The Story of Hybrid Onions

by H. A. JONES and A. E. CLARKE

SCIENTISTS have succeeded in crossing suitable inbred lines of onions and obtained excellent results. One hybrid was more than three times heavier than either parent. Other hybrids were outstanding in shape, size, uniformity, and time of maturity. Even more significant: The results showed great possibilities for using hybrid seed for commercial crop production.

Between these encouraging results and the first development of the methods that make possible the production of hybrid seed of all types and in quantity lay a good deal of painstaking, tedious work—work that some of us believed could never succeed.

In the ordinary onion, male and female parts are in the same flower (the perfect flower), and thus each plant is capable of pollinating itself. To get hybrid seed it is therefore necessary to remove the pollen-containing anthers of the female parent, a procedure known as emasculation. Emasculation is not so easily performed with the onion as with corn, whose male and female parts are entirely separate. In corn, emasculation consists merely in removing the tassel. In the onion, the male and female parts are close together, and emasculation is tedious and difficult, because the pollen-bearing anthers must be carefully snipped out with tweezers—a process entirely too expensive for commercial production.

This obstacle, however, has been surmounted. Onion plants are now available whose flowers are not perfect, as they contain no fertile pollen. They are solely female as far as breeding is concerned, and emasculation is unnecessary. In 1925 a plant of this nature was found in the breeding plots at Davis, Calif., in the variety Italian Red. It was given the pedigree number 13–53. It cannot pollinate itself and thus cannot be carried along by seed, but, fortunately, it usually produces

large quantities of head sets or bulbils, and these are used to preserve and increase this line.

Two somewhat different methods are now in use to produce hybrid onion seed, but in each case the hybrid seed is produced on naturally female plants that have been crossed with desirable males. These methods are not difficult to understand, but they are different from those used for any other crop. In the first the female line Italian Red 13–53, which is propagated by top sets, is used. Hybrid seed is produced on the female plants when crossed with pollen-bearing plants. In this method only two lines need to be carried along, the female line and a selected male parent.

The second way is slightly more complicated, but has greater potentialities. Female plants have been produced in other varieties of onions and are perpetuated through seed and not vegetatively by bulbils, as is 13–53. Consequently, we can make innumerable combinations in our quest for the best hybrids. Three lines must be carried along instead of two. Just why this is necessary will be shown. We shall tell the advantages and disadvantages of the two methods, and because of the singular part played by the Italian Red 13–53 selection, we believe that a record of its discovery and history is important.

In the early fall of 1924, 63 Italian Red bulbs were selected from a commercial lot and planted in the vegetable-breeding plots of the University of California at Davis. The plants were grown through the winter, and the following spring the flower heads were enclosed in manila paper bags to aid self-pollination and prevent crossing. The bags were tapped several times each day to distribute the pollen inside the bag and to facilitate pollination. On August 8, 1925, the seed heads were harvested. The weather was satisfactory for seed setting, and most of the plants gave a good supply. An especially good plant, Italian Red 13–52, produced 5,866 seeds. On 15 plants, however, no seed was produced. Some of this sterility may have been due to seed-stem rot. One of the seedless plants, the one with the pedigree number 13–53, differed from the other sterile ones in that the seed heads were packed with small sets or bulbils. Its 5 seed stems had 136 sets; the ability to produce head sets saved it from extinction. Its designation, 13–53, should not be forgotten, for it is probably destined to be the most important onion bulb selection ever made.

From 1925 on, 13–53 was propagated vegetatively by use of small head sets. As the bulbils can be held in storage for only a few weeks, they are usually planted in the nursery soon after harvest. They are then transplanted to the field in late fall or early winter and over-wintered as growing plants. When they are planted on productive soil, the foliage grows luxuriantly, and the large, spindle-shaped bulbs usually mature in late June or July. Because of their poor keeping quality,

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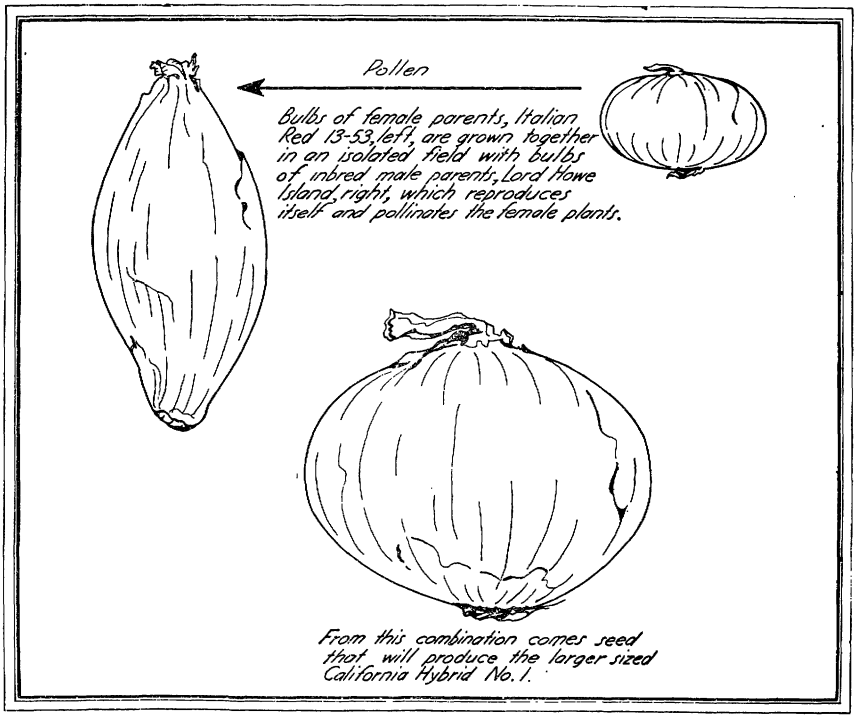


How two onions are crossed to get the California Hybrid Red No. 1. It combines the early maturity of Lord Howe Island and delayed bolting habit of 13–53.

these large bulbs are again planted back into the field in September and overwintered in a mild climate as growing plants.

Since its discovery, 13–53 has been grown under a wide range of climatic conditions. During this time, seed has never been produced when the flower heads were properly protected from pollen by bagging or by isolation. When the flowers are well pollinated, however, they give a heavy set of seed. Even when loaded with seed, the flower heads continue to produce bulbils almost as though no seed had been produced.

In 1934, crosses were made between the female line 13–53 and red varieties like Lord Howe Island, Red 21, Italian Red, Southport Red Globe, and Red Wethersfield. In 1935 and later comparative yield tests were made in California between these hybrids and standard varieties. Some of the crosses looked promising from the very beginning, especially those made with Lord Howe Island and Red 21.

In September 1944, the hybrid of 13–53 × Lord Howe Island was introduced cooperatively by the California Agricultural Experiment Station and the Department as California Hybrid Red No. 1. It combines the early maturity of Lord Howe Island and the delayed bolting habit of Italian Red. It is adapted to the Southwest, where the seed is

planted in early fall and the plants grow throughout the fall, winter, and early spring. Under these conditions, plants grow to a large size, which seems to be essential for the production of large bulbs and high yields. In California, a yield of 73,100 pounds to the acre has been reported, but it is not adapted to the North when seeded directly in the field.

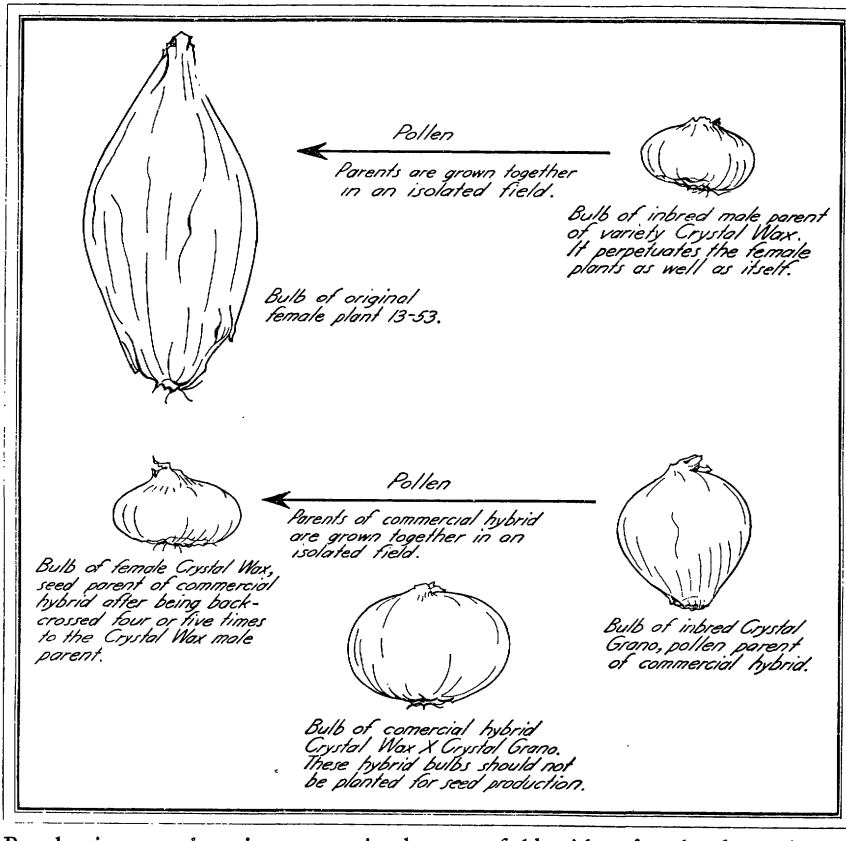
The limitations of 13–53 as a source of hybrid seed are recognized, but breeders work with what they have and not with what they would like to have. We needed female plants in white and yellow varieties, in the early and late varieties, and in the storage types so that hybrids of all commercial types would be available. The method of developing female lines in all types of onions was finally worked out.

We shall not attempt to tell here how the character that permits a potentially perfect flower to perform only female functions is inherited, but we should like to show how this character has been introduced into many types of onions in order to expand greatly its usefulness. This leads us to the second method of producing hybrid onions, whereby the female character is perpetuated through the seed.

When a plant of almost any of the commercial varieties is crossed with the female plant 13–53, the offspring will be one of three kinds: All plants will have perfect flowers, or some plants will have perfect flowers and some female flowers, or all of the plants will have female flowers. In producing hybrid onions, we are especially interested in the crosses that produce all female offspring. Fortunately, in almost all of the important varieties we have been able to get a few crosses that produce only female plants.

These female offspring, when backcrossed to the same male parent, continue to produce all females. With each backcrossing the female plants look more and more like the male parent, and after four or five generations there is no difference in appearance. For the production of hybrids, it is necessary to perpetuate these female lines, and this is done by continually backcrossing to the proper male parent. A single female or a field of female plants under isolated conditions will fail to produce a single seed. They cannot be perpetuated alone. Under certain conditions, however, observed so far only in the greenhouse, plants of these female backcross lines may provide a little good pollen and a few seeds may be obtained. But if rows of the proper male plants are interplanted with the females, insects, such as flies and bees, carry pollen to the female plants, and all the seeds produced on them will be female. As the male parents have perfect flowers, they will pollinate one another and set seed in abundance. So the propagation of the male parent is very easy. Thus, male parent and the female line are carried along in the same plot.

We have now introduced female plants into nearly all the commercial varieties. These include Yellow Globe Danvers, Brigham Yellow Globe, Early Yellow Globe, Sweet Spanish, Southport White Globe, Crystal



By planting a male onion parent in the same field with a female, the male perpetuates itself as well as the female, as shown in the upper section of this chart.

Wax, Yellow Bermuda, Creole, and Stockton G36. Female lines and the necessary male parents have been distributed to a number of seed companies and to experiment stations in most of the important onion-producing States. After female lines have been established, the next step is to find desirable pollen parents to cross with the female lines for the production of commercially acceptable hybrids. We can determine the combinations that produce the best hybrids only by actual field tests.

For this method of producing hybrid seed it is necessary to carry along three separate lots of onions for each hybrid. A female line and a male parent are needed to give continuity to the females, and a second male parent is needed to cross with the females in order to produce types of onions that are desired commercially. In other words, seed from the male parent reproduces the male parent. Seed from the female line reproduces the female line and provides plants for crossing with a third lot of onions to produce seed for the commercial hybrid onion crop.

We have made numerous crosses in the greenhouses at Beltsville. The

cooperating State agricultural experiment stations have made others. Some of them show great promise. One hybrid, a cross between Crystal Wax and Crystal Grano, was developed cooperatively by the California Agricultural Experiment Station and the Department. Hybrids used to produce the commercial crop will not reproduce hybrid seed so they should not be planted for seed production.

Breeding work is under way to incorporate into the hybrids resistance to two major diseases, downy mildew and pink root, and to one insect pest, thrips. Though sporadic in appearance, the downy mildew is probably our most destructive disease of onions. In the North, damage is done chiefly to the bulb crop. On the west coast, it is particularly serious on the crop grown for seed; much of the seed acreage, therefore, has been shifted to other areas where the disease is less prevalent. No entirely satisfactory control method by the use of sprays or dusts has been developed. Apparently the only satisfactory means of control will be by the use of resistant varieties.

In breeding for resistance to downy mildew, Italian Red 13–53 has again come to our aid. Its high resistance to this disease was first observed in 1934 in the breeding plots at Davis. Under California conditions, infection is usually confined to the tips of the leaves, and the spread toward the base is slow. The seed stalks of 13–53, however, are immune. Lesions have never been found even during the most severe epidemics. Now you can begin to see why we consider that 13–53 may be the most important onion selection ever made. Besides its contribution to hybrid onions, it has also given us the best source of resistance to downy mildew. To produce hybrids resistant to downy mildew, it will be necessary to incorporate resistance into the female lines, as well as into the pollen parents.

Pink root is also a major disease in most areas, but it is especially destructive in the South. As the organism lives and multiplies in the soil, chemical control is not practical. Again, we think the use of resistant varieties is the only permanent solution. Resistant lines of Yellow Bermuda are being developed by the Department in cooperation with the experiment stations of Wisconsin and Texas. At the Wisconsin station, the young seedlings are given a severe test. Those surviving are grown to maturity and the bulbs are sent to Beltsville. The resistant plants are used for crossing with female plants, and the various progenies are tested in the South for yield and other desirable characters.

Breeding is also being done to develop lines that resist smut, purple blotch, and yellow dwarf.

The onion thrips—not a disease, but an insect—is without question the most destructive pest on the onion crop the world over. They puncture the surface cells of the leaves and suck out the contents, causing local injury. In severe cases the plants are killed prematurely, and the

yield is greatly reduced. Satisfactory chemical control has only recently been developed. DDT is the first insecticide that has given commercial control. Resistant varieties would require less spraying or dusting and thus reduce cost of growing.

Breeding for resistance to thrips has been under way for some time. Characters have been determined that either reduce the number of thrips per plant or cause the plant to show less injury, but the character that can be used most advantageously in breeding for resistance is glossy foliage. Most onion plants secret a waxy layer, or "bloom," on the surface of the leaf, a deposit that gives a grayish cast to the leaf. It is easily rubbed off. When this waxy covering is absent, the foliage has a glossy appearance. In all field tests, glossy plants show considerable resistance to thrips. This glossy character, derived from a single plant selection from a field of Australian Brown onions and from the variety White Persian, which was obtained in Persia by W. E. Whitehouse of the Department, is being bred into our commonly grown varieties and into the lines that are being developed for the production of hybrid seed. Here, too, it is necessary to have two resistant glossy male parents for the production of resistant hybrids: One to perpetuate the female line; the other to combine with the female line for the production of hybrid seed.

This hybrid work makes possible the combining of those lines that are resistant to the attack of thrips and various diseases, and it provides a method for attaining great uniformity of shape, color, time-of-maturity, and edible quality in the onion and at the same time gives a means of obtaining the greatest amount of vigor. The production of hybrid seed opens up an almost unlimited field for the production of improved onion varieties. We now have unusual opportunties for accomplishment. Excellent tools are available, but improvements will be made only in proportion to the efforts put forth.

THE AUTHORS

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