with information not only about breeding and new varieties exhibited but also about all phases of the daffodil business in both professional and amateur aspects, as well as much that is commercial.

Daffodil breeding is particularly characteristic of English-speaking peoples. Australia, Madagascar, and South Africa have their associations, their breeders, and their accomplishments. The United States can scarcely be said to have made a start as yet, although Kalifornia (Streator), Chief Seattle (Goodell), Peter Puget (Goodell), and Samuel Goodell (Goodell) are meritorious and to America's credit. The last three were actually named by John Van Aalst after Mr. Goodell gave up the work. Several other breeders are now busy, and it is to be expected that results will follow in due course. Byron Center, Mich., already has some good seedlings in the Barrii group. There have been some notable exhibitions of seedlings, particularly at Forest Grove, Oreg., in recent years. A healthy activity obtains in the vicinity of the District of Columbia. A demonstration of the possibilities has been made at the Bellingham Bulb Station.

There is one line of daffodil breeding that is almost entirely unoccupied and that is badly in need of investigation. The French growers have not undertaken the culture of Paperwhite as the Dutch have that of the hardy narcissus. The large commercial cultures of Paperwhite have not been backed up by new progenies of more virile and improved seedlings which are destined to take the place of the older stocks such as have obtained in the Netherlands.

The Paperwhite is a good variety in its way. It is easily grown, it blossoms early, and it is floriferous. However, in character of flower it leaves much to be desired. It also has a rather narrow range of marketability. The suitability of the bulb for forcing is confined to a round, single-nosed specimen, a range of size that is narrow.

The Paperwhite needs to have character put into its flower, and the fecundity of the bulbs needs to be improved so that the flowering quality of double-nosed or triple-nosed bulbs will be comparable with that of the same categories of Dutch stocks. Without a doubt this can be done. If even these two characteristics already existing in White Pearl were engrafted onto the Paperwhite without losing its early-flowering quality, what an improvement we would have!

This is a job for some one in our Southland to take up as an avocation. Some grower, some horticulturist, or some amateur may take it up as a side line to add zest and incentive to his more prosaic tasks. Such work must be done as a side line, for there is little likelihood of a monetary reward. But there is an opportunity for accomplishment, and there is the prospect of producing a Paperwhite flower with more character and a bulb that will give more flowers, even though it be split and unsymmetrical.

Another opportunity appealing to the writer is an attempt to breed trumpet daffodils better adapted to our warm regions, namely, the Atlantic coastal plain from New Jersey to northern Florida. It is a promising field and also a virgin field. Little or no attention has been given to breeding daffodils adapted to particular climates. Practically all of our varieties have come from Great Britain or the Netherlands. Troubles beset the growers of many

of the old-line varieties in our warmer regions. Who can predict what may be evolved by the use of pollen of jonquils, Campernelles, and their derivatives on King Alfred, Sir Francis Drake, Golden Frilled, and others of the hardier varieties?

A veteran daffodil breeder has advised: "Grow seedlings, pedigreed seedlings if you can, but grow seedlings." It is always better if the breeder has clearly in mind what he hopes to accomplish. His object should be to combine the desirable attributes that exist in the two parents into one. This can be done only by careful and controlled breeding. On the other hand, some of the best varieties we have to-day have resulted from promiscuous crossing or from open, naturally fertilized seed. However, the breeder who intends to stay with the job any length of time needs the best of parent stock and should keep a careful record of all his crosses. Even records of unsuccessful crosses and those yielding no useful progeny are likely to be very useful for future reference.

The operation of making the cross does not differ from the same operation in the hybridization of any other plant. The breeder must, of course, get familiar with the essential organs of the flower, especially the stamens, anthers, pollen, pistil, and stigma. The central organ of the flower is the pistil and its extremity is the stigma. On the outside of this and next to it are the stamens, the distal portions of which are denominated anthers, which contain the pollen.

The operator needs a pair of tweezers and a camel's-hair brush. Really nothing more is necessary, although a needle stuck into the end of a piece of wood, like a penholder, and a pair of small scissors may come in handy. A few watch crystals are very convenient for holding pollen, although pieces of paper are very satisfactory.

To actually effect a cross requires that the pollen produced by one plant be transferred to the stigma of the one that is to be used as the seed parent, the other being known as the pollen parent. It is presupposed that the operation is done in a cleanly manner and that all pollen except that applied has been excluded. To accomplish the latter it is imperative that the anthers be removed from the seed parent before they have opened and shed their pollen. This is usually done in the evening before the flowers to be operated on have opened. At the same time the flower is bagged to prevent visitation by insects which may carry pollen to the stigma from sources not desirable.

Pollination (applying pollen to the stigma) is done in the morning shortly after the flower opens naturally. This is usually 8 to 10 o'clock, after the stigma has secreted sufficiently to make its surface viscid. It is then said to be receptive, and the pollen is ready to use as soon as the anthers open.

The pollen desired is collected on a watch crystal or other receptacle and brushed on the stigma with the camel's-hair brush. The protective covering is again restored for two or three days. In order to insure perfect accuracy, it is also necessary to protect the flower of the pollen parent from insect visitation from before it opens until the pollen is collected. After two or three days the cover over the seed parent flower should be removed and the seed allowed to develop to maturity. The seed is then handled as described on page 52.

This procedure insures accuracy of operation, but some of the steps are often omitted. The protection of the flowers of the pollen parent is not always provided for, and even the protection of that of the seed parent in daffodils may be neglected in case the variety does not seed naturally in the locality. Such omissions save much time and enable one to make a larger number of pollinations. It is always a question whether more seed made or greater accuracy in its making is the more desirable.

The production of daffodil seedlings of quality is a slow process. One can not expect to see a single flower sooner than the fourth year, and it will usually be the fifth before many will be grown sufficiently. Then comes the exercise of judgment as to the desirable individuals and the courage to throw the rest away. Only a very small percentage of the seedlings are commonly worthy of even a second trial; 1 in 100 or even 1 in 1,000 may be a common ratio.

Commonly after the grower has made his selections of seedlings and grown them to the sixth or seventh year from the sowing of the seed, a second elimination becomes necessary, and still more must be discarded for reasons that were not apparent at the first blossoming. It consequently takes six or seven years for the breeder to be sure of the real character of his new seedlings. It is not at all surprising if he grows 1,000 to get 1 worthy of propagation.

At the end of six or seven years the breeder has one bulb which may be two to four nosed. He is then ready to begin working up stock, for, be it remembered, a variety of daffodils is obtained by vegetative reproduction from one seedling. If he continues the growing for 25 to 30 years and gets a doubling of the number of bulbs annually, he may reasonably expect to possess about 1,000,000 bulbs under favorable conditions. Such operation, however, does not usually take place. More commonly the producer begins selling at a high price when the stock has been worked up to a few dozen.

The seed of the daffodil should be planted soon after it ripens. At the United States Bellingham Bulb Station it is planted in August following its maturity the last of June or early July preceding. Its viability is reduced if the seed is held for spring sowing, and if kept a year, less than 50 per cent germinates. Again, much of it may not come up until the second year after planting.

It has been the practice there to plant the seed about 100 to 3 feet of row with the rows 3 to 6 inches apart. One inch deep is about right, and a coarse mulch should be provided to prevent disturbance of the soil during the winter. This should be removed before germination takes place in the spring, so as not to interfere with the plants coming up.

The young plants will die down in late June and should be covered with one-half to 1 inch of additional soil, which is left on during the second year. A mulch, again to be removed in the spring, is applied the second winter. At the end of the second growing season the bulbs should be removed from the seed bed to another location where they may be spaced sufficiently to remain two more years, when they will be large enough to blossom.

Where the quantity of seed is small or where climatic conditions are such that it is impracticable to maintain proper moisture con-

ditions in the open field, it is better to put the seed in pots, pans, or flats, plunged in frames. Suitable moisture and temperature conditions can then be maintained. While it is probable that the bulbs will withstand a certain amount of freezing, it is vastly safer to see to it that they are beyond any possibility of being frozen.

## SOME VARIETAL PECULIARITIES

### GREEN FLOWERS

For some reason not well understood, there is a tendency for the flowers of several of the double-flowered forms of daffodils to turn green. The most notable case is that of Double Van Sion, which all through the eastern United States not only turns green, but the trumpet and perianth split to such an extent that the flower is of little or no value after the year of importation. Even the first year from the Netherlands a considerable percentage of the flowers often come green.

This indicates that Netherlands conditions are far from ideal and that even the Dutch, with generations of experience, are by no means able to produce the variety perfectly. It is reported that with them the percentage of green and badly split trumpets varies from year to year, as it does on Puget Sound. So far as it is possible to judge, there is little difference between the quality of the stocks of this variety from the Netherlands and those from Bellingham, Wash., when grown on soils adapted to them.

While it is not understood what causes such behavior, there seem to be several contributing factors. Heat and drought during the dormant period are possibly the most potent. Proper fertility and soil conditions, especially with reference to drainage and porosity, are also important. There seem to be indications that greater perfection is attained at higher altitudes. It is said that the variety requires heavy soil, but the Whatcom silts underlain by an impervious clay at a depth of 15 to 16 inches are not suited to it. A few indications have been seen which point to the suitability of the fine, fertile, porous, river-bank sandy silts of the Pacific Northwest.

Besides Double Van Sion, some of the double incomparabilis, and occasionally even the Double Campernelle, are offenders in this respect. At times Sulphur Phoenix and some of the other Phoenix varieties as well get quite green. Both Holland's Glory (Double Emperor) and Double Sir Watkin turn green very promptly in the Carolinas, but Double Horsfieldii has remained in good color in the District of Columbia.

After flowers of Double Van Sion have turned green in the eastern United States, it takes about three years to bring them back to the perfection of normal stocks in the region of Bellingham, Wash.

It is very evident that a great deal can be accomplished by selection in the maintenance of color as well as in perfection of trumpet. Both the perfect and half-split trumpets have merit. The characters, however, have not persisted under mediocre methods and poor soil conditions, and there is little certainty in making selections and trying to maintain them unless the cultural conditions are suited.

## VICTORIA SPLITS

Instead of dividing and making a large bulb 12 centimeters or more in circumference by the division of the mother bulb, bicolor Victoria will rather frequently divide into a large number of what are sometimes called ring splits or "horse teeth." (Fig. 37.) Eighty or more bulblets are sometimes formed from a single bulb. What really happens in this excessive propagation is a division of the bulb scales into numerous flat or angled, uncoated bulblets. Hollanders usually advise that such bulbs are "weakened" and should be discarded.

The first time such a propagation showed itself excessively in the stocks of the Department of Agriculture was in a planting of large Victoria bulbs set in the fall of 1914 and dug in 1916. Of these, 15,000 were separated and planted about 50 to the row in August, 1916. In two years they had reached 8 to 13 centimeters in size. To insure flowering it was found that a 12-centimeter bulb was necessary, although an 11-centimeter one would usually blossom, but not always. Subsequent years showed that these mostly split normally after they grow up to about 15 centimeters. This 1916 stock is still carried and is scarcely distinguishable from the parent stock or from selections of normally split bulbs made at the time.

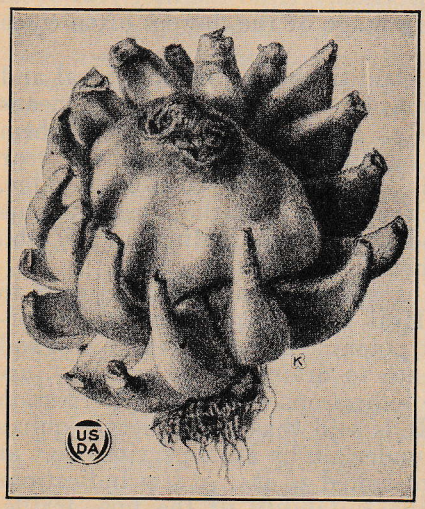

FIGURE 37.—"Horse-teeth" (excessive splitting) of the bulbs of Victoria

The objection to growing the small splits is the length of time it takes to do it. With proper fertility they can be planted 50 to the row and left two years. At this rate, 50,000 to 60,000 occupy only one-sixteenth of an acre. At the end of two years they can be dug and reset 14 and 21 to the row, and at the end of another year they are marketable as single-nosed bulbs. When space, labor, and scarcity of stock are considered, it is not at all certain but that it will pay to grow small splits rather than throw them away. Of course, when the ring splits are very prevalent in any stock they can not be marketed, and whether or not a grower plants his small splits will depend on whether he considers it more economical to take the regular smaller number of large offsets or the larger number of small ones with a longer period for their development.

The desirable thing, of course, and the thing to be striven for, is a stock in Victoria in which the bulbs divide normally by giving large splits which will round up into single-nosed flowering bulbs in one year.

The cause of the excessive splitting has been something of a mystery. Victoria and Paperwhite behave in this way. While the cause of the phenomenon is not understood, control measures are sufficiently

worked out to reduce the difficulty to a minimum if not to eliminate it. The formula for the control seems to be deep planting and good fertility, with always an emphasis on the phosphoric acid and potash elements, especially the former.

## VARIETIES AND CONDITIONS REQUIRING CARE

Care should be the watchword in handling all daffodil bulbs, but the grower will soon learn that some varieties are much more easily bruised than others. Those that have suffered most from rough treatment at Bellingham have been Madame Plemp and Horsfieldii. In one instance 75 per cent of the large bulbs of the first mentioned rotted from too vigorous use of the shaker. Digging was done when the ground was rather wet. Soil clung to the bulbs badly, and consequently the effort to get it off in the shaker proved disastrous. Van Waveren's Giant has been somewhat tender in the same way.

In the eastern part of the United States and other regions having hot summers, special care is necessary with the bicolor trumpets. Victoria has practically disappeared in all the warmer regions. Thorough aeration, quick drying, and careful handling so as not to bruise the bulbs will accomplish wonders. The variety has been successfully grown for three years in Virginia and one year in North Carolina with negligible losses.

A word of caution regarding rough handling in general should be given, because there is a tendency among all growers to disregard it.

## DIFFERENCE IN COST OF VARIETIES

The method of sizing and planting designed to get an even distribution of plant material on the ground has been given in detail on another page. The larger the bulb, the more space must be given to it for development. As an illustration, the planting stock of Empress is very large and must be set 7 to 9 and not more than 14 bulbs to a row, while the planting stock of Pheasant's Eye in experiments in 1919 was all set 21 bulbs to a row. In both of these cases merchantable stocks were produced. In the case of Empress planted 9 to a row the turn-off could not have been more than 9 bulbs, but in the case of Pheasant's Eye it was 21 bulbs or more, or two and one-third times as many. Many comparisons of this kind are possible. The fact that a variety produces a large bulb makes it comparatively expensive to grow.

Another cause of expense in varieties is paucity of reproduction. Desirable varieties that reproduce slowly must be high priced in comparison with those that give abundant increase. The white trumpet, Madame de Graaff, reproduces abundantly, while Peter Barr is shy with its offspring and is also a larger bulb. The latter, if for no other reason, must remain high priced, while the former is a cheap bulb.

King Alfred, for instance, although a good reproducer, must remain a comparatively expensive bulb to grow and force on account of its size. It occupies much more room in the field and about twice as much in the flats as normal-sized Golden Spur.

## CUTTING THE FLOWERS

The production of marketable daffodil flowers from outside plantings is an industry that has existed in this country for a long time. Southern Illinois, tidewater Virginia, the bay region near San Francisco, Santa Cruz, Calif., and to a lesser degree many scattered localities tributary to the large cities have harbored such an industry.

The ventures have proved rather profitable in the past, when stocks were limited and there were but few persons engaged in the business. However, with an increasing number of plantings and the likelihood of flooding any flower market in the country if bulb producers proceed to cut flowers generally, it is problematical just what the future has in store in this line.

On bulb production the effect of cutting off the flower is small. There is some effect, however, because the daffodil stem functions like a leaf. If it is estimated that the stem has half the elaborating surface of a leaf, then the stem represents to the plant one-seventh or less of its entire food-manufacturing capacity. But there is a fallacy in this reasoning, because a plant makes up for a large part of any such deficiency due to removal of its functioning stem area. Besides, the polyanthus grower is very familiar with the growth of 2 feet made by the stem when cut close to the ground as the flowers open. There are no definite experimental data on the subject, but it is doubted whether the loss to the bulb from cutting the flower is over 5 per cent, if, indeed, it is as much as that. Some have estimated it at 10 to 13 per cent.

The largest production of out-of-door cut flowers in this country has been from the cape section of Virginia. This has really been a unique development, conceived originally by a shrewd business woman assisted by her nephew, a commission merchant in Baltimore, where a large percentage of the crop was marketed.

The flowers there were pulled (not cut) from naturalized field plantings of Spurius (Trumpet Major), and allowed to run to grass after one or two years of culture. In the last five years the business of the general region has been placed on a bulb-producing basis, but the cut-flower industry is still pursued, and Spurius flowers are placed on the market in late February and early March from outside plantings.

The flowers in this region are cut (pulled) when well opened and are stood in water for a few hours before being packed. The blossoms are tied in bundles of 25 and stood upright in market baskets which are covered with cheesecloth. The greater part of the product is loaded on the boat in the evening and arrives at destination in the morning in prime condition. (Fig. 38.)

This method of cutting and packing answers very well when the distance is short and the time of delivery prompt, especially with short-stemmed material. With larger varieties a different pack is necessary if the flowers are shipped open. The flowers are tied similarly, but in smaller bundles, with the flowers all facing one way. They are then packed in flat boxes with faces up, a row in the end, then another row just below on the stems of the first. The other end of the box may be packed similarly, but in the reverse manner, so that nearly the whole box is a solid mass of flowers facing upward. One

or more ties are placed across the stems to prevent shifting. This method answers very well for flowers that are to be used immediately.

Most daffodil flowers for long-distance shipment are cut before they open, not only because they keep longer but because the packing is so much less difficult. Figure 39 shows a cut standing in water in preparation for short-distance delivery by truck. Such a cut will all open the next day and be in condition to give the

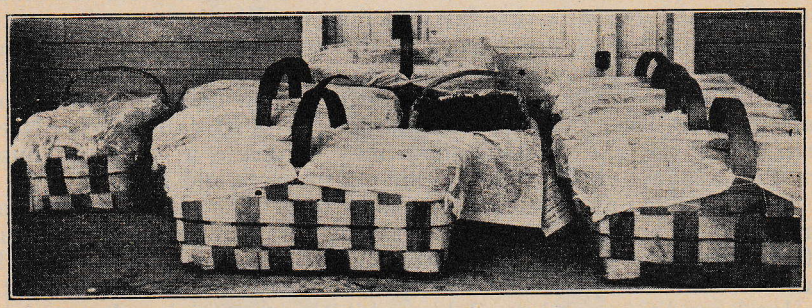

FIGURE 38.—Form of pack employed in getting daffodil flowers to the market from the cape section of Virginia

purchaser the benefit of the full life of the flower. If shipment is made by mail or express, the cut should be made even earlier—not later than the first rupturing of the sheath.

Most daffodil flowers will open in water even if cut a day or two before the sheath is ruptured. At living-room temperatures they develop very rapidly, but if retarded with reduced heat after opening they give their maximum of service. The flowers, cut early and

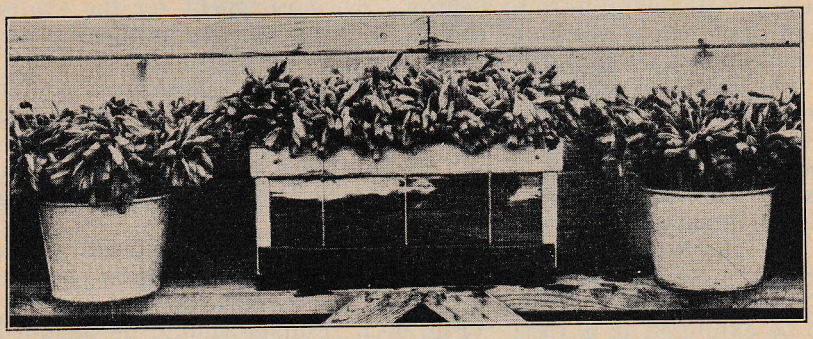

FIGURE 39.—Preparation of cut daffodil flowers for near-by markets in the Puget Sound section

opened in this way, are seldom as large or as perfect as when allowed to open on the plants. They are satisfactory, however, can be enjoyed for a longer period, and may be delivered with less trouble than if it were necessary to wait until the flowers opened on the plants.

The packing of unopened buds presents a minor problem. The cut stems are placed in water for two or more hours after cutting and then packed dry. The stems may or may not be tied in bundles, as one chooses. Each bundle may be wrapped separately in soft

paper and the whole bundle surrounded by waxed paper to prevent evaporation. The different bundles may be placed in the boxes or cartons tightly, so as to prevent shifting, for in tight bud they will stand considerable pressure.

## DAFFODIL SHOWS

The spring daffodil show is doubtless the best agency for the creation of local interest in this favorite flower. We have just begun to make effective use of this agency in this country. The development of interest by means of shows is to be looked for, but this result is only incidental. The value of the information disseminated about varieties and other features and characteristics of daffodils is priceless. In short, the daffodil show may be made a clearing house for the exchange of information among growers and fanciers.

The art of handling such shows so as to get the most out of them can only be acquired through practice. It requires a great deal of study on the part of committees arranging the details of such exhibitions to adapt the classes, prizes, and general arrangements to local conditions and available exhibition materials. It requires still greater skill so to plan that the show will develop greater completeness each succeeding season.

The arrangement of classes will be easily effected on the basis of the classification of the daffodil committee of the Royal Horticultural Society, which is now quite consistently followed. While there is little use in establishing classes of exhibits for such material which is not locally available, it may be desirable to include some such groups in order to stimulate interest and suggest lines of expansion, or the committees can suggest adapted groups which it would be desirable for exhibitors to acquire. Encouragement for the exhibition of unnamed seedlings should be given as soon as there is any possibility of obtaining them for the show.

The details of the staging of exhibits will vary with local preferences, availability of suitable vases, etc., but uniformity rather than diversity should govern in the stagings of any single competitive exhibition. The vases should be uniform and simple, and the exhibits should be viewed against similar background and lighting, else judgments can not be comparable.

The character and arrangement of the exhibition material should be clearly specified so as to attain as great a comparability as possible. This matter may vary, but it is usual for three flowers of a variety to be exhibited in a vase. (Fig. 40.) Foliage should be included, and preferably foliage of the same variety cut to show comparison with the stem. There may be objections at times to the cutting of foliage of expensive varieties; consequently it may be desirable to substitute that of some other.

The preparation of the flower for staging is an important matter. It is not easy for the inexperienced grower to get together in blossom varieties that naturally open at different seasons. No one can get the earliest and latest into blossom at the same time, but it is perfectly practicable to cover a large part of the arc of the blossoming period with flowers open at one time.

The preparation for this should begin at planting time the previous autumn. A great deal can be accomplished by planting later varieties in early situations in the garden. Northern exposure, shady situations, or areas that are cool for any reason will retard


FIGURE 40.—White trumpet daffodils, showing a method of staging for exhibition purposes. A, Madame de Graaff; B, Mrs. Camm; C, J. B. M. Camm; D, Peter Barr

the early varieties, and the opposite characteristics of location will slightly force the late varieties, thus making the flowering simultaneous or closer together.

When the blossoming season has arrived, and some time before the exhibition is to be made, more manipulations are possible to bring

together the varieties that blossom naturally at different dates. Here again the practice is to force the one and retard the other.

Blossoms that are going to be too forward may be cut young, shortly after the sheath has ruptured, placed in water in a cool, dark place, and kept in good condition for two weeks. On the other hand, late ones may be made to open earlier by placing them in a slightly warmer situation where the atmosphere is well saturated with moisture. The proper temperature having been provided, it is not difficult to arrange for the atmospheric moisture. Surrounding the vessels of cut flowers with a tube of absorbent fabric, having its lower end in water, will keep the atmosphere around the plants moist. If this is difficult to arrange, moistening the flowers three or four times daily with an atomizer will assist greatly. Shading the plants in the beds with burlap or other fabric will also serve to retard the development as well as the fading of the flowers.

Daffodil flowers develop best on the plant. All flowers manipulated by cutting and maturing otherwise are usually slightly smaller. Such manipulations are justifiable, however, for the purpose of having the flowers for certain dates, preserving delicate colors, and preventing soiling. All varieties with highly colored cups should be cut as they expand and kept in water and in a much subdued light in order to preserve these colors. In practice, exhibition flowers are mostly opened in subdued light inside.

In changing the flowers from the situation in which they grew to water in a cool place, it is well to bear in mind that the change should not be too great. If the weather is warm, say around 75° F., it would be a great mistake to cut the flowers and place them at a temperature of 45° or 50°. It would be safer to reduce the temperature gradually and finally hold them at 50° to 60°.

Again, some varieties behave differently when cut. The trumpet varieties commonly do not develop in size after cutting in the same proportion as do the poeticus varieties. Experience alone can teach the exhibitor which varieties to cut for development in water and which to shade on the plant for best results, but the experience is soon acquired.

## MALADIES OF THE DAFFODIL

The daffodil is rather free from serious parasites difficult to control. The bulbs and plants are somewhat poisonous; consequently many organisms shun them. Among the parasitic animal forms, however, are three which may become quite destructive unless controlled. These are the nematode *Tylenchus dipsaci*, the narcissus bulb fly (*Merodon equestris*), and the tarsonemus mite (*Tarsonemus approximatus*). The bulb mite (*Rhizoglyphus hyacinthi*) may also infest the bulbs, although it is of minor importance.

There are also various rots which give trouble under certain conditions. When the drainage is poor, the outer coats and often the bases of the bulbs become blackened and putrid, and the plants fail. (Fig. 41.)

In the Puget Sound section, especially on recently cleared land, bulbs that are injured by bad soil or other conditions are often completely permeated by the mycelium of hymenomycetous fungi, giving the impression of parasitism. (Fig. 42.) Often this same

mycelium may be found penetrating the outer coats of perfectly healthy bulbs as a white network of fungous strands. It is not considered parasitic.

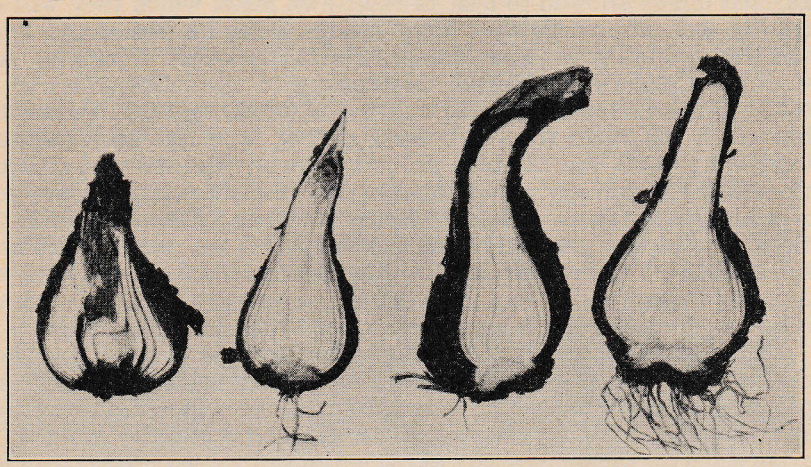

FIGURE 41.—Narcissus bulbs showing various modes and degrees of deterioration due to bad drainage conditions

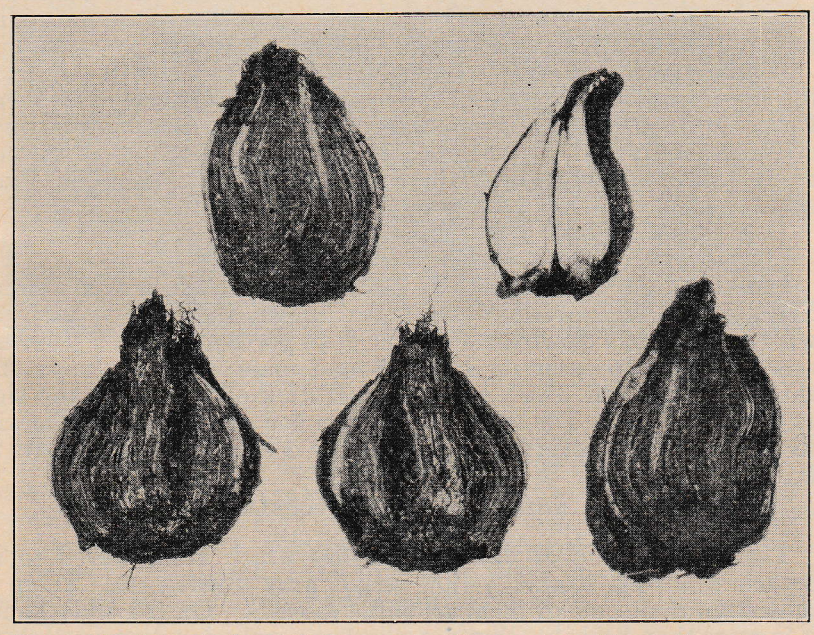

FIGURE 42.—Rotted bulbs of Madame de Graaff permeated with mycelium of forest fungi. Bellingham Bulb Station

### HOT-CLIMATE ROT

Possibly the most difficult malady of the daffodil to control is what may be termed the "hot-climate rot." The bulbs fail and turn to a light-chocolate color, the rot usually (but not always) progressing

from the base upward. This trouble is of little consequence on Puget Sound and in other cool climates, but is very serious on Dutch stocks on the Atlantic coastal plain. Polyanthus varieties are not usually affected unless allowed to heat of their own mass, which they will do readily soon after digging. Very serious losses have occurred from this cause in Texas, New Jersey, North Carolina, Virginia, and southern California. Indeed, this rotting of the bulbs seems to be the limiting factor in daffodil culture in warm regions. So serious have been the losses from this cause that at least two large growers have either quit the business or quit growing the most susceptible varieties. No variety seems immune, but some are much more susceptible than others. Golden Spur, Victoria, Emperor, and the bicolor trumpets generally, but not all of them, are particularly susceptible. The first two are so prone to the trouble throughout the Atlantic coastal plain from Philadelphia southward that their culture is no longer attempted to any great extent by the larger growers.

The secret of successful handling to prevent the losses from "hot-climate rot" is care in the treatment of the bulbs and continual planting on new land. The bulbs should be protected from bruising and should be dried promptly after digging. Success can not be expected with these stocks in warm regions if the handling is rough or if the bulbs are piled so high on the shelves that they remain somewhat moist for even so short a period as two days if the weather is hot. The malady is a storage trouble. Stocks may stand undisturbed indefinitely in perfect health and yet rot badly as soon as dug.

It is said that the Dutch growers habitually had serious losses from the same cause when they sent Golden Spur and Victoria to southern France to be grown a year in order to attain earliness. It is very evident that great care is necessary in the warmer portions of Europe as well as in this country. The reason seems to be the same in all cases.

### FREEZING INJURY

Freezing injury is likely to be looked upon at times as a disease. The evidence is dwarfed plants, leaves brown and dead at the tips, with an indistinct demarcation of the dead portion. Such a phenomenon is likely to occur on Puget Sound under poor drainage and ridging of the soil which allows penetration of cold from the side as well as the top. The bulbs of such dwarfed and injured plants will recover, but the recovery is expensive, for it takes about two years to bring it about.

### MOSAIC AND OTHER TROUBLES

There is a group of daffodil troubles which are referred to as broken, mottling, mosaic, yellow stripe, gray disease, etc. There is indication that some of them are virus diseases. On the other hand, it is more than probable that not all of the irregular distributions of the chlorophyll of these plants are really transmissible diseases. Some varieties are much more addicted to the trouble than others. Indeed, all the stocks of some appear to be imperfect in this respect, while others seem to become addicted to the trouble as they grow old. It is especially worthy of note that the mosaic condition is slow to

spread. The late Rev. Joseph Jacob testified that he could bring about the yellow stripe at will by excessive splitting apart of the bulbs. The whole thing is in a state of flux, but specialists are at work on the problem, with encouraging prospects.

For the present, since the mosaic plants and varieties are undesirable or less desirable than those of good color, the grower is advised to pursue the same practice with reference to them as with all virus diseases, namely, shun them, eliminate them from the stocks by roguing, or, if the whole stock is bad, get rid of it. This is the method of procedure with all true mosaics. Elimination of the affected individuals is the only recommended procedure.

Many varieties are particularly addicted to the trouble. Minister Talma, a recent variety, is mostly yellow striped. Conspicuus, Sir

FIGURE 43.—Sir Watkin, showing stage of development when roguing for mottling can be advantageously performed. This stock is about one-half mottled

Watkin, and Princeps are old varieties seldom entirely free, and the stocks that are pure in color must commonly be rogued constantly to maintain purity of foliage color. Sir Joseph Berkeley is an old variety which is seldom if ever free from the trouble, while some varieties like Double Van Sion, Empress, and Victoria seldom, if ever, have it.

The best time to detect the trouble is when the plants are 6 to 8 inches high and before they have flowered. (Fig. 43.) It is a good plan to go through the field at this time, row by row or bed by bed, to rogue out and discard yellow-striped plants. One of the serious features of the trouble results from the fact that it accumulates in the stock in inordinate proportion when the best bulbs are removed mechanically and the weaker and smaller ones are all planted. Unless the grower exercises care to rogue out these undesirables, he will soon find a predominating percentage of his stock yellow.

### NEMATODE DISEASE

At one time the nematode disease caused by *Tylenchus dipsaci* was a serious menace to the culture of daffodils abroad, but, since the elaboration of the hot-water treatment described on page 67, it is not at all a serious matter, for it can be readily controlled.

The most easily detectable symptoms of the disease occur in the leaves about the time of flowering. The leaves of the affected plants have swollen, hard, and commonly discolored spots in them. If they are drawn between the thumb and forefinger the hard lesions are very noticeable to the touch. Usually in mild and even in rather severe cases this is all the evidence there is, but in bad infestations the leaves and the stems become twisted and variously deformed in a characteristic manner.

The nematode trouble is commonly referred to in the literature as the "ring disease," because in an advanced stage of injury the bulbs often show alternate layers of decayed and healthy tissue when they are cut in two horizontally. This ringed appearance, however, is not an infallible guide or symptom, because the bulbs may decay in this way from other causes.

The rate of progress of the nematode disease from a slight infestation to a beginning of failure of the stocks has been rather slower than is commonly supposed. The spread and virulence of the disease are also much less than has been supposed.

The writer had experience with three infested stocks which functioned rather well for 10 years with a slight diffuse infestation before the bulbs began to rot to any great extent. The infestation was present when the stock first came under his observation; how long they had been infested is not known. The point of importance is that the stock grew and multiplied for 10 years before serious failures began. It is possible that more serious trouble might have occurred earlier in some other sections.

It may be accepted that even a slight infestation of the nema in daffodil stock will eventually engulf that stock unless clean-up measures are adopted. The progress of the disease may be slow, but it will be certain and, in the writer's opinion, will engulf the stocks in 10 to 15 years under the climatic and other conditions prevailing on Puget Sound. Fortunately this disease can be controlled by the hot-water treatment described on page 67. Soil that has become infested by the nema should not be used for daffodils for three years.

In the Pacific Northwest the common mole does a great deal of damage to the daffodil crop in some sections. It is doubtful whether the rodents ever eat any portion of the daffodil plant, but they frequently make their runs under the rows, cutting off the roots, and letting in air under the plants. This is very likely to be the case where bone meal and some other fertilizers are drilled in the rows. Methods of control of these pests are well worked out and discussed by Scheffer (*9*).

### BULB FLIES[4]

The larvae of the lesser bulb fly often inhabit decaying bulbs in large numbers, and although under favorable conditions they are said

[4] The information here given on insects has been approved by the Bureau of Entomology. In case further information on the bulb flies is desired, see Farmers' Bulletin 1362 (*11*).

by the Bureau of Entomology to attack sound bulbs, their abundance may be a result of injury from some other cause. The inexperienced grower, therefore, may be misled by the presence of the larvae of this fly in large numbers into overlooking the principal cause of the injury.

The narcissus bulb fly is at times and in certain localities a decided menace to the daffodil crop. The larva, or grub, lives in the bulb and destroys it, but usually not completely, for in the vast majority of cases there is formed a small offset or often two of them which perpetuate the destroyed bulb. (Fig. 44.)

The insect is a denizen of cool, humid regions. There is considerable question in regard to its survival for any long period in localities having hot summers. Although it was originally known to be present, the writer has failed to discover specimens in certain cultures grown for two years in Virginia and North Carolina. The horticultural inspector of San Diego County, Calif., maintains that the same conditions obtain in portions of southern California. On Puget Sound and in cool regions generally, the insect flourishes and does much damage, but is rather easily controlled or eliminated by several methods herein described.

FIGURE 44.—A narcissus bulb containing a grub of the narcissus bulb fly which has destroyed the main bulb, but there is a narrow leaf from a newly formed bulblet which will survive

### CULLING

Culling has been the most universal method used and until recent years has been the main control employed by the Dutch growers. It consists in picking out the fly-infested bulbs at each digging. This can be done by the appearance, imperfection, softness, or lightness of the bulbs. The method, if carefully pursued, is a good control, but is looked upon as simply a palliative.

### ROGUING

Roguing is also an excellent control. It consists in gouging out in early spring the bulbs that have the grub of the fly in them. If the planting is carefully done, plants which fail to come up or which come with one or two weak leaves can be detected, gouged out, and the fly grubs in them destroyed. After a few trials one can detect the infested bulbs very accurately. This, although an excellent control, is also palliative, but with culling it forms an excellent check.

### SOAKING

Formerly soaking in water at atmospheric temperature for three days was recommended for fly control. Most of the grubs were driven out and could be collected and destroyed from the bottom of the vessel in which they were contained. In practice, though, it is found that many of the grubs simply stick their heads out and return to the bulbs when removed from the water.

### REPELLING

Tobacco powder spread thick enough for a distinct covering over ground and foliage, and crude naphthalene flakes at the rate of 400 pounds to the acre, have each been beneficial for a short time, but flies may be on the wing for two months. However, the flakes when spread thick around border clumps of daffodils and then covered with soil are excellent protection.

### KILLING THE FLIES

In past years at Bellingham, Wash., the flies have been on the wing from May 10 to July 10. During this period they may often be caught or killed. They are very lively in warm weather, but can be picked up by hand in cool, cloudy weather. This is also to be looked upon as an excellent palliative measure.

### HOT-WATER TREATING [5]

Immersing the bulbs in water held at a temperature of 110° to 112° F. for 50 to 60 minutes will kill all the grubs. No eggs of the narcissus bulb fly are involved; consequently the kill is complete. A better plan, when the treatment is for the fly only, is to treat for 1½ hours at 106° to 108°. It should be remembered, however, that if the stock is to move in interstate trade, the present requirements of the quarantine must be adhered to with a treatment of one hour at 110° to 111½° where this fly alone is concerned.

### CULTIVATING

Stirring the surface of the soil, and especially banking up the soil on the rows of daffodils a week or 10 days before the flies come out in the winged stage, will cover up many of the immobile pupæ so that the flies can not get out. This also serves to put the surface of the soil in such condition that the flies find it more difficult to oviposit in position so that the young grubs can reach the bulbs. Pupæ covered with 1 to 1½ inches of soil failed to emerge. Pupæ fully exposed to the sun for three days in Virginia died.

### DEEP PLANTING

Very deep planting has obvious mechanical and reproductive disadvantages; nevertheless there is an optimum safe depth which has commonly not been attained in the Northwest, as witnessed at times by winter cold injury. Deep planting seems to make for fly control in that it increases the fly's difficulties of operation. It is significant that bulbs missed in digging and subsequently put deep by the plow are not infested in subsequent years. It is also significant that this country got its importations of the fly from the Netherlands, rather than from France, where the planting is deeper and the summers hotter and drier.

### TRAP PLANTING

Shallow-planted areas scattered through daffodil fields are found to be worse infested where the fly is prevalent. This suggests shallow trap plantings which may be dug and destroyed or treated at the end of the season.

### FUMIGATION

A method of disposing of the larvæ of the various species of bulb flies by cyanide fumigation has recently been devised. The bulbs are inclosed in a tight container in which is also placed calcium cyanide at the rate of 12 ounces to 100 cubic feet for a period of four hours.

## THE TARSONEMUS MITE

A mite which has recently been described by H. E. Ewing of the Bureau of Entomology as a new variety, *Tarsonemus approximatus* var. *narcissi*, is parasitic on daffodil bulbs. It is an important and destructive parasite if allowed to accumulate in the stock, but since it succumbs readily to the hot-water treatment (hereafter described), it becomes of minor importance in commercial practice.

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[5] See also p. 67.

## THE HOT-WATER TREATMENT

The hot-water treatment prescribed by State and Federal plant-quarantine regulations for infested daffodil bulbs as a condition of domestic movement is 110° to 111½° F. for two and one-half hours where nemas are concerned and 110° to 111½° for one hour where only the larvae of the bulb flies need consideration. If the bulbs are to move in interstate trade, hot-water treatment therefore can not deviate from these requirements. Where, however, a grower is concerned with his own planting stock and desires to treat it for the purpose of eliminating infestation therefrom, he may heat the bulbs from 110° to 112° for three or even four hours if he wishes to make a more effective clean-up. On the other hand, all the benefits of the hot-water treatment aside from the elimination of the nema seem to be attained by a temperature of 105° to 108° for one and one-half hours with little or no floral injury.

The problem, therefore, in connection with the treatment is the maintenance of a constant temperature. This is well worked out for other industries, and application of the principles has been made in various forms to the treatment of bulbs.

The oldest machines to be used for treatment in this country were imported from England. (Fig. 45.) They consisted of cylindrical galvanized-iron tanks with a capacity of about one-half ton of bulbs. The tanks were equipped with a heater in the form of a coiled pipe placed in the bottom and connected with a steam or hot-water boiler, controlled by needle valves, and in some cases by a pressure-reducing valve in addition. About 10 inches above the heater a slatted false bottom was placed, and perpendicularly through the center of the tank a perforated tube was installed in which the temperatures were taken. This tube or pipe also controlled the drainage of the tank.

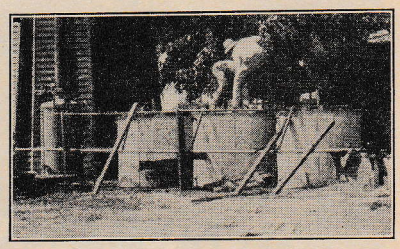

FIGURE 45.—An imported bulb sterilizer employing a battery of half-ton tanks

This simply constructed machine contains the essential features embodied in the more modern American developments. To this has been added one important element in this country, i. e., the agitator, which is essentially a marine propeller, with blades mostly of 6 to 8 inch diameter, operated by an electric motor. In all cases it is placed below the false bottom and serves to better unify the temperature throughout the mass of bulbs. Some machines have an auxiliary heater through which the water in the tank is forced by a pump operated by the same motor that rotates the agitator.

In 1926 the Department of Agriculture prepared for the use of bulb growers plans and specifications of a tank which may be used in the hot-water treatment of bulbs. Briefly, these specifications provide for a tank made of metal either with or without insulation in the form of lumber or other poor-conducting materials to prevent the radiation of heat. The essential characteristic of this machine is the automatic thermostatic controls, which consist of thermostats,

pressure valves, and air pumps operated on well-established principles. (Fig. 46.)

Other types of machines have been built for electric-current heating. These differ essentially from the previous ones in the one feature of heating by electricity.

The machine installed at the Bellingham Bulb Station is essentially a huge thermos bottle. (Fig. 47.) The rectangular tank of ½-ton capacity of bulbs is made throughout, cover and all, of 2½-inch lumber, which is a good insulator. Steam for heating is controlled entirely by hand valves and is delivered through a ½-inch pipe directly into the water through a noiseless water heater or steam muffler discharging in front of the propeller. (Fig. 48.)

This machine is commonly loaded with bulbs at a temperature slightly higher than the maximum. During the 5-minute loading period the temperature will drop to about 105° F. In a few minutes it is run up to 110° to 112° again and held there by simple hand-valve controls for 20 to 30 minutes, until the bulbs are heated through. The steam can then be entirely cut off and the propeller stopped. The tank will hold the temperature for 2½ hours with a drop of only about 1° in an atmospheric temperature of 70°. It is better, however, to push in the switch controlling the propeller motor for a minute or more about the middle of the period to prevent any possibility of stratification in the tank. The temperature is registered by a 15-inch cylindrical bulb thermometer inserted through an auger hole in the center of the cover.

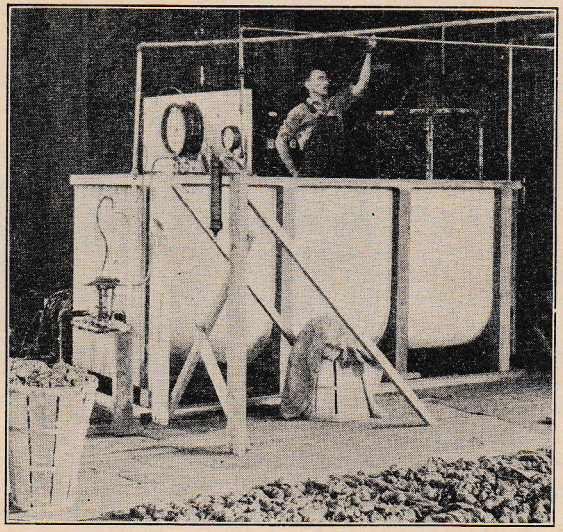

FIGURE 46.—Treating tank installed by the Wilmington, N. C., Bulb Growers' Association, based on plans drawn by the United States Department of Agriculture. The steam boiler, air pump, and propeller are not shown

The treating machines thus far considered are commercial in character and mostly of ½-ton capacity, although some are constructed to handle a ton at one time. They are, therefore, adapted to large operations. The small grower and the fancier who need to treat 1 or 2 bushels of bulbs at a time need smaller units and less expensive equipment. There are many ways in which the small grower can proceed, and many adaptations are possible if the simple fundamental principle is kept in mind. To meet this requirement one small treating unit has been installed at the Bellingham Bulb Station. (Fig. 49.)

The tank in this small machine is constructed on the same plan as that of the large one already described. The radiating surface in the bottom of the tank consists of two sections of a regular floor

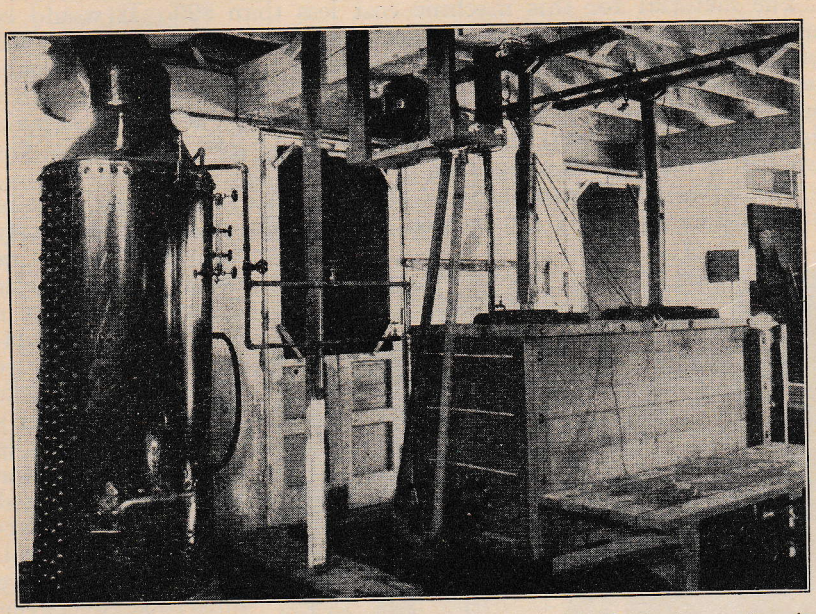

FIGURE 47.—The Bellingham Bulb Station sterilizer, which holds the temperature in a manner similar to a thermos bottle

radiator such as is used in house heating. This is connected by ¾-inch flow and return pipes with a single section of an identical radiator around which is constructed a small brick furnace, as illustrated in the figure. Two valves control the flow and return. Between the heater and the valve on the return pipe there is inserted a "tee" connecting with an expansion tank.

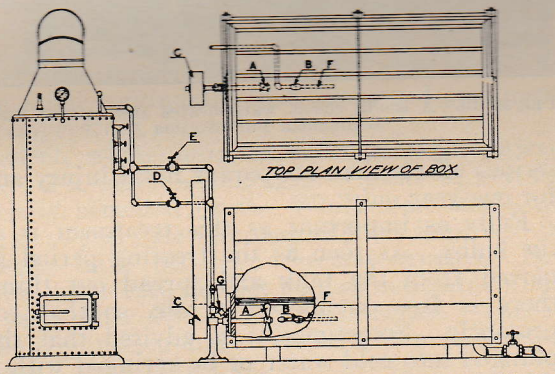


FIGURE 48.—Plan of the Bellingham Bulb Station sterilizer: A, propeller; B, injector; C, propeller pulley; D, needle valve; E, globe valve; F, a 10-inch piece of 1-inch pipe; G, grease cup

This small machine, capable of holding 1 to 2 bushels of bulbs, has no agitator, but otherwise it does not differ from the larger machine previously described except that it is heated by hot water instead of steam. It is operated in the same way, but, owing to the small bulk of water, it does not hold the heat so well. It may, therefore, be necessary to admit more heat once or sometimes twice during the 3-hour period. There are many ways in

which the small grower can maintain uniform heat between 110° and 112° F. in small machines. The better the insulation, the easier this is accomplished.

The material for this machine cost less than $20. It would be more satisfactory, but a little more expensive, to substitute a tank heater for the crude furnace. If the kitchen range with its water back is conveniently located, it can easily be connected with such a tank if the grower is equipped with a few pipe tools. The main thing is to have the tank well insulated. If gas is available, the problem is very much simplified.

The bulbs are loaded into the tank in all of these machines in wire baskets especially constructed to economize space, or in loosely woven burlap or other cloth sacks. There is probably a little better circulation with the wire baskets, but the sacks seem to be perfectly satisfactory. It is understood that the sacks are mostly used in both the Netherlands and England.

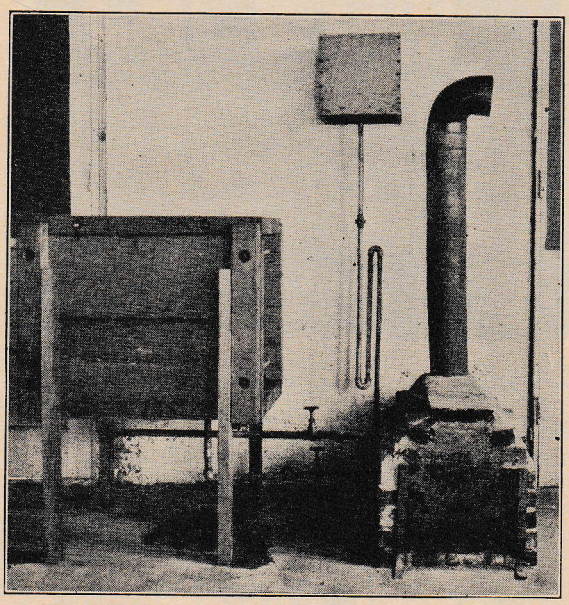

FIGURE 49.—A small, cheap, water-heated sterilizer at the Bellingham Bulb Station

The temperature must be kept between 110° and 112° F. during the entire 3-hour period. A lower temperature may not kill the nemas, and a higher one is in danger of injuring the bulbs. However, a temperature of 1° higher for a short time will seldom produce more serious effects than temporary floral injury and some leaf distortions for one year only.

Fully as important as this treatment is the after treatment of the bulbs. As soon as the treating period is up the bulbs are removed from the tank and spread out thin in a situation where there is free circulation of air, so that cooling will take place promptly. Sometimes it is advised that the baskets or sacks be plunged into cold water or be syringed with the hose. This is considered severe treatment and is not necessary. It is probably safer to spread the bulbs out thin to cool more gradually in the open air.

The bulbs should not only cool promptly but should dry without any delay. This is important everywhere, but more especially so in warm regions, where rotting is prone to occur if there is neglect of either of these factors. The advice given at times, to plant immediately after treatment, is likely to be misinterpreted in that

when the bulbs are removed from the tank to the field there may be sufficient delay to cause injury before they are spread out and cooled. "Promptly" should mean exactly that. The bulbs should not remain in the containers even overnight. A few hours in hot weather may do damage.

How soon treated bulbs should be planted will depend largely on conditions. If the weather is hot and the ground wet, the stocks will be much safer if dried thoroughly before being planted.

The time at which bulbs should be treated bears an important relation to the time of digging. Injuries may occur if treatment is too early. The bulbs should dry on the shelves for 3 to 5 weeks before treatment when the minimum injury to the flowers is desired. Treatment about 2 weeks after digging is quite satisfactory for planting stock. However, there will be more malformation of the flowers than if it is done later, but the foliage need not suffer.

The change of water in the treating vat is of much practical importance. The frequency of the change will depend on a variety of conditions. If the bulbs are thoroughly worked over and cleaned, it may not be necessary to change the water so often as it will when the processing occurs while the bulbs bear considerable soil and débris. Again, if there is a great deal of rot which has not been thoroughly eliminated in the stocks, a more frequent change of water is advisable for obvious reasons.

Generally changing the water once a day is sufficient. Often it may be practicable to have a good head of steam on as the last batch comes off at night. This may be turned on to heat the water up to 150° to 180° F. during the night, thus effecting a sterilization and obviating the necessity of changing the water more often than once in two days.

Adapting the hot-water treatment to different sizes of bulbs because of the variable time which it takes to heat different-sized bulbs through has little application in practice. An attempt to make such an adjustment would necessitate more careful sizing than is usually practicable and always sizing before the treatment is applied. The matter is too complicated for practical execution. The best plan is to adopt the standard period and give it to bulbs of all sizes, keeping in mind continually that prolonged treatment is safer than too high temperature.

The hot-water treatment, while designed to correct parasitism, seems in some cases to have other advantages. Stocks of certain kinds seem to be especially benefited by it. While some stocks do not blossom so well the next year, the vast majority are improved in vigor, provided the bulbs have not been recently treated. The beneficial effect of the hot-water bath has not been so noticeable when the treatments follow each other at 1 or 2 year intervals. This is thought to be due to the elimination and subsequent slow recurrence of the recently discovered Tarsonemus mite.

Experience in this country is not extensive enough as yet to warrant the listing of varieties that are or are not benefited by the treatment given more frequently than parasitism necessitates. Two years of experience at the United States Bellingham Bulb Station shows quite conclusively that Golden Spur stocks have been benefited by two treatments in successive years. The same seems to be true of

Double Van Sion. This corresponds with reports from the Netherlands, where it is understood that stocks receiving hot-water treatment oftener than is required by parasitism are treated at a slightly reduced temperature and for a shortened period, commonly a temperature of 106° to 108° F. and a period of about two hours being employed. This will accomplish all benefits to be secured from the treatment except destroying the nemas.

It seems more than probable that a still wider application of the hot-water treatment will eventually be made. Already one or two growers claim benefits from the inclusion of a small quantity of formaldehyde in the treating vat. The use of some of the organic mercury compounds seems to bear promise.

The hot-water treatment of the bulbs, even when the temperature is not carried above 110° to 111° F., usually causes some modification in

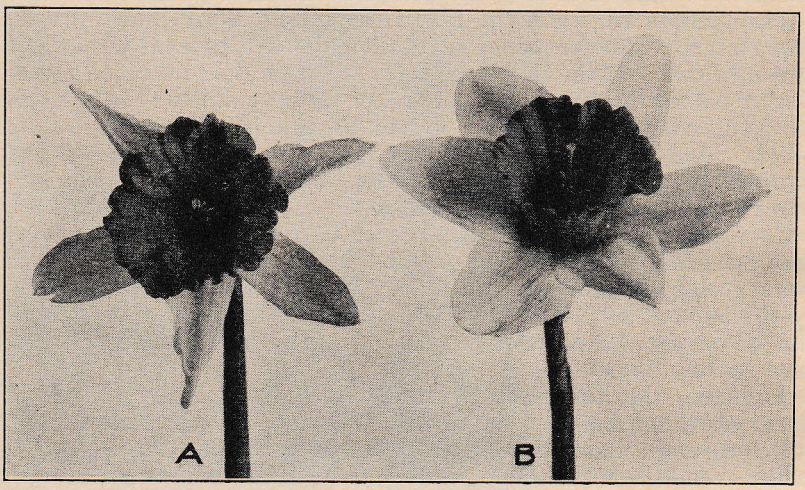


FIGURE 50.—Great Warley flowers: A, Treated for three hours at 111.6° to 110.4° F.; B, check

the flowers, but if this temperature is applied after a proper period of curing, these modifications are usually slight but vary with the variety. The higher the temperature the more pronounced the modification. The petals become slightly contracted (fig. 50), especially toward the distal one-half or two-thirds, and there is commonly a notched condition where the slight dwarfing begins. The fluting of the trumpet mouth is prone to be more or less modified. In extreme cases there is a very pronounced dwarfing, and there may be complete "blindness" with either a blasting of the flower or a failure of the scape to emerge.

An occasional effect on the foliage is characterized by the spotting of the tips of the leaves to a more pronounced disturbance of the coloring matter, resulting in a decided mosaic effect, covering an inch or more of the distal portion. In other cases there is a pronounced disturbance of the palisade cells of the leaf, rendering its surface papillate-roughened in long lines which may unite to form irregular areas. When only a few lines occur, the effect is not so

noticeable, but in bad cases the leaves become distorted, thickened, bent, and twisted.

While a lengthening of the time of treatment is safer than an increase of the temperature, even a lengthening of the time may cause conspicuous although not seriously injurious effects. In one case King Alfred bulbs very slightly infested with nemas were treated in season at 110° to 111° F. for four hours with no leaf injury observable in either field or flat, but the flowers were very badly deformed. Treatment of this variety similarly late in the season had a pronounced effect on the foliage, but only slight injury to the flowers.

The hot-water treatment, designed originally to eliminate the nema, in some cases accomplishes more. It destroys all other known animal pests. Investigators have observed benefits in the vegetative vigor of treated bulbs beyond the expectation from the elimination of the flies and the nema, and it has been supposed that some physiological changes are brought about by the treatment. It has recently been found that the Tarsonemus mite is also eliminated by the treatment, and this accounts for a very large part at least of what has been looked upon as a residual benefit.

Only planting stock should receive hot-water treatment unless the demands of interstate movement require otherwise. It is now thought that benefit occurs from treatment of such stock every three or four years, probably owing in large measure to the depredations of the Tarsonemus mite. However, in the absence of nema infestation, a temperature of about 106° to 108° F. continued for two hours seems to be ample.

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