 2/8-2/14    | 1                                                                       | 1          | 6         | 11         |           |           |
| 17   | 2/15-2/21   | 1                                                                       | 3          | 4         | 9          |           |           |
| 18   | 2/22-2/28   | 2                                                                       | 5          | 3         | 6          |           |           |
| 19   | 3/1-3/7     | 4                                                                       | 10         | 5         | 12         | 1         | 1         |
| 20   | 3/8-3/14    |                                                                         |            | 7         | 11         |           |           |
| 21   | 3/15-3/21   | 2                                                                       | 4          | 3         | 6          |           |           |
| 22   | 3/22-3/28   | 2                                                                       | 9          | 9         | 25         | 3         | 6         |
| 23   | 3/29-4/4    | 3                                                                       | 9          | 8         | 20         | 2         | 6         |
|      |             | <u>61</u>                                                               | <u>253</u> | <u>69</u> | <u>160</u> | <u>6</u>  | <u>13</u> |

### Watering plants in the benches

Commercial florist practices on watering were followed in the 1941 trial. Resultant growth of the plants was not of the firmness desired (fig. 7), and foot-rot was serious.

In the 1942 trial the bench was uniformly and thoroughly watered on Dec. 13 as the plants were benched, and subsequently on Dec. 26, Jan. 21, Feb. 14, March 6, 13, 23, 26, and April 3. Sufficient water was applied at each watering so that some of it leached out through the bottom of the bench. No additional water<sup>1</sup> was given until tensionometers<sup>2</sup> indicated about 25 cm. tension of mercury, at which time the regular watering as given above was applied.

### Disease control in the 1942 trial

All plants in the 1942 trial were inspected carefully each week to detect presence of disease. None was ever found. The slight mildew present on the plants when they were benched was eradicated by a sulfur fumigation.

The plants were benched when they had only three or four pairs of leaves, and care was taken to prevent injury to any of these leaves. Special care was taken at each watering to prevent damage to the leaves. Florists regularly strip all leaves from the lower part of the stems in the winter crop to provide the air circulation deemed necessary to prevent foot-rot infection. In the 1941 trial the removal of these

---

1

A light springing of the upper leaves was given on the afternoon of Feb. 22 by an inexperienced workman. Arrangements were immediately made to ventilate heavily during the night to dry the leaves. Only a mild mildew resulted.

2

The four tensionometers were designed, constructed, and supplied by Allen T. Knight of the Department of Horticulture of Michigan State College.



Fig. 7. Weak growth of 1941 crop.  
(compare with fig. 16)

leaves produced neither an observable difference in growth nor a reduction in the amount of disease present. The 1942 crop was checked at 4 inches, an unusually close spacing for Stocks, especially for the winter crop. Leaf growth was exceptionally vigorous; hence the bench area was nearly matted by the leaf growth. Care was taken, however, that watering was done only in mid-morning of a day when the temperature was rising.

#### PRESENTATION of DATA

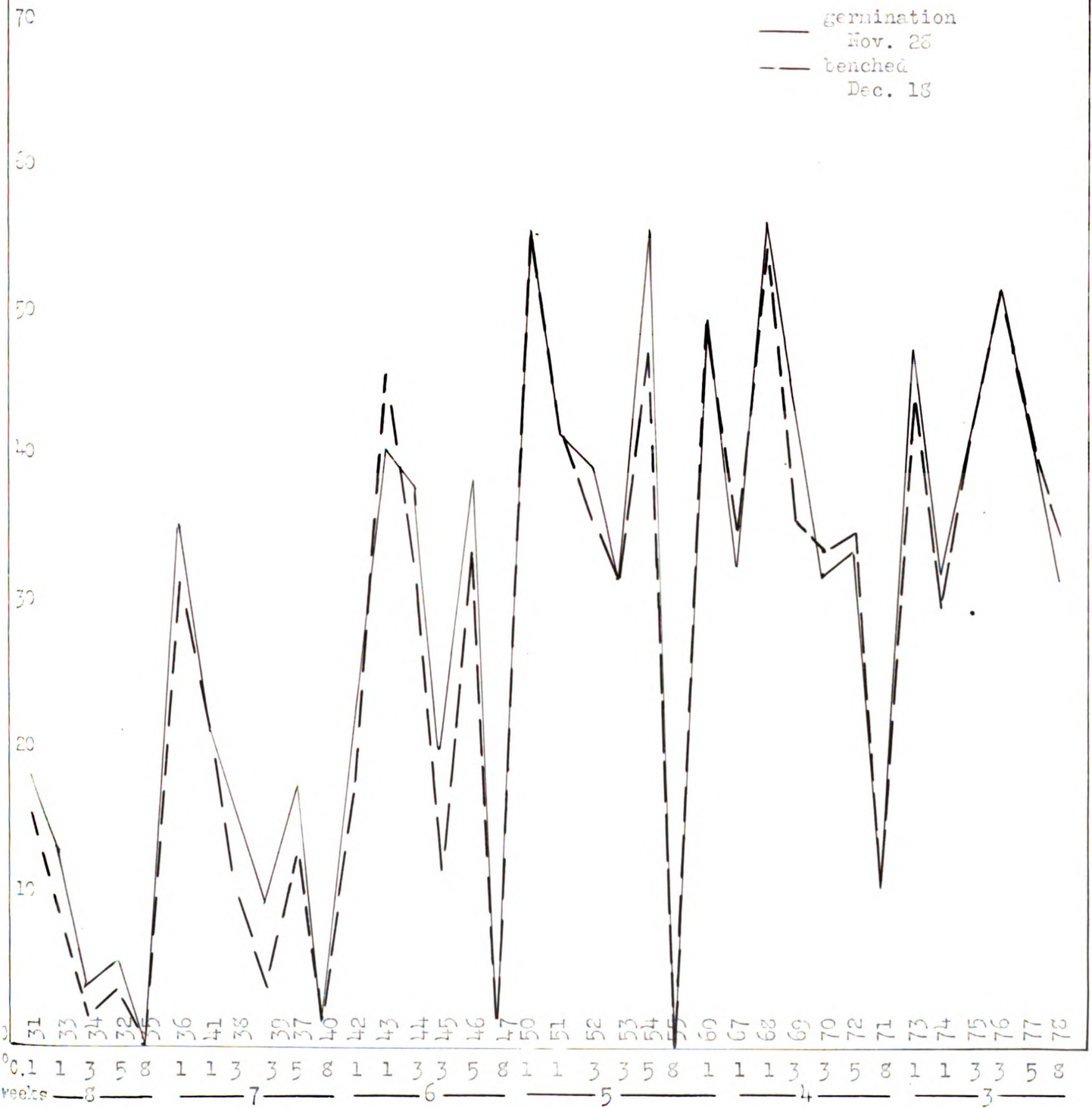
##### Germination and Benching Percentages

Each lot consisted of 100 seeds, selected for apparent uniformity. Germination naturally varied between lots, thus controlling the number of plants matured in each lot. All seedlings which seemed able to withstand transplanting were benched. In no instance did mortality after benching exceed 8 per cent, except in the 1941 lots which were affected by foot-rot.

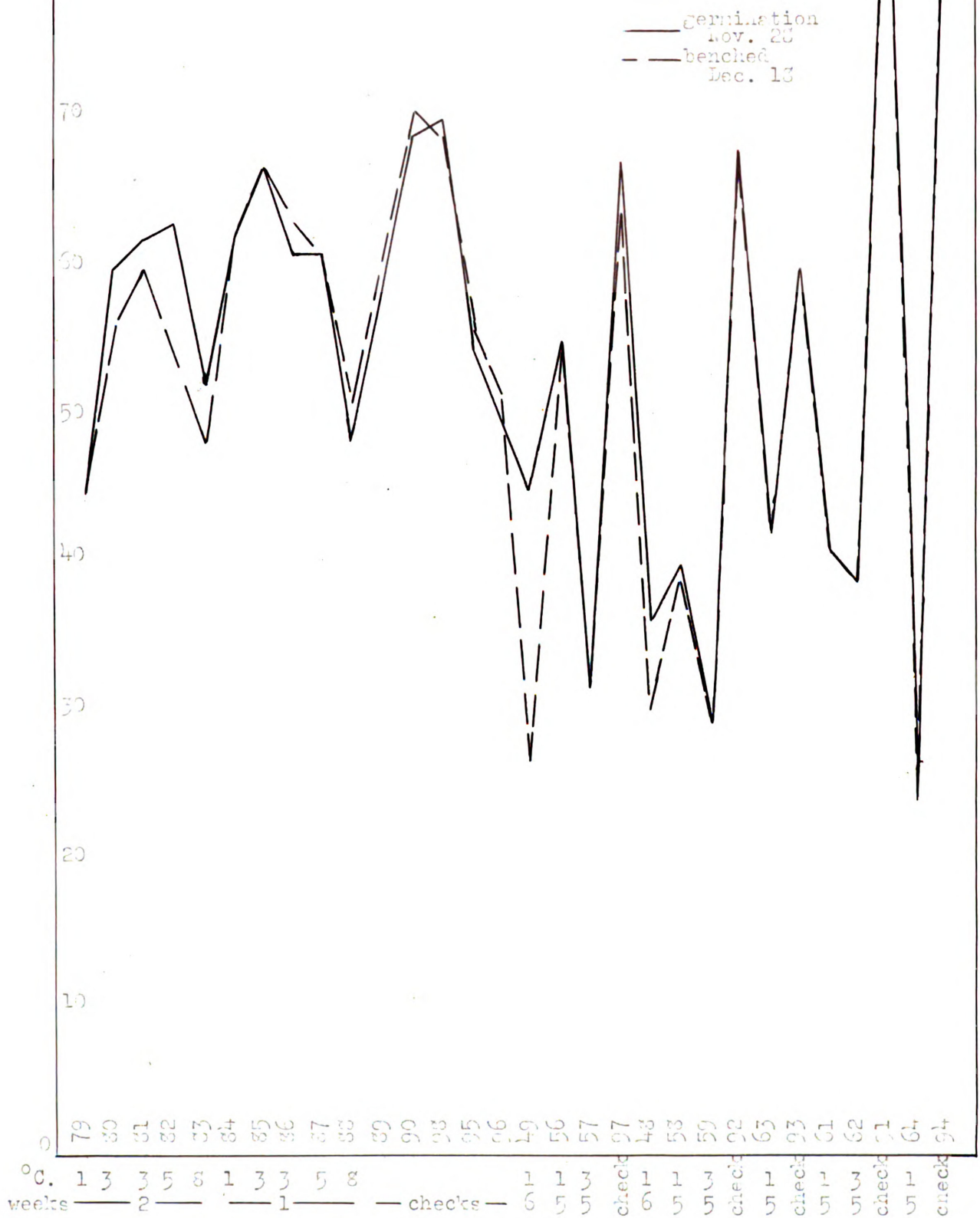
Germination and benching percentages for the 1942 trial (Fig. 3) indicate that germination of treated seeds apparently was reduced progressively as the length of treatment increased, and proportionately as the temperature increased. Seeds of the column Stocks, however, are relatively inexpensive; hence even a moderately severe reduction in the germination percentage would not necessarily render vernalization an unprofitable process. Two-year-old seed gave the same response to the treatments as it had the previous year.

percent

Fig. 8. Germination and benching percentages  
1942 trial



100 96



### Time of flowering

It was assumed that nothing less than a 4 day difference in the time of flowering would be reasonably significant and of commercial importance to the florist.<sup>1</sup>

No significant difference in time of flowering was found in either trial (figs. 9, 10, 11 & 12). The normal 4 day difference in time of flowering of the single-flowered plants occurred in both trials. Percentages of non-flowering plants were also normal.<sup>2</sup> Apparently there was no varietal difference in response to treatments, since the Ball Lilac-lavender variety normally flowers a few days before the Ball Pink variety and approximately 10 days before the other varieties (fig. 13).

### Stem-length of plants

Stem-length is an especially important consideration in determining quality in the column Stocks. Records were made of average heights of the plants in each plot at each date the records for time of flowering were made (figs. 14 & 15). The April 4, 1942, data were computed from actual measurements of each plant in the trial.

---

1

Stocks are usually cut when 8-10 florets have opened. Florets usually open at a rate of at least one per day. In the present investigation it was found too time-consuming a procedure to count as open only those in which 10 florets had opened; hence a plant was considered to have flowered when one floret was fully open.

2

It would seem that the vernalization treatments should first exhibit their influence through a reduction in, or elimination of, this condition, since the theoretical reason these plants fail to flower is that they have returned to the original biennial habit and thus require a period of exposure to low temperatures before they are able to flower.



Fig. 9. Total number of plants in flower  
at various dates - 1941 trial

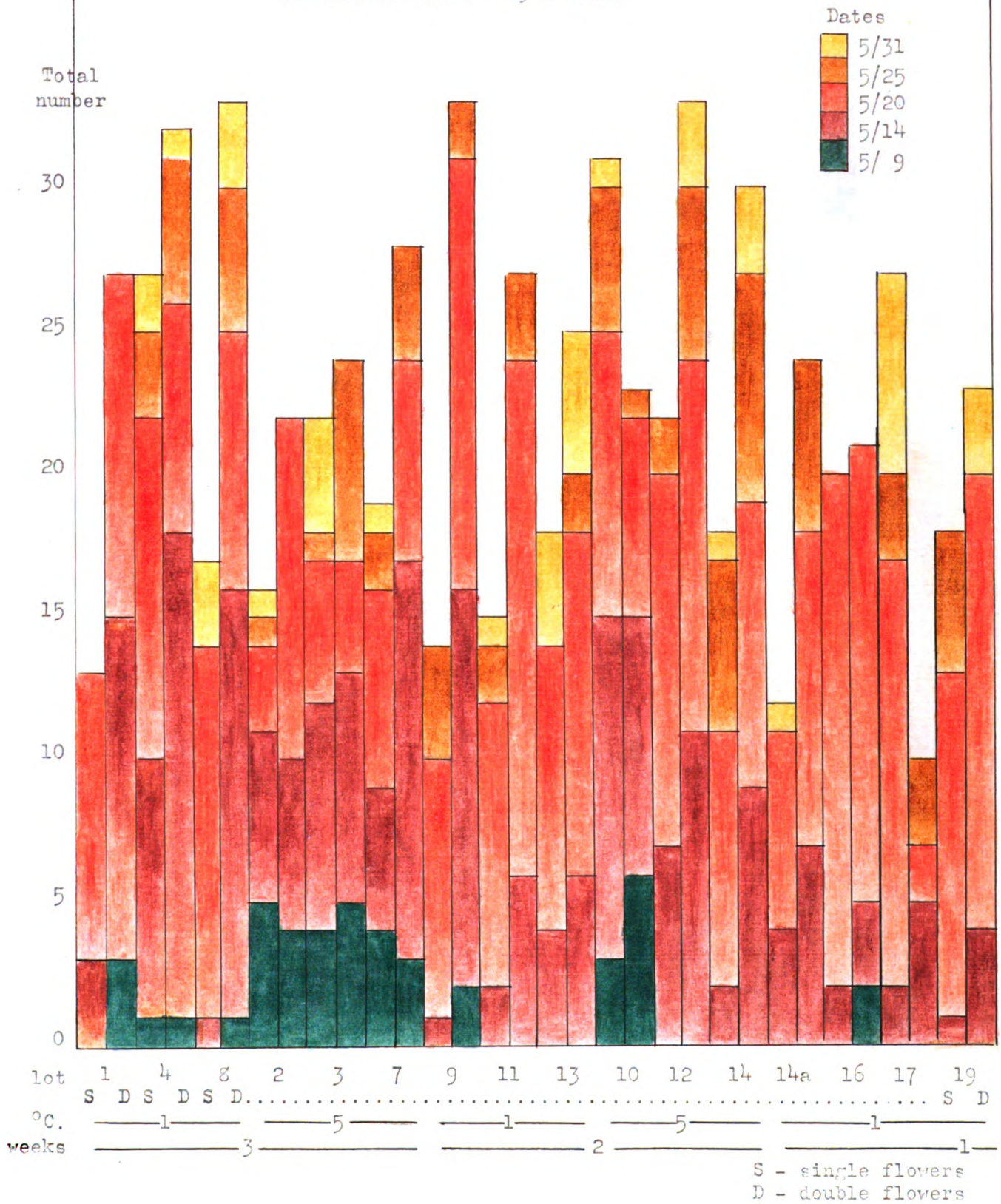




Fig. 9.-(cont.): Total number of plants in  
flower at various dates  
1941 trial

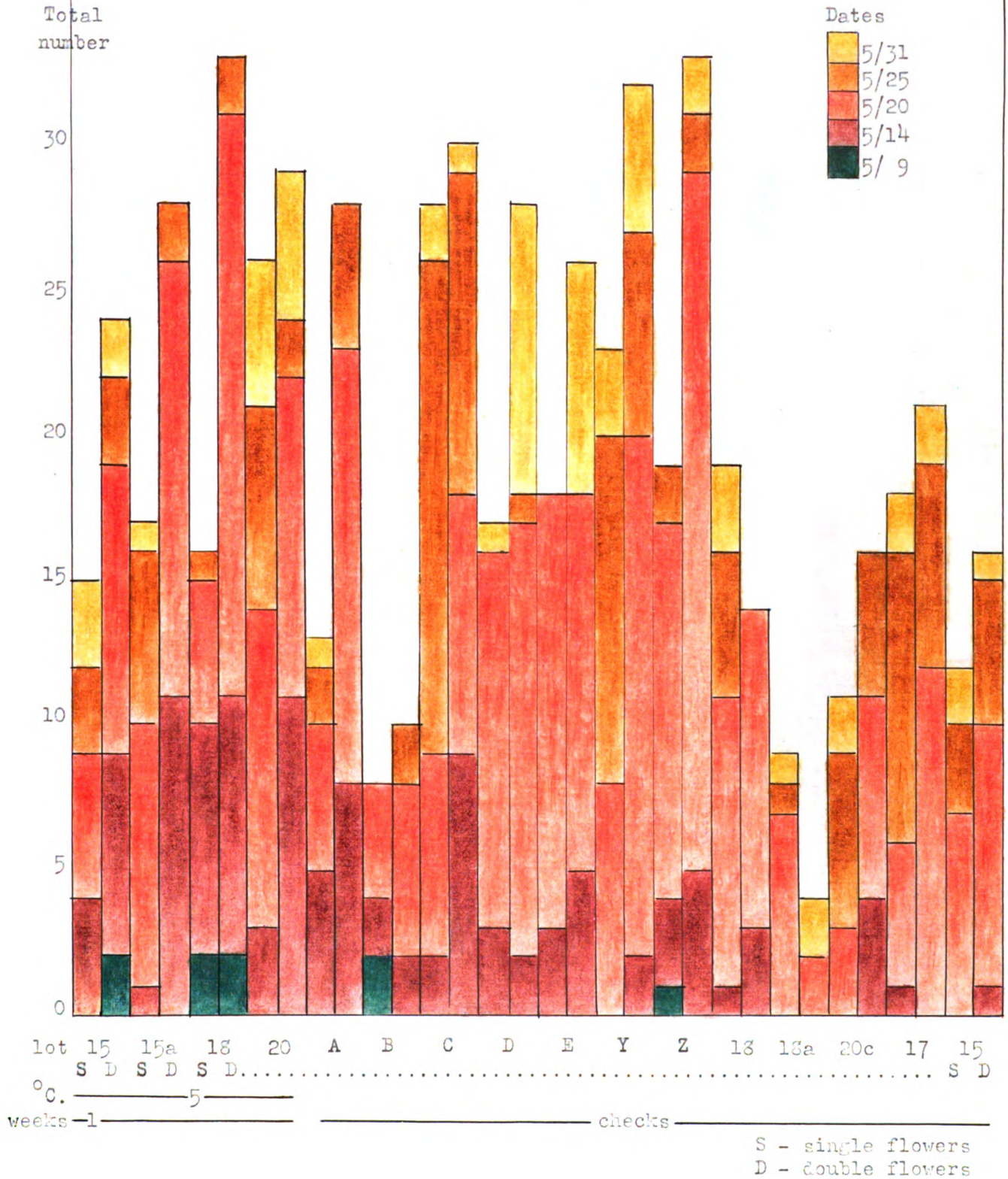
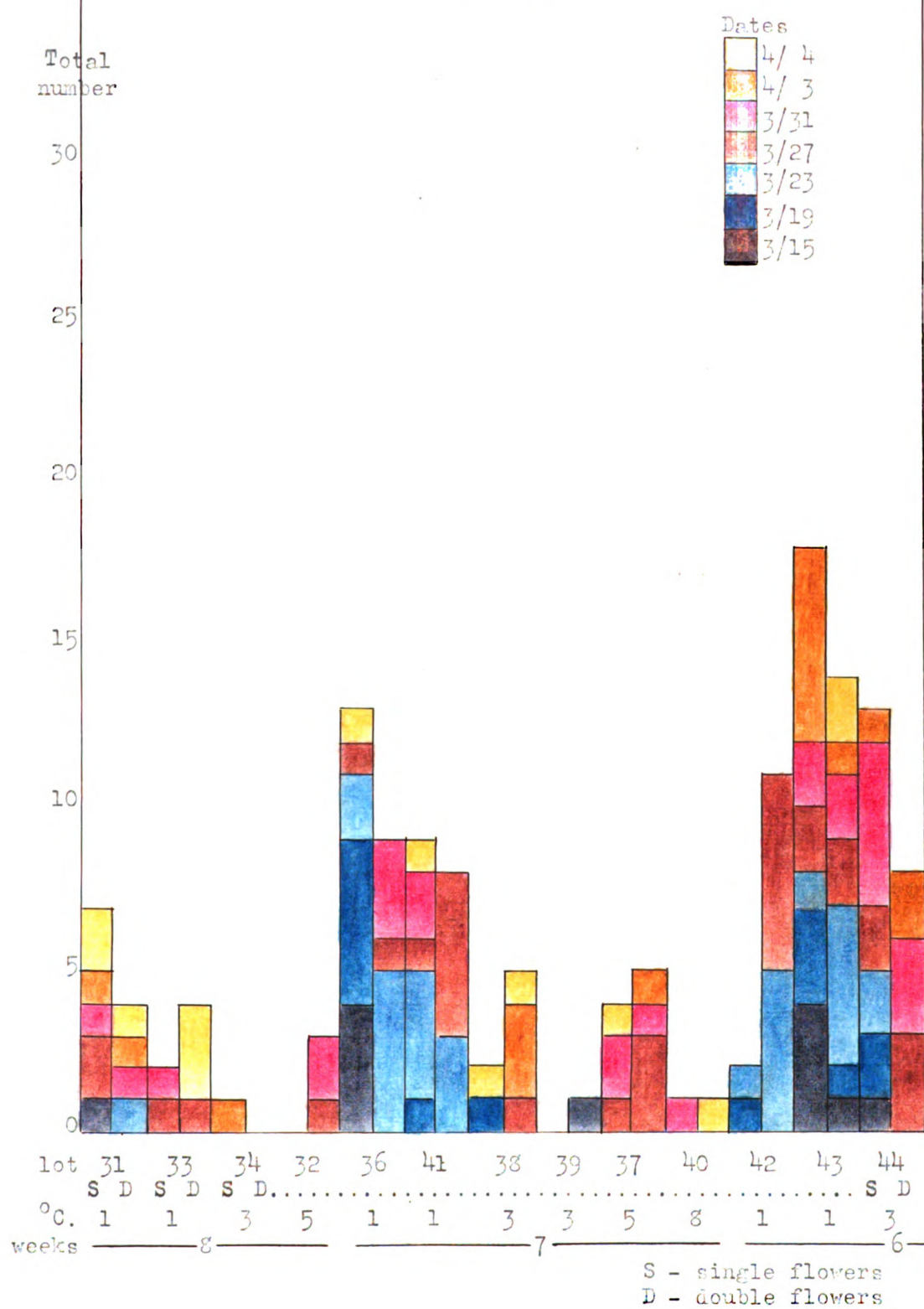
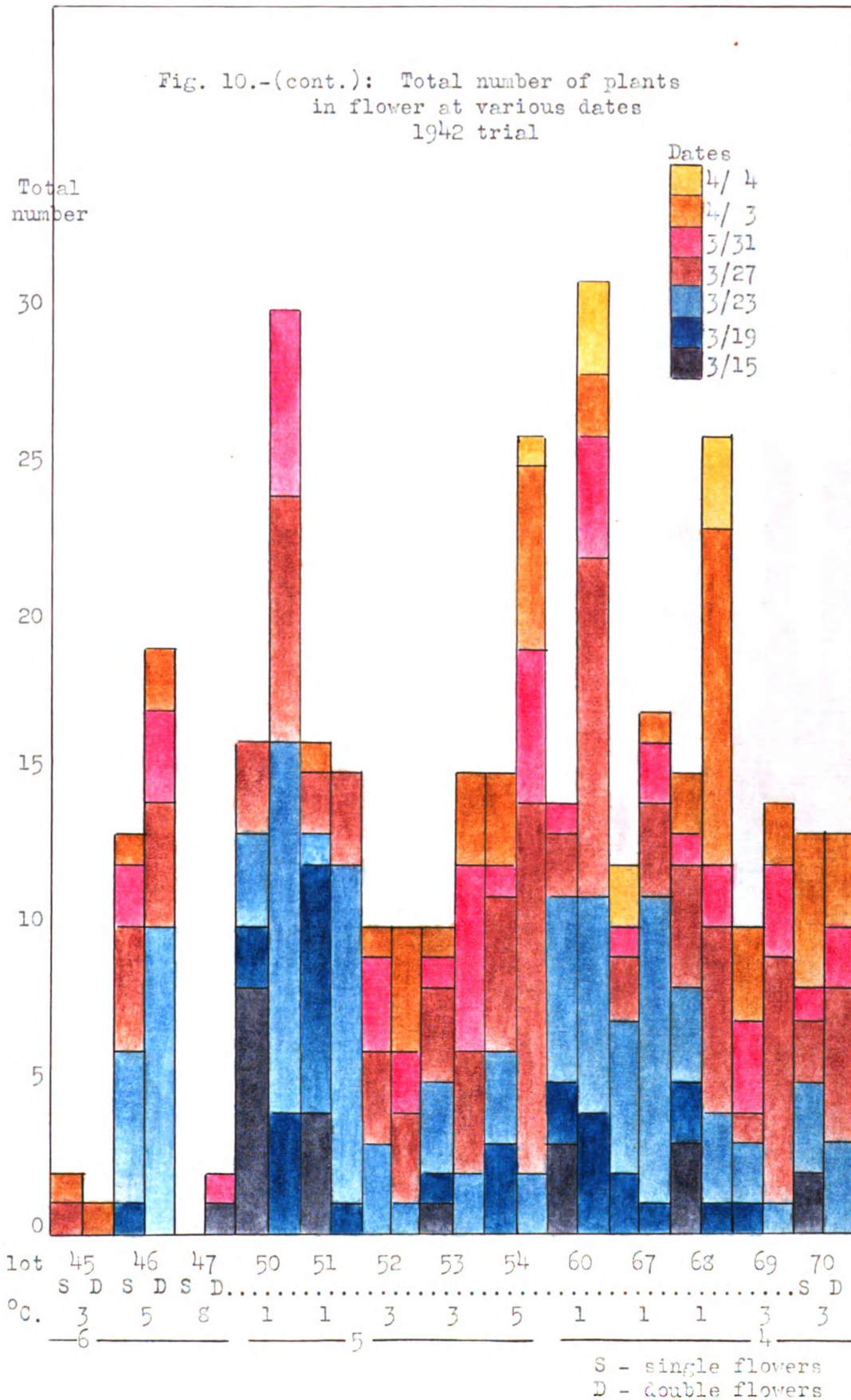
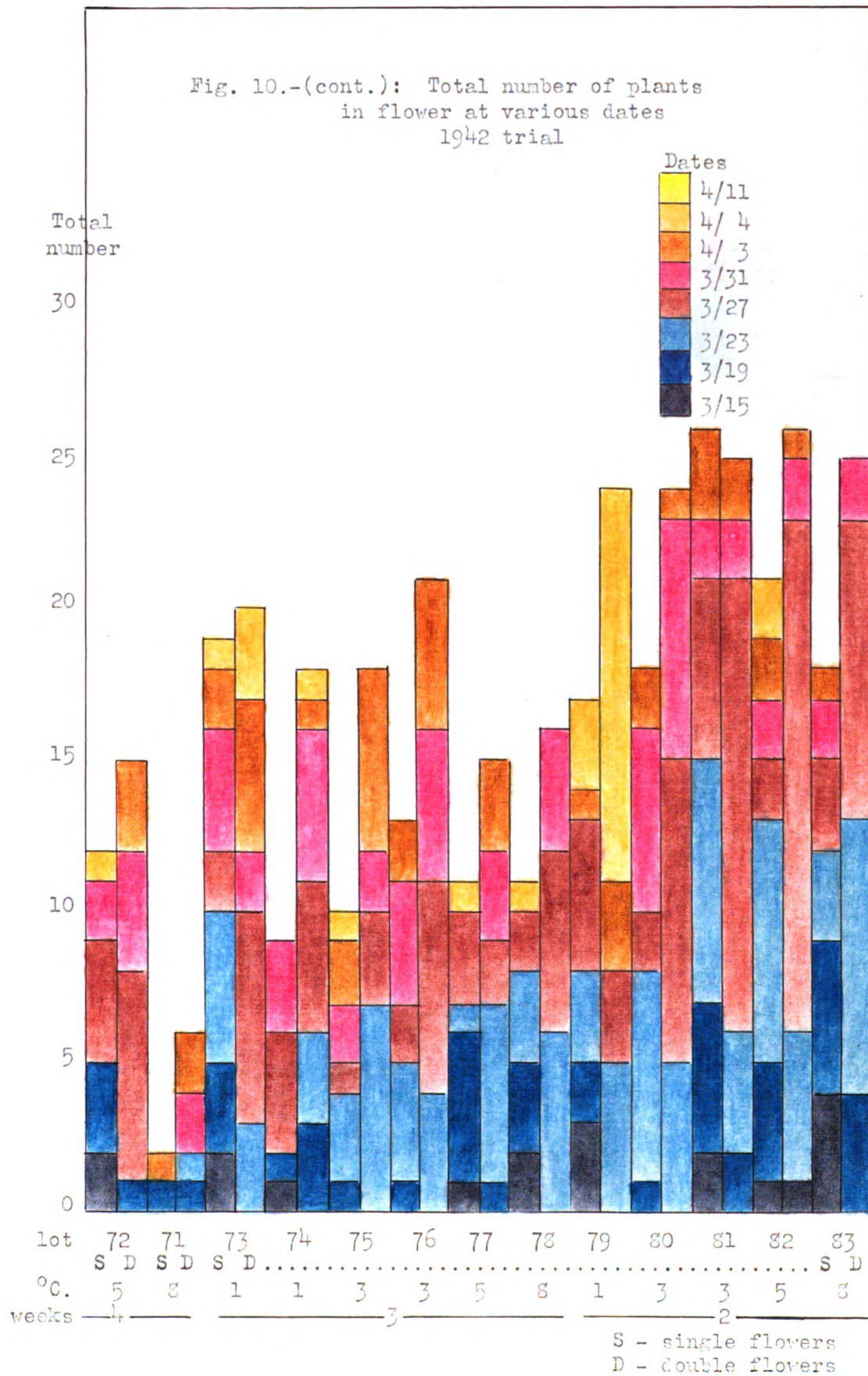


Fig. 10. Total number of plants in flower at various dates  
1942 trial











number

Fig. 10.-(cont.):  
Total number of plants  
in flower at various  
dates - 1942 trial

Dates

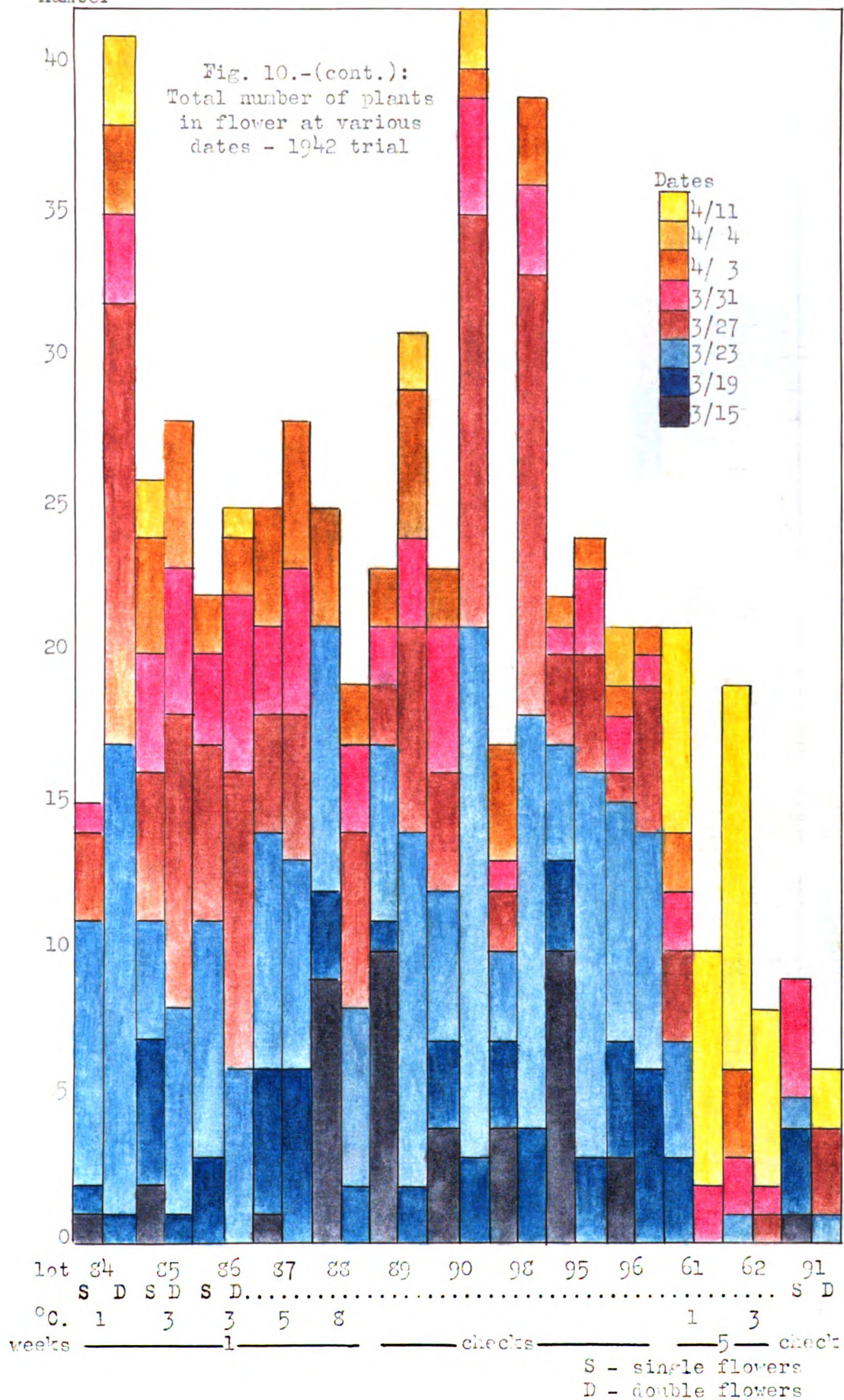


Fig. 10.-(cont.): Total number of plants  
in flower at various dates  
1942 trial

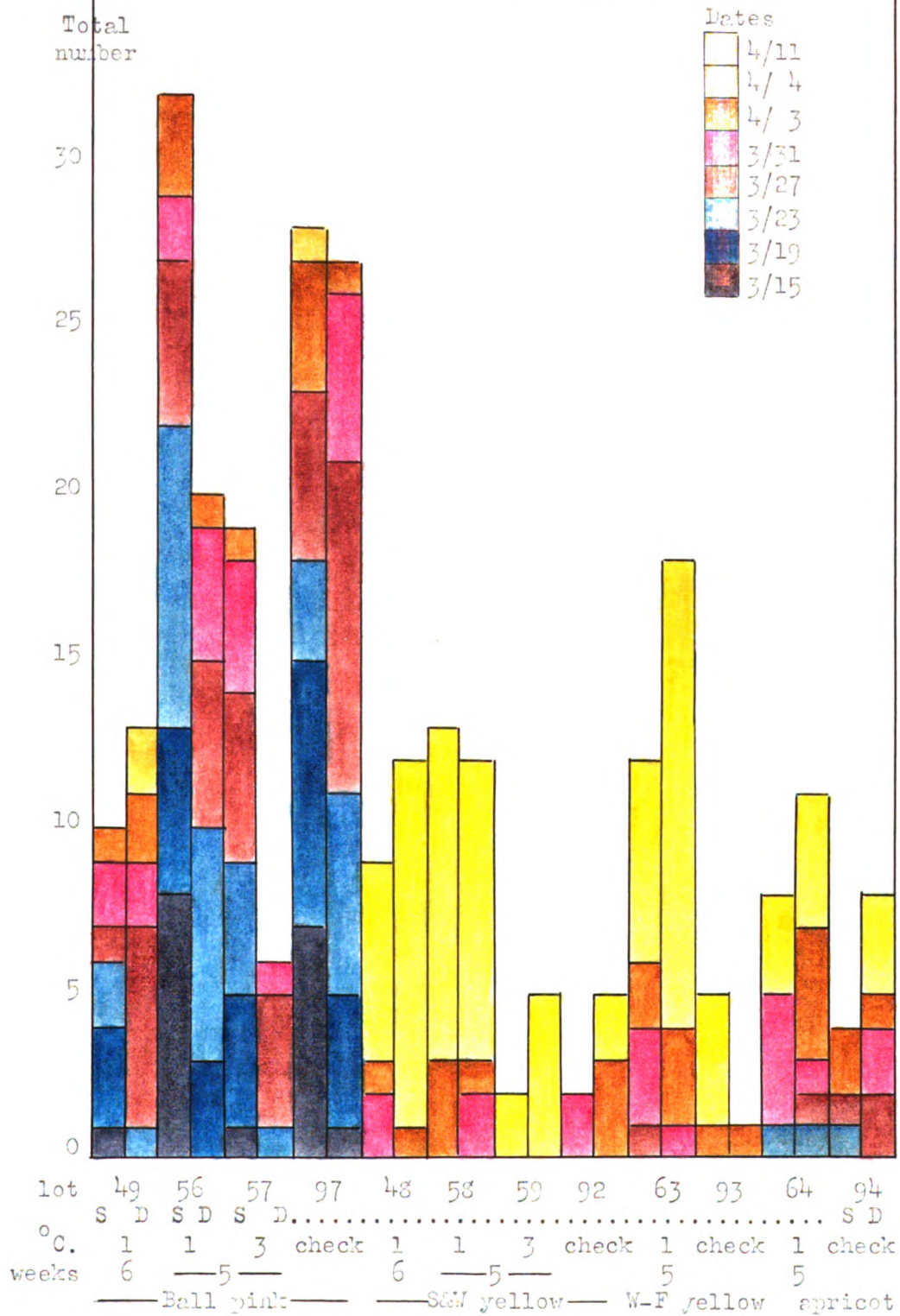






Fig. 11. 1941 crop - May 25, 1941,  
showing uniformity of plants



(444)



Fig. 12. 1942 crop - April 2, 1942,  
showing uniformity of plants



Fig. 13. Varietal response to vernalization

- No. 9 - Stumpy & Walter Yellow Wonder  
6 weeks @ 1° C.
- 10 - Waller-Franklin Yellow Wonder  
5 weeks @ 1° C.
- 11 - Lot 41 - 7 weeks @ 1° C.

Fig. 14. Height of plants at various dates  
1941 trial

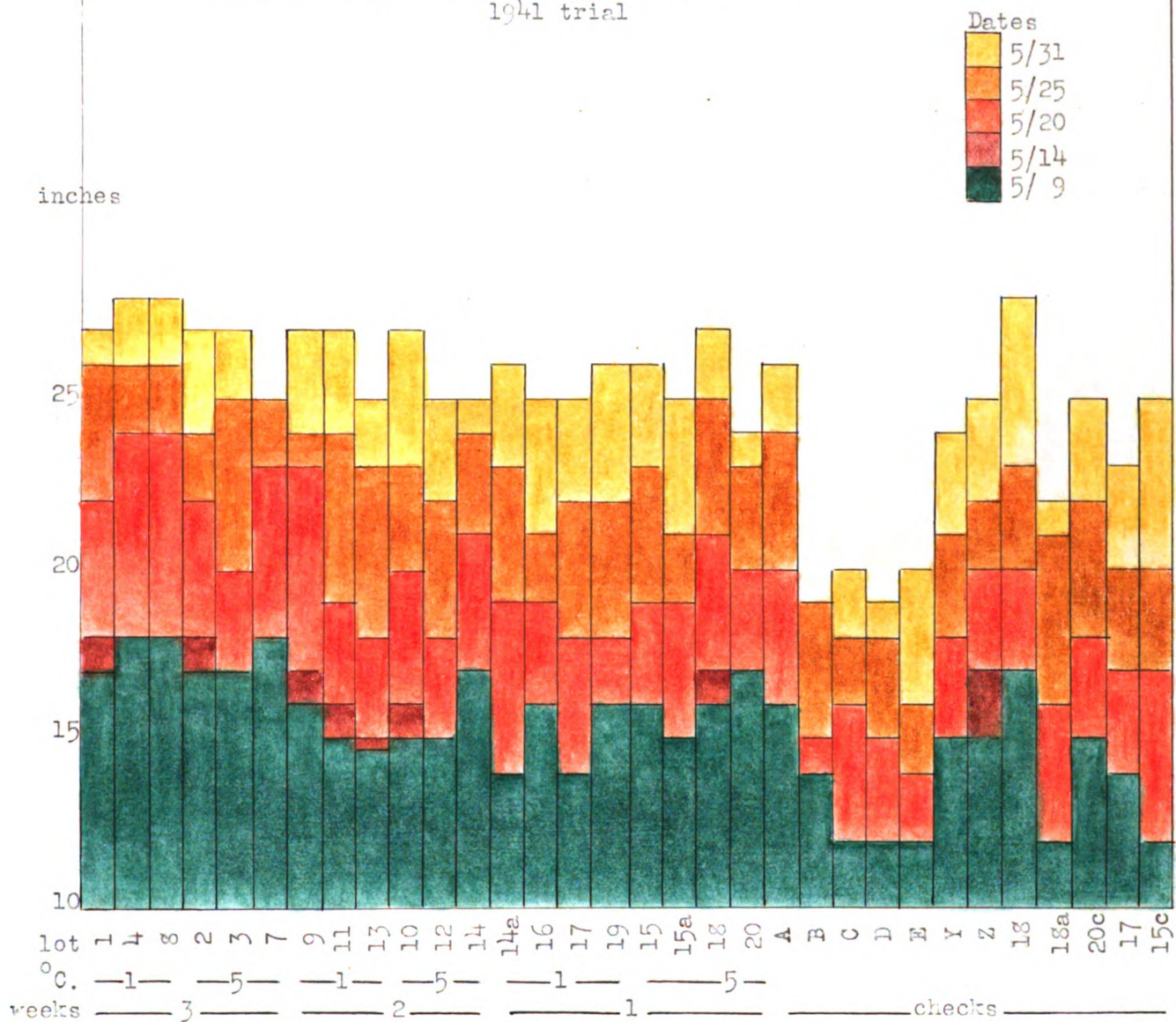




Fig. 15. Height of plants at various dates  
1942 trial

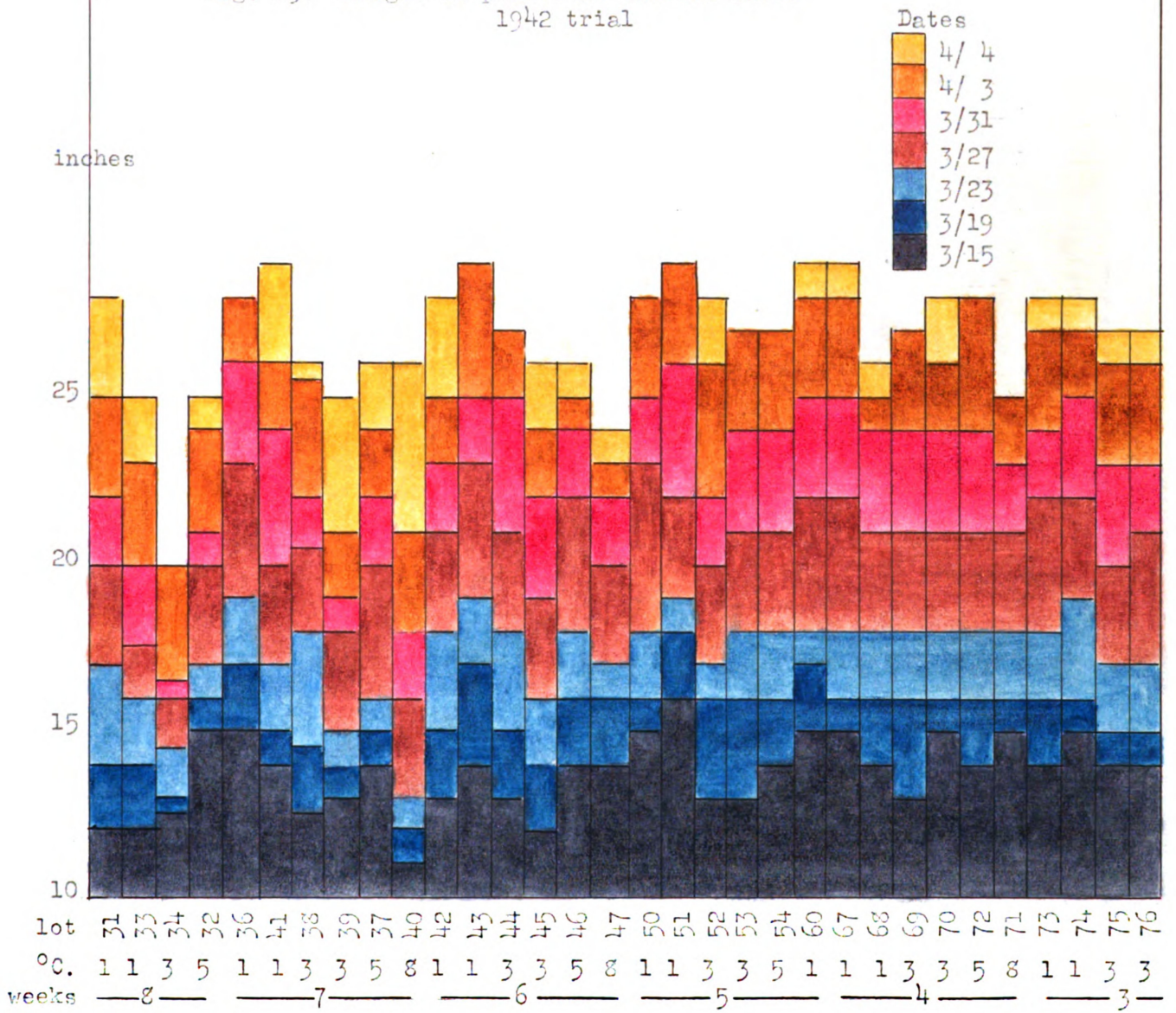
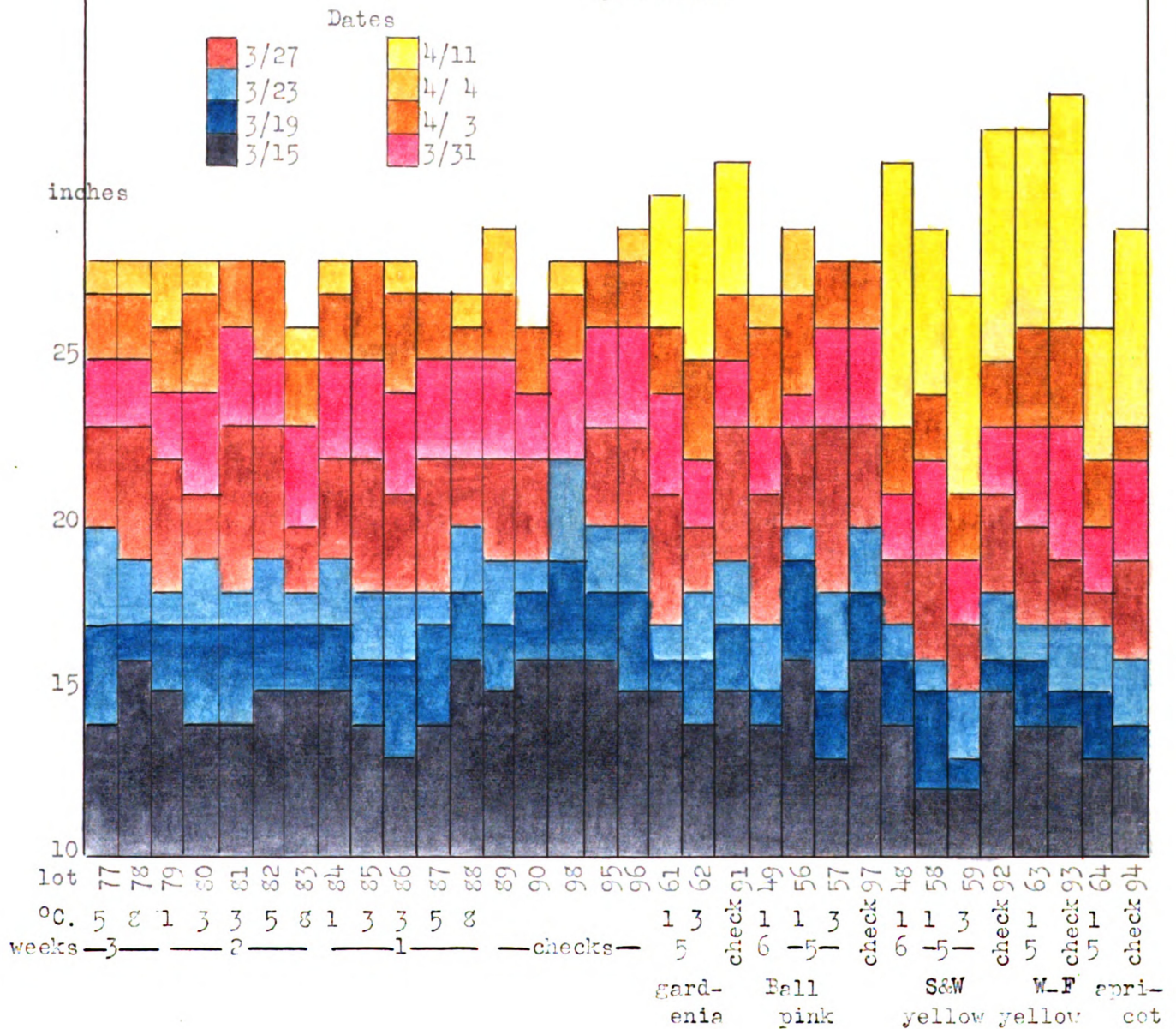


Fig. 15.-(cont.): Height of plants at various dates  
1942 trial



No significant difference due to treatment was found in either trial. The author does feel, however, that the variation between stem-lengths of the flowering plants in Lots 90 and 91, duplicate check lots grown under apparently identical conditions<sup>1</sup>, indicates an excessive lack of uniformity (fig. 16).

Table 5. Flowering plants: April 4, 1942

| lot             | double-flowered  |                      | single-flowered  |                      |
|-----------------|------------------|----------------------|------------------|----------------------|
|                 | number of plants | stem-length (inches) | number of plants | stem-length (inches) |
| 90              | 42               | $26.0 \pm 1.42$      | 23               | $25.5 \pm 2.62$      |
| 91              | 39               | $27.5 \pm 1.51$      | 17               | $26.2 \pm 2.03$      |
| 91 <sup>2</sup> | 31               | $23.8 \pm 1.70$      | 23               | $27.7 \pm 2.35$      |

<sup>1</sup>

Lot 90 was sown 14 hours before Lot 91. The flats were adjacent on the shelf in the greenhouse, and the lots were bunched adjacently.

<sup>2</sup>

Lot 91, a duplicate of Lot 90, was bunched at the opposite end of the bench.





Fig. 16. Duplicate check lots 90 and 93  
April 2, 1942

note extra height of lot 93 (20)

## DISCUSSION

The results of the present study indicate that the column Stocks are unaffected by low-temperature thermo-phase vernalization treatments such as were used in 1941 and 1942. It is recognized that they might have reacted positively if other vernalization treatments had been used, or if the seed had been produced under environmental conditions which made possible the pre-harvest completion of a pre-thermo phase. It is likewise recognized that the results of certain investigators indicate that vernalization occurs only when the moisture content of the seeds is within a critical range, and that if this is true for Stocks, it may be assumed that the seeds in the present study were subject to vernalization only for the comparatively short period during which the moisture content was within the critical range. Little drying occurred in the lots stored at 0-1° C.; hence these possibly never were subject to vernalization.

It is also recognized that few temperatures were employed, and that those used in 1941 were inadequately controlled. However, from the nature of the problems involved, this study is, of course, of only preliminary and exploratory nature. The immediate objective was the determination of the reaction of column Stocks to certain low-temperature thermo-phase treatments.

Vernalization will probably be of commercial importance to the florists growing Stocks only in that it would seem advisable to use

seed which was produced under such environmental conditions that a natural pre-harvest vernalization could occur. The use of such seed, combined with a method of seedling production in which the plants are bunched directly from the seed flat at the end of the third to fifth week, probably will produce at no added expense an earliness of practical importance.

#### SUMMARY

- 1 Column Stocks of five commercial varieties were unaffected in time of flowering in 2-year trials of certain low-temperature thermo-phase vernalization treatments.
- 2 Seed germination was materially reduced by the treatments, with the reduction increasing progressively as the temperature was increased and proportionately as time was increased.
- 3 Age of seed did not influence the response to the treatments.
- 4 There was no varietal difference in response to the treatments.

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Literature relevant to the subject of the study is presented in three parts. The first refers to the literature cited in the text, the second to literature which, although it is not reviewed here, contains valuable information to which the reader could refer, as indicated in the titles, while the third (included in Appendix B) contains separate bibliographies for the following subjects: Stocks and their production, Biological changes associated with vernalization, Effects of chemicals upon the vernalization process, and seed viability and germination at low temperatures.<sup>1</sup>

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1

Where the original paper was not seen by the present author, the following designation has been made:

asterisk: review read in Bulletin 17: "Vernalization and phasic development of plants".

Circle : paper known only by citation of other authors.

asterisk:

Where abstract was read in an abstract journal, this reference has been included with the original.

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## APPENDIX A



## S. A. - 1940 S - 1940 S. A. A.

|                 |   |    | Florida - Florida |             |          |             | Florida - Florida |   |          |   |
|-----------------|---|----|-------------------|-------------|----------|-------------|-------------------|---|----------|---|
| No. of S. A. S. |   |    | S. A. S.          |             | Bottles: |             | S. A. S.          |   | Bottles: |   |
|                 |   |    | Total             |             | Total    |             | Total             |   | Total    |   |
|                 |   |    | inches            |             | inches   |             | in.               |   | in.      |   |
| 64              | 1 | 16 | 7                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 |                   |   |          |   |
| 65              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 66              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 67              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 68              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 69              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 70              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 71              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 72              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 73              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 74              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 75              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 76              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 77              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 78              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 79              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 80              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 81              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 82              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 83              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 84              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 85              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 86              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 87              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 88              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 89              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 90              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 91              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 92              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 93              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 94              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 95              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 96              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 97              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 98              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 99              | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |
| 100             | " | "  | 1                 | 27.2 ± 0.12 | 1        | 27.2 ± 0.12 | 1                 | 1 | 1        | 1 |

## SMALL-LENGTH - 1944 TRIAL

| Lot                | Temp.<br>°F. | Pace | Flowering Plants |                  |          |                  | Non-flowering |               |          |               |
|--------------------|--------------|------|------------------|------------------|----------|------------------|---------------|---------------|----------|---------------|
|                    |              |      | Singles:         |                  | Bunches: |                  | Singles:      |               | Bunches: |               |
|                    |              |      | Total            | Height<br>inches | Total    | Height<br>inches | Total         | Height<br>in. | Total    | Height<br>in. |
| 86                 | 1            | 7    | 17               | 26.0 ± 1.60      | 41       | 26.4 ± 1.60      | 2             | 20.5          |          |               |
| 86                 | 3            | "    | 20               | 26.0 ± 1.71      | 89       | 26.0 ± 1.73      | 7             | 18.3          | 3        | 21.7          |
| 86                 | "            | "    | 22               | 26.2 ± 2.40      | 85       | 27.0 ± 1.50      | 0             | 18.1          | 1        | 25            |
| 87                 | 5            | "    | 25               | 27.3 ± 2.59      | 23       | 27.2 ± 1.70      |               |               | 1        | 10            |
| 88                 | 5            | "    | 25               | 27.1 ± 2.10      | 18       | 27.3 ± 2.31      | 3             | 13.8          | 1        | 13            |
| 89                 | check        |      | 23               | 27.7 ± 2.30      | 51       | 28.0 ± 1.70      | 0             | 15.8          | 1        | 34            |
| 90                 | "            |      | 23               | 25.8 ± 2.82      | 42       | 26.0 ± 1.40      | 3             | 20.3          | 1        | 24            |
| 90                 | "            |      | 17               | 26.2 ± 2.00      | 39       | 27.0 ± 1.71      | 8             | 18.3          | 3        | 24.5          |
| 95                 | "            |      | 22               | 26.9 ± 2.60      | 24       | 26.4 ± 1.22      | 5             | 16.0          | 1        | 25            |
| 96                 | "            |      | 21               | 27.2 ± 1.97      | 21       | 26.7 ± 1.57      | 1             | 10            |          |               |
| 99                 | non-         |      | 4                | 30.7 ± 3.71      | 1        | 30               | 1             | 17            |          |               |
| 01                 | standard     |      | 2                | 31.5 ± 0.50      | 0        | 31.3 ± 2.75      | 1             | 10            |          |               |
| 100                | lots         |      | 16               | 29.0 ± 2.00      | 10       | 31.3 ± 2.05      |               |               |          |               |
| Ball Pink:         |              |      |                  |                  |          |                  |               |               |          |               |
| 40                 | 1            | 40   | 10               | 27.3 ± 2.32      | 13       | 26.7 ± 2.12      | 2             | 17.7          |          |               |
| 56                 | "            | 35   | 30               | 27.4 ± 2.30      | 89       | 27.0 ± 1.17      | 2             | 17.7          |          |               |
| 57                 | 3            | "    | 10               | 27.3 ± 2.70      | 0        | 27.5 ± 1.10      | 1             | 17            | 3        | 24.0          |
| 67                 | check        |      | 20               | 27.1 ± 3.31      | 27       | 27.0 ± 1.21      | 7             | 15.4          | 1        | 24            |
| S+W Yellow Wonder: |              |      |                  |                  |          |                  |               |               |          |               |
| 40                 | 1            | 40   | 9                | 30.0 ± 1.30      | 12       | 30.3 ± 1.27      | 0             | 18.0          |          |               |
| 56                 | "            | 35   | 13               | 29.0 ± 1.30      | 12       | 29.3 ± 2.23      | 7             | 14.1          |          |               |
| 59                 | 3            | "    | 2                | 30.0 ± 0.80      | 5        | 27.0 ± 2.50      | 15            | 27.5          |          |               |
| 62                 | check        |      | 2                | 34.5 ± 0.50      | 5        | 30.2 ± 1.32      | 3             | 16.3          | 1        | 29            |
| W-F Yellow Wonder: |              |      |                  |                  |          |                  |               |               |          |               |
| 63                 | 1            | 35   | 12               | 30.0 ± 3.30      | 18       | 32.0 ± 1.34      | 9             | 20.1          |          |               |
| 93                 | check        |      | 5                | 29.2 ± 5.45      | 1        | 33               | 2             | 25.0          | 1        | 28            |
| S+W Gardenia:      |              |      |                  |                  |          |                  |               |               |          |               |
| 61                 | 1            | 35   | 21               | 29.0 ± 3.11      | 10       | 29.5 ± 2.92      | 5             | 16.3          | 1        | 31            |
| 62                 | 3            | "    | 19               | 28.9 ± 3.12      | 3        | 29.1 ± 1.09      | 5             | 18.3          | 2        | 27.5          |
| 91                 | check        |      | 9                | 32.2 ± 1.12      | 6        | 30.8 ± 2.07      |               |               |          |               |
| Ball Apricot:      |              |      |                  |                  |          |                  |               |               |          |               |
| 64                 | 1            | 35   | 0                | 26.5 ± 3.07      | 11       | 26.4 ± 2.26      | 1             | 17            |          |               |
| 94                 | check        |      | 4                | 26.3 ± 1.40      | 0        | 26.5 ± 1.31      |               |               |          |               |

## NON-STANDARD TREATMENTS

Lot 150 was the remainder of a Sept. 5, 1941 sowing of selection No. 227-30A of Ball Lilac-lavender made<sup>1</sup> for a nutrient bench crop. These plants were 6 inches tall when received by the author. They had been allowed to wilt several times, and were rather severely wilted when benched Dec. 18.

Lots 65 and 66 were 5-inch seedlings of a Sept. 29 sowing of seed of the same lot when they were benched Dec. 18. They had been sown in sand, and had been fed the nutrient solution at irregular intervals. Lot 65 had been spotted once in the original 5-inch pot. Lot 66 was crowded, and had been subject to several severe wilts, the last occurring Dec. 18.

The first flowers on Lot 150 were produced in late February. The lot was ready for cutting in mid-March, the usual time for an early September sowing. Plants of the same lot first flowered under the nutrient culture method in a 50-55° F. greenhouse in early February. This latter crop was ready for cutting Feb. 25.

Lots 65 and 66 flowered only about 3 days earlier than the standard lots, but vigor and stem-length were significantly increased (fig. 17). The increased value of the crop, however, hardly justifies the longer growing season required. The results are worthy of note in that they indicate the value of a rapid growth-rate in Stocks as young seedlings, and they substantiate the author's contention that a 60-65° F. temperature until the plants are benched is to be preferred to the standard 50° F. one.

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1

By John Spooner.



Fig. 17. Non-standard treatments

|        |        |          |
|--------|--------|----------|
| No. 65 | seeded | Sept. 20 |
| 66     | "      | Sept. 20 |
| 150    | "      | Sept. 5  |

## EXPOSURE of 7-inch SPECIMENS to LOW TEMPERATURE

Observation of the growth rates of the benched plants in the 1942 trial until they were 7 inches tall indicated slight possibility of significant difference in time of flowering between lots. At the suggestion of Director V. R. Gardner, benched plants were exposed for a few hours to a low temperature. The intent was to expose them to a  $0-1^{\circ}$  C. temperature for 4 hours.

An insulated refrigeration chamber in which the air from the greenhouse was blown across dry ice (carbon dioxide) was designed. Two rows of plants, to the width of the bench, were included in a treatment. At the time no plants had flower buds in evidence.

A minimum temperature of  $3^{\circ}$  C. was produced in a Feb. 5 treatment. The Feb. 7 treatment included one of the same rows. The minimum temperature was  $0.5^{\circ}$  C., that of the first 3 hours approximately  $1.5^{\circ}$  C., with the temperature then rising rapidly to  $12^{\circ}$  C. when the treatment was discontinued.

Plants seemed unaffected by the treatments. Time of flowering was not affected.

## APPENDIX B

STOCKS (Matthiola incana) and their PRODUCTION

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