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Onions

RALPH W. JORDAN

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Field of Onions at Harvest Time.

ONIONS

BY

RALPH W. JORDAN

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1915

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PREFACE

The author has written this book on the theories and methods of growing onions in a spirit of co-operation and helpfulness to those who are interested in the growing of this crop. It has been my desire to call attention to some of the more important phases of the subject which pertain to the growing of the crop in a commercial way. Details are dwelt upon in places where necessary to make the methods of culture and care of the crop clear to the beginner. Methods, however, differ widely, according to the locality. Local conditions often demand changes. The book is not an encyclopedia of facts, but a presentation of a few of the better methods.

The encouragement and helpfulness of Professor Wendell Paddock, of Ohio State University, has largely made the book possible and I am especially indebted to him. Special acknowledgment is made to Stephen N. Green, of Ohio Experiment Station, for Figures 2, 3, 4, 5, 8, 9, 10, 11, 12, 15, 16, 17, 19, 24 and 26; to A. D. Selby, of Ohio Experiment Station, for Figures 33 and 34; to J. S. Houser, of Ohio Experiment Station, for Figure 31; to F. H. Chittenden, of the U. S. Department of Agriculture, for Figures 29 and 32; to H. C. Thompson, of the U. S. Department of Agriculture, for Figures 27 and 28 and frontispiece; to C. G. Woodbury, of Purdue University, Department of Horticulture, for Figures 13, 14 and 30.

RALPH W. JORDAN

Columbus, Ohio,
March 27th, 1915.

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ONIONS

CHAPTER I

THE ONION

Historical. The onion takes its name from the city built by Onias (B. C. 173) near the Gulf of Suez. The onion has been domesticated a very long time and is one of the earliest of cultivated plants. Drawings of it are found on the Egyptian monuments. Its indigenous form, however, is not well understood. Under long continued cultivation and selection the bulbs have developed into large shapely organs. It has for centuries found favor with the Egyptians and Israelites and is now cultivated and popular in almost every country of the world. The place of its origin is unknown; but it occupied a vast area in Western Asia during a very early epoch, extending, perhaps, from Palestine to India. Early historic records refer to it frequently as an article of food, also as a preventive of thirst while on the march or traveling in the desert.

In olden times the growing of the crop was confined chiefly to the alluvial river valleys; but by improvement the different varieties have been adapted to a diversity of conditions. It is only within the last quarter of a century that rapid growth and development of the industry has taken place in the Northern and New England States. The past decade has witnessed the development of the Bermuda onion industry in Texas, until now we have our

markets supplied during the whole year with successive crops from our own country.

Botany. The onion belongs to the *Allium cepa*, a widely variable species forming a part of the botanical family which includes the lilies and the several forms of asparagus and smilax. It is generally a biennial, although some forms, such as the tree onion and multipliers, are perennial. The latter are used for bunching purposes. Usually, however, it is grown for bulbs as an annual. The bulbs are variable in color, being yellow, red, white and the intermediate shades of these colors. Now and then a bulb does not develop, and the neck, or stalk just above the bulb, remains relatively thick. Such onions are termed scullions, and they may be regarded as run down or reverted forms. The seed stalks are slender and tall. The seeds are angular in shape and black, and are borne in a dense and compact cluster at the end of the seed stalk.

Importance. The onion is one of the most important vegetable crops in the United States. It ranks third in commercial importance, the crop being valued at more than \$10,000,000 annually. The shipping and keeping qualities of onions are excellent. The bulbs will stand considerable rough usage and keep a long time under unfavorable conditions. These qualities are important factors and have helped to materially increase the demand for the bulbs. The old adage, "Keep onions in the house and you will keep the doctor away," has borne fruit. Onions are more increasingly regarded as a healthful article of food. This fact together, with a better understanding of their palatability, has increased their use very widely. The industry of onion growing has been developed rapidly as is shown by the curve of production, Chart 1. This chart gives the production of the Northern and New England States

from 1894 to 1914 and is based on two-year averages of crop production in millions of bushels. The figures were taken from the onion crop report of the American Agriculturist. Almost the entire crop is used within our borders, and immense importations are at the present time necessary to supply the demand. Spain, Egypt, Bermuda, and the South Sea Islands supply our country with more than a million bushels annually.

Within the last decade the Bermuda onion industry has gained a wonderful impetus in Texas and the neighboring Gulf Coast States. The increased production from these quarters has been more marvelous in the rapidity of the increase than that of the Northern and New England States. The onion from this district outranks its competitor from the Bermuda Islands in quality and is found on the market at about the same time.

Chart 1. Production of Onions by Two-year Averages.

The Northern and New England States include New York, Ohio, Massachusetts, Indiana, Michigan, Illinois, Wisconsin, Pennsylvania, Connecticut and Rhode Island, the states being named in their relative order of production as based on their average output of the last three years. Chart 2 shows the proportionate acreage by states. The crop is grown largely in a commercial way on muck soils in these areas, but numerous instances could be cited where the crop is profitably grown on upland soils.

The wide adaptation of the onion to all climates and soils from the Gulf to the 49th parallel and from Massachusetts Bay to Puget Sound makes it a very useful product both as regards the home garden and from the commercial point of view. The demand on the market for a good article continues from January first to January first.

Climatic Requirements. The leading varieties are usually planted under different climatic conditions. The most tender sorts, the foreign types, such as the Bermudas and Denias, are better adapted to the Southern latitude of the United States in California, New Mexico, and the Gulf States. They do very well in the North, if the season is lengthened by starting them under glass, and even under the most favorable conditions they produce fine crops when the seed is sown outside. The American types which are represented by the numerous Danvers and Globes are grown mostly in the North, but will likewise do very well in the South under proper care. The onion has adapted itself to the different climates through centuries of cultivation. In the warmer parts of Europe, such as Italy, Portugal, and especially Spain, the type of the large thick-necked, long season, short-keeping and very mild, sweet quality onion has been developed. Cultivation for hundreds of years in these parts without the introduction of outside strains has

Chart 2. Acre Production of Onions
by States.

produced this type. In the same manner the onions grown in California gradually acquire the characteristics of the slower ripening Southern European types. Vast quantities of seed used by Northern growers are raised in California, and, unless the stock be replenished from the North each season, the bulbs grown from the California seed will fail to mature at harvest time. Even in the North care must be exercised in the selection of bulbs for seed purposes, lest the thicker neck or bottle shape type predominate. This type requires a longer season in which to mature sufficiently, and, therefore, is likely to have poorer keeping qualities.

A temperate climate without extremes of heat or cold is best for the onion. The industry is scarcely ever profitable where there is no winter and summer or rainy and dry seasons. Comparatively cool conditions at the time of seeding and during the early part of the growth, with plenty of moisture are necessary, and a dry soil with warmer temperatures prevailing is desirable during the time of bowling and ripening. In the North the seed is usually sown during the time of spring rains and the crop is harvested in late summer, when dry conditions may be expected to prevail.

Figure 1. In the North the Seed Is Sown in Early Spring.

In the South the seed is drilled earlier, since the bulk of the growth must take place under comparatively cool conditions. The amount of rainfall necessary to produce a crop of onions will depend largely upon the soil and its drainage. Many of the muck soils in which the soil water remains near the surface will require very little rainfall; in fact, the best crops are produced on these soils with a smaller amount of rainfall, but very evenly distributed. Excessive rainfall sometimes causes thick-necks or scullions.

In the southern part of the United States the climatic conditions are overcome by growing the crop during the late autumn and winter; early spring and summer being the time of cropping in the North. The period of growth of the onion in the North ranges between one hundred and thirty and one hundred and fifty days. If the seed is grown under glass and transplanted (a method not generally employed in an extensive way in the North) the crop may be grown from seedlings in about one hundred days. The farther North the onions are grown, the shorter the season in which they mature. That is to say, onion seed grown in the North will produce mature bulbs in a shorter time than seed from the warmer climates under like conditions.

CHAPTER II

SOIL REQUIREMENTS OF THE ONION

Soil Preferences. Onions may be grown on practically any soil that is in good physical condition, well drained, and having plenty of humus. Heavy soils are not suitable, because they furnish a poor seed bed, in that the surface is likely to bake and crack, injuring the young onions; in that the bulbs are checked in growth with the result that sculions are produced; and in that weeding is rendered very difficult. The bed should be free from rubbish, stones and weed seed. Seeding and cultivation are thus made less difficult and the expense and burden of caring for the crop is materially reduced.

Sandy loams or clays containing a considerable amount of sand are often well adapted to onions. Heavy applications of manure should be made or leguminous crops should be grown, and plowed under so as to lighten the soil. More fertilizer will be required than upon ordinary muck soils, to produce a paying crop. Onions produced on upland soils are of excellent quality, firmer, and, therefore, good keepers.

We are more concerned with the muck type of soil, since it is the one mainly used in the North. In most instances it has been reclaimed by draining swamps, not many years ago regarded as practically worthless, but now good onion land, and frequently worth from \$300 to \$500 per acre. Peat and muck are two different terms and should be kept in mind as applying to distinct soil types.

Peat is composed of a coarse fibrous residue of the original vegetation in the earlier stages of decomposition

and disintegration. It is yellow brown to dark brown in color. Even though having a permanent water table just below the surface, its capillarity is so poor that the crop producing powers are limited largely on account of the lack of moisture retaining capacity. An aerated peat soil is acted upon by micro-organisms and the processes of oxidation; the fibrous structure is lost and it becomes pulverized; the color changes from a yellow brown or a dark brown to a dark brown and black material, known as muck. It represents peat in an advanced stage of decomposition or decay, ripening into its old age. The organic matter being in a finely divided state, its plant food constituents are rendered more available to growing vegetation. At the same time the soil has a more satisfactory relation to the moisture supply.

Mucks vary in depth from a few inches to fifteen, twenty or even thirty feet. By analysis they are found to be exceedingly rich in nitrogen, which, of course, if available in large amounts, would be wasted. It is not, however, rapidly converted for the use of plants. In physical appearance mucks are very fine and black. On account of the larger amounts of organic matter in mucks as well as their high state of fertility and ease of cultivation, these soils are most productive and profitable for onion culture. They are also well adapted to onions in that the black soil warms up rapidly in the spring, thus favoring early planting. Further, the mucks are retentive of moisture, and drought seldom curtails the growth.

Drainage. Mucks settle to a considerable extent upon drainage, on account of the shrinkage caused by drying out. A tile system is soon rendered worthless by its own change in level, thus causing it to clog with sediment in low places. Occasionally the tile are laid on boards, or continuous

wooden conduits are used, thus obviating the aforesaid difficulty. Open ditches are generally used at first, in this way permitting the land to settle for a permanent tile drainage system later. Open ditches should be spaced at a distance of 150 to 200 feet apart. They should have a depth of three to four feet. A marginal ditch is usually dug around the edges of the marsh to carry away water from springs and the overflow from the surrounding higher lands.

Based upon the examination of a large number of tile drained fields by A. R. Whitson, of the Wisconsin Station, tile drains should be placed from three to four rods apart on muck soils for truck crops, in order to produce the best results. As in the open ditch system, a marginal tile is usually laid to carry off the spring and surface flow. The onion is a shallow-rooted crop, consequently a tile at twenty inches depth would be satisfactory, were onions alone to be considered. For ordinary crops, however, the drain should be placed at a depth ranging from three to four feet.

CHAPTER III

VARIETIES OF ONIONS

Varieties. Commercial varieties of onions may be distinguished in general by the color of the skin, shape of the bulb, and the size.

1. YELLOW VARIETIES.

a. Yellow Globe Danvers. Also called Danvers' Yellow, Round Yellow Danvers, Yellow Globe, Danvers, and Ohio Yellow Globe. It is a selected strain of Yellow Danvers, not so perfectly globular as some other forms, skin yellow, flesh white, fine grained, solid, and of excellent quality, good for storage purposes, and grown more extensively than any other yellow onion.

b. Yellow Danvers. Also called Round Danvers. It has a thin yellow skin, white flesh, is finely grained and firm, round and of good size, of excellent quality, a good keeper, and compared with the Yellow Globe Danvers, it ripens earlier.

c. Southport Yellow Globe. It has a yellow skin with white flesh, is globe shaped and of good size, being larger than the Yellow Globe Danvers, matures later, is a good keeper, and is widely grown.

d. Prizetaker. The seed was first grown in California from Spanish onions. It is the best of the large mild onions, globular in form, having bulbs weighing from one to two pounds, with skin of a rich yellow color, of pure white flesh, finely grained, used largely as a transplanted onion, and a poor keeper. Only medium-sized specimens should be stored.

e. Giant Gibraltar. Very similar, if not the same as

the Denia, a Spanish onion, used for transplanting, and, compared with the Prizetaker, the flesh is milder. It is a poor keeper in storage.

f. Bermuda. A foreign type grown largely in Texas.

2. RED VARIETIES.

a. Southport Red Globe. A globe-shaped onion, with skin deep red, and flesh of splendid quality, mild and fine grained, a good keeper in storage, and widely grown wherever the red variety is cultivated.

b. Red Wethersfield. This onion is rather flat in shape, grows to a good size, has deep purplish red skin and purplish white flesh, is of moderate to coarse grain, and a good keeper and shipper.

c. Early Red Flat. Also called Early Red. An early maturing onion of flattened form, which does well on a cold soil, and is a good keeper.

d. Red Bermuda. A foreign type.

3. WHITE VARIETIES.

a. Southport White Globe. A globe onion of good size, of pure white skin, of white flesh and of mild flavor, and a good keeper. It requires better care than the yellow or red varieties.

b. Silver King. The bulbs are large, flattened, of white flesh, and have good keeping qualities.

c. Silver Skin. Also called White Portugal. A well known white variety, subject to the attack of the Dry or Black Neck-Rot.

d. White Barletta. Also called White Queen, New Queen and White Pearl. An extra early yielder, with small, flattened bulbs of handsome appearance and mild in flavor, a good keeper, and excellent for pickling.

e. White Bermuda. A foreign type.

4. BROWN VARIETY.

a. Australian Brown. An early maturing variety, of dark brown skin, white and solid flesh, and is one of the earliest maturing onions we have.

The soil, markets and climate should be taken into consideration in selecting the variety. The climatic factors have already been mentioned. The choice of markets and shipping qualities will be treated later. The soil, however, will be mentioned at this time. The yellow and red sorts are better adapted to muck soils. All kinds do well on sandy loams and light soils. Deep, rich alluvial soils of the river bottoms and delta regions are the best for the Egyptian, Spanish, and Bermuda types.

CHAPTER IV

GOOD SEED ALL IMPORTANT

Seed. The seed is one of the most important factors in the growing of onions. In fact, there are few crops grown where good seed counts for so much as with the onion. Growers so generally neglect the matter of purchasing good seed that their negligence has become one of the limiting factors of production. There are just two important losses that may arise from the selection of poor seed: (1) it may be too old, and (2) it may come from poorly selected bulbs.

Vitality of Onion Seed. Experiments on the longevity of onion seed have been conducted by the Connecticut Station with the results given in the following table:*

Vitality of Onion Seed

CALIFORNIA GROWN SEEDS.	No. Samples	Per Cent.
Seed stated to be less than one year old.....	400	88.18
Seed stated to be between one and two years old....	220	77.46
Seed stated to be between two and three years old..	2,023	57.34
Seed stated to be between three and four years old..	1	10.00

Plotted by curve in Chart 3, it will readily be seen that onion seed should not be used the second year. The best of onion seed should run from 95 per cent to 100 per cent in germinating power. The loss in production from the best of old seed, no matter how thickly sown, will be greater

* Connecticut Station Biennial Report, 1909-1910, part 12.

Chart 3. Germination Test of Onion Seed.

than the cost of new seed; for, while the germination of old seed may run even as high as 80 per cent, a great many of the plants will die. Nine hundred and thirty-seven samples of Connecticut grown onion seed were also tested by the Connecticut Station during seventeen consecutive years. The seed has always been less than one year old when tested. The result showed that 75.1 per cent had germinating power, a rather lower per cent than we might expect. Of the fresh seed, 62 per cent was the lowest and 89 per cent was the highest test at any time during the seventeen years. Of course, the seed tested was of the market run and may not have been washed to take out the light stuff. All seed should be tested to ascertain its germinating powers. The desirable grade should run from 85 per cent to 90 per cent.

Testing the Seed. Onion seed may be tested for germination by counting out one hundred seeds from a representative sample or lot for the purpose of germinating. Several methods are in vogue. One good way, a fair test and yet severe, consists in planting the seeds in a box of moist soil. Place the box in a warm, light place. The seed must not only germinate but produce plants. Poor

seed will often germinate, but the seedlings lack the vitality to push up through the soil and make plants. Testing several lots of one hundred seeds each is, of course, more exact, but not necessary, unless the first test proves disappointing. In the latter event, other tests should follow to prove the merits of the first trial.

Figure 2. Bottle Type.

Trueness to Type. Chart 4, pages 00 and 00, with its key on pages 00 and 00, shows the resulting crops from the general run of seed purchased on the American markets today. The key shows the strain or variety as well as the name of the seedsman. These experiments were conducted by the Ohio Experiment Station in co-

Chart 4. Onion Variety and Strain Test

Onion No.	Globe	Per Cent	Scul-lions	Per Cent	Bottle	Per Cent	Flat	Per Cent	Off Col.	Per Cent
1	578	90.9	.....	.....	33	5.2	18	2.8	7	1.1
2	980	93.8	.....	.....	48	4.6	.....	.....	16	1.6
3	390	50.3	2	.3	360	46.4	2	.3	21	2.7
4	400	62.4	.....	.....	230	35.9	2	.3	9	1.4
5	715	88.9	1	.1	62	7.7	6	.7	20	2.8
6	292	65.8	1	.2	116	26.1	4	.9	31	7.
7	295	73.7	.....	.....	.....	.....	90	22.5	15	3.8
8	235	86.7	4	1.5	23	8.5	3	1.1	6	2.2
9	60	46.9	.....	.....	15	11.7	48	37.6	5	3.8
10	150	35.6	.....	.....	270	63.9	2	.5	.....	.....
11	100	90.1	.....	.....	8	7.2	2	1.8	1	.9
12	19	63.4	3	10.	3	10.	4	13.3	1	3.3
13	640	89.4	.....	.....	74	10.3	.....	.....	2	.3
14	468	94.6	.....	.....	26	5.2	1	.2	.....	.....
15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
16	115	90.6	.....	.....	11	8.6	.....	.....	1	.8
17	137	91.3	.....	.....	9	.6	3	2.	1	.7
18	69	93.3	.....	.....	1	1.3	2	2.7	2	2.7
19	138	80.2	.....	.....	23	13.4	1	.6	10	5.8
20	140	20.1	.....	.....	5	.7	540	77.6	11	1.6
21	605	78.2	.....	.....	50	6.4	95	12.3	24	3.1
22	1,420	97.4	.....	.....	13	.9	2	.1	23	1.6
23	960	93.8	.....	.....	35	3.4	.....	.....	28	2.8
24	890	97.6	.....	.....	19	2.1	.....	.....	3	.3
25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
27	450	79.8	.....	.....	105	18.6	4	.7	5	.9
28	100	84.	.....	.....	16	13.4	.....	.....	3	2.6
29	235	59.5	.....	.....	157	39.7	.....	.....	3	.8
30	90	73.7	1	.8	15	12.6	4	3.2	12	9.7
31	110	63.1	.....	.....	60	34.5	2	1.2	2	1.2
32	522	55.3	.....	.....	395	41.9	.....	.....	26	2.8
33	275	57.1	.....	.....	195	40.4	5	1.	7	1.5
34	293	67.7	.....	.....	131	30.3	8	1.8	1	.2
35	82	65.1	.....	.....	30	23.8	6	4.8	8	6.3
36	253	74.6	.....	.....	74	21.8	4	1.2	8	2.4
37	155	66.5	.....	.....	70	30.4	4	1.7	3	1.4
38	262	51.1	20	3.9	230	44.8	.....	.....	1	.2
39	265	38.8	2	.3	410	60.1	.....	.....	5	.8
40	50	52.6	.....	.....	45	47.4	.....	.....	.....	.....
41	90	58.4	.....	.....	60	38.4	4	2.7	.....	.....

Key to Onions Sown in the Onion Variety and Strain Test

- Onion No. 1—Henderson's Yellow Globe Danvers
2—Stoke's Yellow Globe Danvers
3—Farquhar's Yellow Globe Danvers
4—Thorburn's Yellow Globe Danvers
5—Dreer's Yellow Globe Danvers
6—Maule's Yellow Globe Danvers
7—Thorburn's Yellow Danvers
8—Stoke's Philadelphia Yellow Globe Danvers
9—Stoke's Yellow Danvers.
10—Dreer's Australian Yellow Globe
11—Thorburn's Large Yellow Globe
12—May's Yellow Globe
13—Vicer's Ohio Yellow Globe
14—Horr-Warner's Ohio Yellow Globe
15—Stoke's Michigan Yellow Globe
16—Stoke's Ohio Yellow Globe
17—May's Michigan or Ohio Yellow Globe
18—Maule's Ohio Yellow Globe
19—May's Yellow Globe Danvers
20—Maule's Mammoth Silver King
21—Burpee's Yellow Danvers
22—Burpee's Southport Yellow Globe
23—Vaughan's Fancy Yellow Globe Danvers
24—Carle's Ohio Yellow Globe
25—Plot not planted
26—Maule's Southport Yellow Globe
27—Henderson's Southport Yellow Globe
28—Stoke's Southport Yellow Globe
29—Farquhar's Southport Yellow Globe
30—May's Southport Yellow Globe
31—Dreer's Southport Yellow Globe
32—Stoke's Mammoth Yellow Prizetaker
33—Dreer's Prizetaker
34—Henderson's Prizetaker
35—Farquhar's Prizetaker
36—Maule's Prizetaker
37—Thorburn's Yellow Globe Spanish Prizetaker
38—Farquhar's Ailsa Craig
39—Stoke's Ailsa Craig
40—May's Ailsa Craig
41—Thorburn's Ailsa Craig
42—Maule's New Commercial
43—Maule's Southport White Globe
44—Stoke's Southport White Globe
45—Dreer's Southport White Globe
46—Ferry's Yellow Globe Danvers
47—Vick's Yellow Globe Danvers

Key to Onions Sown in the Onion Variety and Strain Test

- Onion No. 48—Ferry's Michigan Yellow Globe
 49—Plot not planted
 50—Plot not planted
 51—Farquhar's Southport White Globe
 52—Stoke's Southport Red Globe
 53—Farquhar's Southport Red Globe
 54—Dreer's Southport Red Globe
 55—Maule's Southport Red Globe
 56—Henderson's Southport Red Globe
 57—Dreer's Large Red Wethersfield
 58—Maule's Large Red Wethersfield
 59—Henderson's Large Red Wethersfield
 60—Stoke's Australian Brown
 61—Farquhar's Australian Brown
 62—Dreer's Australian Brown
 63—Carle's Ohio Yellow Globe
 64—Burpee's Yellow Globe Danvers
 65—Vaughan's Southport Yellow Globe,
 66—Livingston's Ohio Yellow Globe
 67—Johnson's Philadelphia Yellow Globe Danvers
 68—Burpee's Southport Yellow Globe
 69—Johnson's True Round Yellow Danvers
 70—Johnson's New Early Yellow Globe
 71—Bolgiano's Yellow Globe Danvers
 72—Livingston's Select Yellow Globe Danvers
 73—Johnson's Southport Yellow Globe
 74—Vaughan's Early Flat Yellow Danvers
 75—Plot a duplicate of 24 and 63

operation with the writer. They have not been published in bulletin form. A glance at the chart will reveal the fact that the onion seed market is deplorable. For instance, look at onion No. 6. It is supposed to be a Yellow Globe Danvers, and yet it has no good features to commend it. So far as the type is concerned, it is 65.8 per cent globe. It shows .2 per cent scullions, 9 per cent flat, 7 per cent off color and 26.1 per cent bottle. The bottle onion is, as the term indicates, a long drawn out onion. Its keeping qualities are likely to be poor. Now look at onion No. 71. It is also of poor character, going by the name of Yellow Globe Danvers, but is 68.2 per cent flat. It is also 1.8 per

cent off color, 7.9 per cent bottle, and has 9.7 per cent scullions, leaving but 12.4 per cent of the globe type after which the onion is named. The matter of scullions does not seem to be so serious, as the percentage of these is never more than 10, a result due, perhaps, to the fact that they are of such poor quality as

Figure 3. Flat Type.

to be incapable of perpetuating themselves. The average number of scullions is .6 per cent. Off color is perhaps the most serious handicap that an onion may have; for there is nothing quite so prominent as an odd colored onion in the crate or sack. It will be observed that there is in no case more than 26 per cent off color. The important thing, however, is the fact that but eight of the sixty-six strains that germinated scored perfect in color. The average percentage of off color is 2.7. In the bottle and flat types we have the greatest extremes. The widest variance of the former is 63.9 per cent, and of the latter, 77.6 per cent. The average of the bottle is 21.2 per cent, and of the flat, 5.5 per cent.

Onion No. 24 is the best of the whole group. It might be said that the bulbs for this seed were home selected, being picked from onions held in several commercial storages. It is the Ohio Yellow Globe (Yellow Globe Danvers) and, according to the method of scoring used, is 97.6 per

cent perfect. It is 2.1 per cent bottle; but the most serious criticism, perhaps, is the fact that it is .3 per cent off color. It will be remembered, however, that only eight of the sixty-six have perfect scores in color and the percentage off is very low. Onion No. 22 might be regarded as the second best, but for the fact that the percentage off is mostly in color. This scores the onion lower than the same percentage off in shape. Onion No. 14 should undoubtedly be rated second, both on account of its high percentage of globe onions in the lot and because it is perfect in color. This strain again is one built up by growers selecting from thousands of bushels of bulbs.

Home Grown Seed. It is on account of the risk taken in purchasing seed at large that many growers prefer raising their own. It is necessary for the grower to depend upon the seedsman, if he buys in the market; for there is no way of distinguishing poor seed by ordinary inspection. Germination does not tell the whole story. For seed purposes the best bulbs are selected. A clear cut ideal of the exact shape, size, color, thickness of shuck and length of neck is the first requisite. Secondly, seed should be grown from bulbs of the exact type for the greatest possible number of generations.

The purpose for which the onion is grown, as well as the various local conditions with which the gardener must contend, makes the shape of the onion important. In general it may be said that a flat onion is earlier than a globe shaped onion of the same strain. Earliness, on the other hand, means a shorter growing season, and, consequently, a smaller number of bushels per acre. The converse is also true, without reference to other qualities, that the longer, drawn-out, bottle type of onion requires an extension of time in which to mature. Late maturity means more bushels per

Figure 4. Ideal Shape of Onion.

acre, but, since the crop must be harvested within season, late maturity is likely to mean poor keeping quality. One must decide somewhere between the extreme flat and the long, drawn-out, bottle onion. Figures 2, 3 and 4 show the extreme and ideal shapes of onions.

Relative to keeping quality, size is just as important as shape. Large onions are poor keepers, unless they have a lengthened season in which to mature. Still, the market demands a good sized onion; hence, in order to produce maximum yields through a series of years and yet meet the demand of the market, one must consider shape and size as of great importance.

Color should be representative of the variety. A deep rich, bright colored onion will often sell at several cents per bushel more than light, faded out, or off color stock.

Thickness of shuck or skin varies considerably with the different strains. The thicker the shuck, the better the shipping qualities. Other things being equal, a thick shuck is preferable.

Our ancestral type of onions had thick necks. Through centuries of selection the present commercial onion has been developed from its primitive stage. Scullions and bulbs having thick necks represent a reversion toward the primitive type. Bulbs having conical tops may be said to have a tendency in that direction. Thick-necked onions, even though it be possible to clip the tops, are more subject to decay, as the living green tissues present a ready means for the bacteria of decay to enter the bulb. For seed purposes one should be careful to avoid onions having or tending to have thick necks.

Growing Seed. One method of growing onion seed consists in selecting the best bulbs from storage stock each year. The best looking onions are picked out at the time

of screening and placed in separate crates. The bulbs are planted in early spring. During the summer tall seed stalks are produced, bearing a ball of seed at the tip. The seed is gathered, threshed out and used the following year for growing the commercial crop. This method is superior to planting the average run of onions, even though the best grade of storage stock is used.

The second method is essentially the same so far as the details of growing the crop are concerned. A comparatively small number of the very choicest specimens are selected. These are known as mother bulbs. The mother bulbs are planted out and produce a crop of seed. Instead of being used for commercial purposes this crop of seed is kept separate and planted out in the spring. The choicest of the bulbs grown from the seed are planted out the third year and the resulting seed is saved. With the exception of what is saved to continue the choice seed stock, this seed is sold or used for the general crop. The second method is the one used by the more progressive seed growers.

Necessity forces one to use the first method for immediate needs. By planning, however, one can adopt the second method to provide for future needs. Two important things are necessary: one is a small amount of capital; the other, a large amount of patience. So far as capital is concerned the grower has a tangible asset at the end of each season, worth more than the effort required in promoting this plan. At the end of the first season the grower would not part with his seed from the mother bulbs for an equal quantity of ordinary seed. If the original selection of the mother bulbs were of the best, at the end of the second season one should expect a larger and better quality crop of onions. At the end of the third season, if the law of selection holds true, a crop of superior quality seed will be produced.

So far as permanency in the onion business is concerned, it is indeed worth while to take pains with seed selection and seed growing. Too many of us care little about taking the infinite pains in our work that spells Success. One is reminded of the old savage, who, after having tried civilization for forty years, decided to return to savagery and spend his old age, saying that civilization was not worth the trouble.

The Seed Crop. It is essential to use upland soil for the seed crop. The high nitrogen content of muck soils is undesirable. A fertile, loamy, well drained soil containing an abundance of lime is the best. A good wheat or oats soil is usually a good soil for growing onion seed. Fertilizer containing a small amount of nitrogen, a fair amount of phosphorus and a good amount of potash, is required. A one per cent nitrogen, eight per cent phosphorus, ten per cent potash mixture, or thereabouts, should answer the purpose. Depending upon the fertility of the soil, between three hundred and eight hundred pounds per acre should be used.

The bulbs to be used for seed purposes should be allowed to fully mature before harvesting. Medium specimens of the large, mild onions will keep better for seed purposes than representative size bulbs. They are given the same care the best of growers give their storage stock. Heating, sweating, or freezing will cause them to sprout before time to plant in the spring, and will, therefore, weaken the vitality of the seed plant. The bulbs are planted during early spring, about the same time that the seed is drilled for the main crop. They are planted in rows wide enough apart for horse cultivation. A one-horse plow or any other plow-like tool that will open up a furrow four inches deep is used to lay out the rows. The bulbs are placed upright

in the bottom of the furrow and covered. The distance between the bulbs should about equal their diameter. The larger the bulb the greater the distance apart. From 125 to 150 bushels will be required for an acre of ground.

The onion seed ground should be cultivated lightly with the object of preserving the moisture and killing any weeds. As the season advances the soil should be worked towards the row, in order to give better support to the seed stalks. Should some of the stalks show weakness, a little hand work may be necessary in banking up the soil firmly around the top of the bulb. Figure 5 shows an onion seed crop approaching harvest time. The seed itself turns black at a very early date and furnishes no indication of maturity, so far as color is concerned. The heads are gathered just before the earliest maturing seed pods shatter when handled. The stems are clipped at about three inches from the head. The field is gone over several times, cutting off only those heads that are ready.

The stalk heads should be spread out on a tight floor in an airy place for curing. Should the floor space prove insufficient, trays with wire bottoms may be constructed so as to rack together. The seed should be stirred quite frequently, especially if more than two or three inches deep. One should, however, spread it out as thinly as possible. Dryness of seed from the day of harvesting is of great importance. Dampness at any time tends to weaken the vitality, which, if once lost, is never regained.

Onion seed is threshed out any time during the fall or winter. For small quantities a flail is used; for larger amounts a regular threshing machine. After threshing the light weight seed, small particles of hulls and other foreign matter not previously removed are taken out with a fanning mill. Not all of the light weight seed is taken out by this

Figure 5. Onion Seed Crop.

latter process. Some growers wash their seed in addition to running it through the fanning mill. The seed should be washed in a tub or barrel of water. The lighter seed, regarded as inferior in germinating and healthy plant producing qualities, remains on the surface. When the water is poured out of the tub, the heavy seed on the bottom is spread out thinly on stretched canvas in an airy or warm place. The canvas permits any surplus water to drain away quickly. The seed is frequently stirred to assist evaporation. If the operation is carried through rapidly, no harm will result. Should the grower desire to remove the light seed from his supply, but fear the process, he can wait until time to seed in the field.

After threshing and fanning, the seed is again spread out so as to prevent heating. From three to four pounds of seed may be expected from each bushel of onions planted. Four or five hundred pounds per acre is regarded as a good crop.

CHAPTER V

FERTILIZERS: LIME AND MANURE

Commercial Fertilizers. Originally it was thought muck lands needed no fertilizers. They were supposed to contain unlimited stores of plant foods, sufficient to supply crops indefinitely. Muck soil is rich in that it is made up largely of organic matter and contains large quantities of nitrogen. In the early days some well decomposed mucks with the addition of nothing but wood ashes grew enormous crops of onions for a few years. Muck soils, however, have their limitations, and where they are farmed intensively it has been found profitable to use large quantities of fertilizers.

The agencies that render nitrogen available for the use of the plant do not start to work until the ground is thoroughly warmed up and the season pretty well advanced; hence an application of nitrogen early in the season is of great advantage in giving the plants a proper start. By mid-season the nitrogen producing activities of the soil are of great assistance to the crop.

The potash found in soils is a result of decomposition of feldspars, present in clay soils, but not found in mucks. Consequently we have a very limited amount present in mucks, depending largely upon the materials washed in after the formation of the organic matter. In addition, the onion is known to be a gross feeder of potash. Large quantities are used in making the bulb. Potash is the limiting factor so far as the elements of fertility are concerned, and the results obtained in many cases are directly dependent upon the amounts added.

The best experimental work on fertilizers for onions on muck soils is that of the Cornell Station. These experiments were continued for three years and consisted of eighteen plots having combinations of the three important elements of plant food. Chart 5 gives the results of seventeen of these plots. Phosphoric acid and potash gave the largest increase in crop production. The largest single yield being plot six, which had 600 pounds of sulphate of potash and 1,000 pounds of acid phosphate per acre. The increases from nitrate of soda were relatively small. The next two heaviest yields were plots twelve and thirteen. Both of these carried 500 pounds of nitrate of soda, thus demonstrating the utility of small applications of nitrogen. The yield decreased with the largest application of raw rock phosphate. The results, with lime added across the plots, indicated that the soil experimented upon needed but little calcium. Manure, however, was beneficial upon the cross plot treatment. These experiments bear out the practice of the majority of growers, who use fertilizers containing little or no nitrogen, but having large amounts of potash. The Cornell Station recommends the following fertilizer standards for muck soils. They should be applied at the rate of 2,000 pounds per acre for truck crops.

2 to 3 per cent of nitrogen.

4 to 5 per cent of phosphorus

10 to 15 per cent of potash.

Chart 5

	Per Acre	Yields
1—Check.....		11,000 lbs.
2—Sulphate of potash.....	600 lbs.	19,918 "
3—Acid phosphate.....	1,000 "	19,086 "
4—Nitrate of soda.....	500 "	18,201 "
5—Check.....		17,612 "
6—Sulphate of potash.....	600 "	
Acid phosphate.....	1,000 "	26,317 "
7—Sulphate of potash.....	600 "	
Nitrate of soda.....	1,000 "	21,131 "
8—Acid phosphate.....	600 "	
Nitrate of soda.....	1,000 "	19,056 "
9—Check.....		13,207 "
10—Check.....		14,302 "
11—Sulphate of potash.....	200 "	
Acid phosphate.....	500 "	
Nitrate of soda.....	500 "	22,371 "
12—Sulphate of potash.....	800 "	
Acid phosphate.....	500 "	
Nitrate of soda.....	500 "	24,517 "
13—Sulphate of potash.....	200 "	
Acid phosphate.....	1,500 "	
Nitrate of soda.....	500 "	24,852 "
14—Check.....		19,824 "
15—Sulphate of potash.....	1,200 "	
16—Raw ground rock phosphate.....	1,000 "	16,211 "
17—Raw ground rock phosphate.....	2,000 "	14,435 "
18—Check.....		15,818 "

**Cross Plot Treatment of Lime and Manure, Each Application across
One Third of All Plots**

	Per Acre	Yields
A—Check.....		15,100 lbs.
B—Lime.....	1,500 lbs. CaO	16,900 "
C—Manure.....	8 tons	19,300 "

Good crops of onions are grown with a smaller per acre application where onions follow other heavily fertilized crops or where manure carries a part of the elements of fertility. With large applications it is essential to have other crop growing conditions in the best possible shape, in

order that returns may be realized sufficient to warrant application.

Lime. As with upland soils, the fact that some mucks need lime cannot be disputed on good grounds. Furthermore, the decomposition of large amounts of organic matter in mucks makes them especially subject to accumulative acid conditions. After the soil is well drained and aerated, unless neutralized by a natural supply of lime, an application sufficient to counteract the acidity of the surface soil is advantageous. Where the muck is underlaid by beds of marl or limestone, the content may be sufficient for an indefinite period. On ordinary mucks about 2,000 pounds of limestone per acre, applied from every three to six years, will usually be found sufficient. Limestone is to be preferred to the quicklime. The latter has an undesirable caustic action upon the organic matter in mucks.

Manures. Since mucks are made up largely of organic matter, some growers use no manure on their land. Many persons are not so favorably situated as to be able to cover large areas with manure. Other growers make occasional applications, perhaps once in three years. Whatever may be the practice, it is generally conceded that the bacteria found in manures are especially beneficial to the organic matter of new and raw muck soils. They assist in decomposition and prove invaluable in the way of adding beneficial organisms of decay.

Manures should be applied to muck soils upon some previous crop, unless well composted. Coarse and raw manures are likely not only to contain large amounts of weed seed but to furnish a breeding place for the onion maggot. They also tend to keep the soil open, thus making it too dry for the crop.

CHAPTER VI

PREPARATION OF THE SEED BED AND SEED PLANTING

Preparation of the Soil. The best results and the greatest yields are obtained by caring for the work in a most thorough manner on a moderate acreage. More careful fitting of the land is required for but few other crops. The land is usually plowed in the fall, and, unless exceptionally well drained, is laid off in beds from sixty to eighty feet in width. These beds run the width or length of the field, as the local circumstances may demand. The plow furrows for the first few years are turned towards the center of the beds. This practice produces a slightly convex surface, or bed, causing any surplus water, especially that from spring rains, to run off rapidly. The general land however should be level, so as to prevent washing, since the seed is drilled rather shallow and the roots of the young plants are near the surface. It should not be possible for water to stand upon the onion bed any period of time after the seed is planted. All low or hollow spots should be filled, else the crop is likely to be partially or completely destroyed within the area having poor surface drainage. For the purpose of leveling, a plank set upon edge may be used. The plank which acts as a scraper, is equipped with thills for one horse and handles for the driver. The handles are used to press the plank into the soil, so as to catch up some of it, and are lifted slightly when the low places are reaches, thus dumping it. Some earth will be carried from the higher to the lower places. In this way a better level may be secured.

Various kinds of disks, harrows, drags and smoothing boats are used to prepare the soil. Individual growers have their own preferences. The land is first disked, or harrowed, and then dragged. Fertilizers should be well worked into the soil. As the onion is a surface feeder, it is best to keep

Figure 6. Fertilizer Spreader.

the elements of its food in the top few inches. A spreader, like that shown in Figure 6, is necessary for this purpose. If the land is loose, a roller must be used to pack it down.

Figure 7. Planker for Smoothing Ground.

Over working muck soils may render them liable to drifting. A heavy wind upon a dry soil may prove fatal to the seed before it is out of the ground. The soil should be smoothed before seeding. Three or four planks, having their edges spiked together, are sometimes used. Figure 7 shows a

Figure 8. Onion Seed Drill.

planker made in this way. All horse tracks are filled in by its use, and the bed is ready for the drills.

Drilling the Seed. Hand seed drills, as shown in Figure 8, are used in planting onion seed. The drills are set in accordance with the germination test. If the seed is not too old and comes according to the test, the drills can be regulated so as to obviate the necessity of thinning. Test the drills by running over a long strip of paper marked off in feet. From sixteen to eighteen seeds per running foot will be a sufficient amount. Onion seed is usually drilled in rows fourteen inches apart, and from four to five pounds per acre are used. The exception is in the case of white seed, which is generally sown at the rate of six pounds per acre. Keeping the rows straight and at an equal distance apart facilitates cultivation. Several drills are sometimes hitched together and pulled by a horse.

In heavy soil the seed should be drilled about one half an inch deep. In mucks it is put into the ground from three fourths of an inch to two inches deep. Ordinarily three fourths of an inch is deep enough, but since the muck areas are so flat and usually unprotected from the winds, a few days of dry weather will make it possible for a high wind to blow the seed out, if it is put into the ground only three quarters of an inch. Two inches may be too much, if the soil is heavy or well packed, but may be considered a right depth, if the soil is loose. A few plantings for wind-breaks are of decided advantages and are used in some places.

Early seeding is of importance, since the bulbs make most of their growth before hot weather comes on. In northern regions seed is planted just as early as the ground can be fitted, the latter part of March or the first part of April.

CHAPTER VII

THE LESSER ONION CROPS

Onion Sets. The onion set industry has attained more importance around Chicago, Illinois; Louisville, Kentucky; and Chillicothe, Ohio, than perhaps in any other localities. Onion sets are merely partially grown or small sized onions, their diameter running not more than one half or three quarters of an inch. From forty to one hundred and twenty pounds of seed are used on an acre. The rows are spaced from seven to fourteen inches apart. The thickness of the onions and the consequent crowded condition produces a very small bulb. The difference in the amount of seed used depends largely upon the fertility of the soil and width of rows. With rich soils more seed will be needed to keep the plants crowded lest the onions grow too large.

The seed is sometimes spread into the row about two inches wide by means of a special attachment to the drill. It is sown about the same time, and the crop is cared for in about the same way as onions grown for bulbs. The crop is ready to harvest in about ninety days after drilling the seed. Onion sets are pulled just after the necks begin to dry up, but while the stems are still erect. At the time of pulling, the tops are twisted off. The bulbs are crated and either cured in covered stacks in the field or hauled to curing sheds. Bulbs over three quarters of an inch in diameter are screened out and sold for picklers.

Green or Bunch Onions. Green or bunch onions are produced in several ways. The sets are usually planted in early spring and are pulled whenever they attain the desired

size. Small sets will produce green onions in from six to eight weeks. The larger sets grow to proper size in less time. They are marketed by peeling the outer tissues off, washing, tying in bundles and trimming both roots and tops.

Onions grown from seed in the ordinary manner may be used for green onions. The product grown from seed will not be ready for market as early as green onions grown from sets. The very earliest green onions are produced by fall planting of top onions, also called perennial tree onions, or multipliers, also called potato onions. Both of these onions differ from common onions and are distinct races. The multiplier has two or more cores, which, unless they are pulled as a green onion, continue to divide, and produce large, ripe bulbs. The core of the bulb of the top onion also divides, if permitted to grow beyond the green onion stage; but, like the multiplier, it does not attain any considerable size. The top onion sends up a slender stalk which bears a cluster of bulbs at the tip in the place of seed. Both the top cluster and the bottom divided bulbs can be used for green onions. They mature a little after mid-summer and should go through a rest stage or be cured before fall planting.

In the Northern states the multipliers or top onion bulbs are planted early in September in rows about fourteen inches apart. In milder climates they may be planted later. The bulbs produce some growth before winter sets in; but during a severe winter they should be covered slightly with straw, loose manure or leaves. A south exposure will help materially in advancing the crop in spring.

Pickle Onions. Pickle onions are small sized onions produced by crowding. The seed is drilled at the rate of from twenty-five to thirty pounds per acre. White varieties are largely used. The rows are usually spaced 12 inches

apart. Otherwise the crop receives the same general treatment as large onions. Pickle onions run larger than sets. They may be graded into three sizes: those smaller than $\frac{3}{4}$ inches in diameter; those running from $\frac{3}{4}$ to $1\frac{1}{4}$ inches in diameter; and those over $1\frac{1}{4}$ inches in diameter. A good demand exists for onions used in pickling during the late summer and autumn.

Transplanted Onions. The transplanting method consists in starting plants under glass in late winter and transplanting them to the field in early spring. The crop then has the advantage of cooler weather for the greater part of its growth. It has for its object the growing of more bushels per acre by a maximum use of the land as well as growing larger and more uniform bulbs.

This method of growing onions is used in a small way in a great many localities of the North. The Texas crop of Bermudas is grown entirely by this method. Transplanting may never come to be used in a large way until a transplanting machine is perfected, to put the young seedlings in the field in a more rapid manner than is now possible, and yet a favorable opportunity exists to supply our markets with large, mild onions. Good prices are paid for domestic stock, and at present we are largely dependent upon Spain and Texas to supply the demand.

The Giant Gibraltar and Prizetaker varieties are used for transplanting. The seed is planted in good rich soil in the greenhouse or hotbed. It should be sown so as to give the plants plenty of room in growing. Plant at the rate of about two pounds of seed for an acre in the field. The most difficult thing about growing the seedlings is to time the growth, so as to have plants just the right size for placing in the field. It will take from eight to ten weeks' growth under glass to prepare for field use. One should

calculate the approximate date of field transplanting and from that date time his plants. From the middle of January to the middle of February has been found satisfactory for the North. Care should be taken to prevent attack from dampening off fungi. A damp air and high temperature provide the right condition for infection. The fungus attacks the plants above the surface and destroys them completely. The use of sterilized or fresh soil in the beds each year will obviate this trouble. Water during the morning hours, so that the plants will dry off quickly and keep the air in a dry condition by proper ventilation.

The tops of the plants should be clipped from time to time, keeping them at a height of about four inches. At the time of transplanting both tops and roots are pruned.

Figure 9. Onion Plants Ready to Transplant.

The plants should be about the thickness of a pencil for field use, as shown in Figure 9. One should see that they do not get too large and crowd one another. The seedlings should be subject to temperatures more nearly corresponding to that outside at the time of transplanting and the water supply should be lessened. This is known as "hardening off." Good ventilation is given in the greenhouse. If hotbeds are used, the sash are removed a greater length of time each day as the season progresses, until, finally, they are left off entirely. Plants grown in boxes in the house can be taken in and out to harden. The young plants can stand light frosts after transplanting.

Loamy, upland soils, or those having a good content of organic matter are used for the field crop. Mucks are not at present generally employed. The transplanting method should, however, appeal to owners of muck tracts and it deserves a more thorough trial. The plant bed receives about the same treatment as a seed bed for the crop grown directly from seed. The onions are set in rows fourteen inches apart, and

Figure 10. Transplanting Onions in the Field.

Figure 11. A Crop of Transplanted Onions.

the plants are spaced from four to six inches apart in the row, the width depending upon the fertility of the soil and the desires of the grower to set the largest possible number of plants per acre. It will take all the working days in a month for one man to transplant an acre. Four or

Figure 12. Ohio Grown Transplanted Onions.

five men should be employed for planting an acre, so as to complete the task in a reasonable length of time. If the soil is heavy and dry, it may be necessary to use a dibble, but ordinarily one can work more rapidly by using one's fingers. Figure 10 shows the method of operation.

The crop should be taken care of in the same manner as onions grown directly from seed. Little or no weeding will be required on upland soils. Figure 11 shows a growing crop of Denias. After pulling, the onions are usually cured in cribs or sheds. One thousand bushels, or more, may be expected from an acre. Since the onion is a strictly fancy product and commands fancy prices, the crop is graded and packed in the Spanish type of crate. Figure 12 shows a crate of Ohio grown Denias. Mild onions are marketed largely during the fall, when the demand is at its height. Large onions do not have as good keeping qualities in storage as the smaller varieties have; but, if they are well matured, sound, and of medium size, they may be kept for the early spring markets.

CHAPTER VIII

THE CULTURE OF THE ONION CROP

Cultivation. Rains following the seeding operations tend to pack the soil and make it difficult for the tender seedlings to break through the surface. Stirring the soil by means of a wire weeder or scratcher obviates serious results from this source. This tool is from two to four feet in width and is run over the onion fields across the rows. Figure 13 shows one style of wire weeder. Fields are frequently gone over the second time with the weeder after the onions are out of the ground two or three inches, the results being highly beneficial in preserving moisture and

Figure 13. Wire Weeder.

preventing the growth of weeds. A dust mulch is formed which conserves moisture and kills innumerable small weeds just starting. As a result, the soils, especially uplands, warm up faster.

Wheel cultivators are used just as soon as the onions are sufficiently grown to enable one to distinguish the rows. There are several kinds which may be used according to the preference of the individual grower. The double knife

Figure 14. Double-wheel Cultivator.

cultivator in some form has come into general use. Figure 14 shows one that straddles the row. The cultivator shown in Figure 15 goes between the rows. The blades stir the soil as they are pushed along by the operator, forming a dust mulch. Many weeds are killed outright and others have their root systems exposed to the sun. The fields

Figure 15. Single-wheel Cultivator.

are cultivated over every week or ten days during the early part of the summer. From eight to fourteen cultivations are necessary according to the rainfall, sunshine, temperature and amount of weed seed in the soil. The onion is a shallow rooted crop and is likewise cultivated shallow to

Figure 16. Single-wheel Cultivator with Shovels.

prevent root injury. Some growers substitute a triple set of shovels for the last cultivation. The shovels turn the soil against the row, protecting many of the exposed bulbs from the sun. This gives them a better color. If run deep enough, the shovels sever many of the roots, thus hastening

maturity. This is of great advantage when the crop is unusually late in maturing. Figure 16 shows a single wheel cultivator equipped with three shovels.

Weeding. One of the greatest economic problems is that of weeding. Acreages are often cut down and the land that would otherwise be desirable is not farmed on account of the labor problem, which has not as yet been solved in all places. Again one may see fields of onions abandoned to the weeds during mid-season, all because the plans of the grower were not adequate. Both the amount of labor required and the rate paid may limit the acreage. The amount of weeding necessary varies with the fertility of the soil, foulness of the land, rainfall of the season, and the management of the grower in combating the pests. It costs less to destroy small weeds than big weeds. Keeping ahead in one's work reduces the expense of cleaning up the crop. Again, if the weeds are allowed to grow up with the

Figure 17. Height of Onions at Second Weeding.

onions, becoming tall, it not only costs more to pull them, but the onion plants suffer from shading, robbery of plant food, and removal of earth from around the stem at the time of weeding.

There is considerable difference in the amount of weed seed in the land; but, with an average soil, two or three hand weeding are sufficient. With a wet season or foul land, the amount of labor required is tremendous. The bulk of the work is performed during the early part of the season. Figure 17 shows the size of one crop at the time of the second weeding. Later in the season, when the ground is covered with a good mulch and the onions shade it, but few seeds will germinate. It will cost all the way from fifteen to thirty-five dollars per acre to keep the land free from weeds. Small boys and girls are generally used for the work, since they are more efficient than men and their

Figure 18. An Army of Workers Weeding and Cultivating.

labor is of less expense. Foreign labor is used in some localities where the labor problem is acute. Figure 18 shows an army of workers weeding and cultivating.

With care the amount of weed seed can be reduced to a minimum. As soon as the onions are stacked for curing or removed from the ground, any large quantity of weeds can be raked up, carried off and burned. The land can also be disked, or harrowed, thus destroying the smaller weeds while immature. A large amount of weed seed can also be destroyed by a good system of crop rotation. Coarse cultivated crops, such as celery, cabbage and potatoes, give better opportunity for the destruction of weeds. Hemp has lately been introduced in some of the northern onion growing sections. This crop is sown broadcast, or with a grain drill. It covers the ground completely and grows eight or ten feet high, smothering out all weed life.

Irrigation. In the West and Southwest, the furrow, sub-flooding and overhead systems of irrigation are in use. In many places these are essential to growing a successful crop. In the North, irrigation is not generally practiced, although the overhead pipe systems are being used more and more every year. The pipes are carried from two to ten feet above the ground on posts. Nozzles are placed in the pipes about three feet apart. Figure 19 shows the overhead system of irrigation. Exclusive of pumping plant, such a system costs from \$125 to \$150 per acre to install. Where city water is to be had, the pumping plant is not necessary. If a pumping plant is built, the size is usually made sufficient to care for a third or half of the acreage under pipes at one time. The cost of operation varies according to the amount of water applied. About fifteen dollars per acre represents a fair allowance for this charge. Growers report an increase of from one fourth to

Figure 19. Overhead Irrigation of Onions in the North.

twice as many bushels of onions per acre by the use of overhead irrigation. With light soils and dry weather, an application of water is extremely helpful in preventing drifting. Moisture is most beneficial to onions during their early stages of growth. Dry conditions are essential at the time of ripening; hence water applied by irrigation would be most beneficial during the early part of the season. Some muck areas have too much moisture rather than not enough; others have an ample supply at the right depth, rendering irrigation unnecessary.

The cost of installing a system of irrigation is a relatively high, per acre, investment. The installation of such a system is in most cases a problem of economics rather than one in crop production. Its utility will depend not only upon the increased crop production but also upon the value of the land, the total investment in other equipment and the management of the property. Since the system

is permanent, one must take into consideration its value in growing crops other than onions. In considering an increase in crop yield by adapting improved means of growing a crop, the grower should first, last, and at all times, consider all methods of improvement. Good seed, good drainage, proper use of fertilizers, manure and lime, supply and cost of labor, rotation of crops, proper tools, adoption of right marketing methods, adequate buildings, and the irrigation of crops, are all important factors in the growing of onions. The grower must consider the relative importance of these factors, on the one hand, and his capital on the other. Even a limited amount of capital, properly and carefully distributed among the different factors of crop production, will be amply sufficient. Such a trifling detail as the investment of fifteen cents' worth of time in setting the onion drill to drop just so many seeds per foot may bring returns a thousand times bigger than \$125 invested in an acre of irrigation. Irrigation will undoubtedly pay in those instances where the grower has already taken advantage of the most advanced methods of crop management and production adopted by progressive growers. It will be used more and more every year. The grower's problem, however, is to properly combine the factors of crop production according to his resources.

CHAPTER IX

THE MATURED ONION CROP

Harvesting. No hard and fast rule can be set for the time of harvesting. At the time of ripening, the tops wither and the roots let go of the soil. The frontispiece shows a field ready to pull. On account of soil condition or attacks by pests, the crop may ripen early. On the other hand, the onion may die with the stem standing erect. In the latter event, the keeping quality will be poor. One should not wait, however, for the tops of such onions to break over, be they few or many. If grown for early market, the crop is sometimes pulled green. The tops are clipped by hand from one half to one inch from the bulb with sheep shears or knives. The onions are screened and hurried off to market in well ventilated cars. If grown for quality or storage stock, they should be pulled as soon as ripe. Should wet weather set in, delay in harvesting would mean a second growth, rendering harvesting more difficult and injuring the keeping quality of the crop. Yellows and reds are thrown into windrows for partial curing. Figure 20 shows the pulling operations. If thoroughly dry externally, they may be crated immediately; otherwise, they are permitted to remain upon the ground for a few days, the length of time depending upon the condition of the crop and the weather. The bulbs are crated with tops on and stacked in the field for complete curing. The stacks are covered with boards or tarpaulin for rain protection. Figure 21 shows a crop of onions curing in stacks. In this condition they may remain in the field until freezing weather, but are usually topped

Figure 20. Pulling Onions.

within two or three weeks. In order to preserve the color from sun injury, the white varieties are pulled while the necks are still green, and topped by hand. Being more

Figure 21. Onions Curing in Stacks.

easily injured by unfavorable weather conditions, they are usually carted from the field and cured under cover. Care should be taken to keep them dry and from heating. In some districts all classes of onions are cured in cribs or sheds. The bulbs are hauled from the fields just after crating and placed under cover. The sheds may be built open, without sides, consisting simply of a roof. Such a shed, fifty by one hundred feet, can be built for \$800. Another style of shed is similar to a double cornercrib, as seen in Figure 22.

Figure 22. Placing Onions in a Curing Shed.

The siding is spaced for ventilation, the same as a crib. The two cribs are connected overhead, making a covered driveway between. Such a double crib 180 feet long, or enough cribs to total that length, will be sufficient for storing ten thousand bushels, exclusive of the driveway, and will cost approximately \$1,000.

The use of sheds for curing is not general, but is followed out elaborately in some districts. Sheds and cribs are helpful in preserving the color and curing the crop in the best possible manner, and fewer crates are needed in harvesting. Where the onions are marketed before freezing weather, they are useful in protecting the crop during the fall.

The machine topper, operated by gasoline power, is used in many places to clip the tops from the bulbs, as seen in Figure 23. Scullions, unsound and untopped onions are picked from the carrier of the machine at the time of topping. A sorter attachment grades the onions into two principal sizes, those more and those less than one and one quarter inches in diameter. Where the machine sorter is not used, the onions are run over a screen set at one and one quarter inch, as seen in Figure 24. Such a screen is about thirty

Figure 23. Topping Onions by Machine.

Figure 24. Onion Screen.

inches wide, ten feet long, narrowing to a mouth fifteen inches wide, forty-four inches high at the top end and thirty-seven inches high at the bottom. The sides of the screen box are six inches high. Strip iron is used for the bottom of the screen box and is set according to the grade of the onions. Different screen boxes may be made for various grades of onions and are used interchangeably upon a single frame. The smaller sized onions from the general crop are sometimes graded again by running over a three quarter inch screen. These seconds, or picklers, as they are called, are sold in the fall, while the demand is still good during canning season. From the topper the onions are placed on the car or in storage.

Where the topper has not come into general use, the onions are topped into crates right off the windrows, as seen in Figure 25, and placed in storage, or run over screens and placed in cars.

Storing. For storage purposes the onion must be well ripened and thoroughly cured. Good storage onions should rattle like blocks of wood when poured from one crate to another. A bright appearance, gained by careful curing

Figure 25. Topping Onions by Hand.

and avoiding lengthy exposure to the sun, is essential for highest market prices. Figure 26 shows a crate ready for storage.

Storage buildings should provide for ample ventilation during the fall months and be frost-proof in winter. During damp or warm days the storage openings should be closed, but opened again at night. Good ventilation is secured by providing a good inlet and outlet for air. Tile

openings in the building foundation at the floor line, along the side wall, provide for the inlet of cool air. A trap door in the ceiling provides an outlet for warm air. Some storages have a basement. The main floor is constructed of planks, spaced so as to give good under ventilation to the onions above. Where the solid floor is used, crates are set upon

Figure 26. Crate Ready for Storage.

strips or planks, spaced for ventilation beneath the stacks. Several methods of assisting the movement of air in the stacks are in vogue. They are all based on spacing the crates so as to allow openings for air movement. Figure 27 shows stacking and spacing in storage.

A storage building of wood has a total of four or five thicknesses of boards, three or four of paper, and two dead air spaces from four to six inches in thickness. Such a building, thirty by sixty, will hold ten thousand bushels and will cost about \$2,500. Figure 28 shows a series of storages convenient to loading track.

The temperature of the storage should be kept just high enough to prevent freezing. From 32 to 40 degrees is the margin, but from 34 to 36 degrees is perhaps better. A stove may be necessary to heat during severe weather, especially if the storage is only partly filled. If the onions

Figure 27. Onions in Storage.

Figure 28. Onion Storage Houses.

remain in storage any length of time they are again screened before putting in cars, in order to remove all loose peels, decayed bulbs and sprouted tops. During cold weather cars should be warmed before loading by means of an oil stove. Freezing does no harm to the onion, if it is protected so that it will remain frozen until used. The thawing out process should be a gradual one. While frozen, care should be taken in handling; for they are easily bruised when in that condition.

Marketing. Chart 6 shows why it will pay to store onions. The two year averages for January and October prices are charted. The prices were taken from the New York onion market, as reported by the American Agriculturist. By taking two year averages it will readily be seen that January prices are always higher than October prices, through a series of years. Counting in the depreciation of stock and the expense of storage, the higher prices obtained by holding will warrant storage in most cases. A careful study of the total production soon after harvest, together with a general

Chart 6. The New York Onion Market in Two-year Averages.

tendency to hold or sell, will often give the grower a key to the situation, but even with such knowledge the grower cannot forecast with accuracy. The consumption itself will finally depend upon the coldness of winter. A long and steady cold winter will increase the demand remarkably. Taking all things into consideration, it will be best, perhaps, to store a part or all of the crop each year, provided good quality onions and good storage facilities are at hand, since this is the season when consumption is greatest.

The general movement of the onion crop is toward our large centers of population. New York is the great onion market of the country. This is due not only to the number of people, but also to the large foreign population. One of the peculiar things about marketing onions is the fact that certain markets have developed a demand for certain stock. New York is a good market for all sorts, but especially whites and picklers. Yellows predominate in the market of such cities as Philadelphia, Baltimore, Washington, Pittsburgh, Cleveland, Cincinnati, Toledo and Detroit. The reds are marketed in the East only to a limited extent, while most of them find their way to the southern cities, such as St. Louis, Memphis, Birmingham, New Orleans and Nashville, where the negro population is large.

Whites are marketed almost entirely in bushel crates. Some growers have a trade name and grade the onions according to certain standards. Since they are harder to cure and store, they always command a higher price. The yellows and reds are marketed in sacks or in bulk according to the market and the desires of the customer. Sacking the product is almost necessary somewhere in the numerous steps of marketing. If the onions are nicely graded and put up in sacks, weighing just a trifle more than the selling weight, one is always repaid for his trouble. As a rule the

markets will more than pay for the price of sacking. The sacks hold from seventy to one hundred and forty pounds, but the one hundred pound sack may be regarded as the standard.

Onions are supplied from the different sections in about the following order: The Northern crop comes in during August and lasts until the latter part of March. The Spanish comes into competition with this crop during the fall and winter. In April the Egyptian onions make their appearance, followed by the Texas Bermuda crop during May and June. The Louisville, Kentucky, section supplies the market during July just following the Texas crop and is pretty well cleaned up by the time the Northern grown stock appears. The Kentucky onions, like those from Texas, are grown under glass and transplanted. Quite an acreage is devoted to this crop about Louisville. It will be seen that the Spanish crop is the only direct competitor of the Northern crop.

The official estimates of acreage in Spain were made in 1910 for the last time when there were 11,481 acres. The acreage is being increased from time to time and the growers are becoming better organized. They are beginning to make their shipments under co-operative agreement. At the present time they have some advantage over the inland grower of onions in the United States. The freight rate from Spain to New York City is only twenty cents per bushel. From Ohio points, for instance, it varies from twelve to seventeen cents. The tariff has been recently reduced from forty to twenty cents per bushel, which will give the Spanish grower a cost of forty cents per bushel for marketing, over a former marketing cost of sixty cents. The consumption of Spanish onions in other countries has been higher per capita than in the United States, but with the recent

reduction it will probably be increased; but, on account of the increased consumption from year to year in the United States and some of the handicaps attendant to an increase in an acreage in Spain, it may not be expected that an enlargement in imports will do much harm. It might be mentioned in passing that the lands in the province of Valencia, Spain, are so intensively cultivated that there are cases on official records where one hundred acres support one hundred and sixty families, and where single families live on the products of four tenths of an acre. The land is officially estimated to be worth, on an average, \$650 per acre. Certainly under these conditions the acreage cannot be increased rapidly.

Yield and Cost of Growing. The yield of onions from muck land varies considerably. The State averages for the three years of 1911-1912-1913 are given in Chart 7. The best growers count from four hundred to six hundred bushels as an excellent crop and there are occasional reports of from eight hundred to a thousand bushels. Estimates of the cost of growing an acre of onions vary from sixty to one hundred dollars per acre. There are a few who apply as much as seventy-five dollars' worth of fertilizers per acre, which will bring the cost of growing well up to one hundred and fifty dollars. While a net profit of one hundred dollars per acre is above the average, a profit of from one hundred to one hundred and fifty dollars is often made. On a cost basis of seventy-five dollars per acre in caring for the year's crop, the expenditures can be divided about as follows:

Average Production Taken From Crops of 1911-1912-1913.

Cost of Growing One Acre of Onions

Manuring (1-3 of a 3-year expense).....	\$8.00
Plowing and harrowing.....	8.00
Seed.....	8.00
Drilling.....	1.00
Weeding.....	20.00
Cultivating.....	14.00
Harvesting.....	16.00
	<hr/>
	\$75.00

Returns

Average production of 300 bu. @ 50c.....	\$150.00
Cost of production.....	75.00
	<hr/>
Net profit.....	\$75.00

Another interesting fact is revealed in Chart 8. It will be seen by this that the total amount of money received for a crop has a relation to the total amount of onions grown. Both 1912 and 1913 were years of large crops. The cash

Chart 8. A Small Crop is Worth More Than a Large Crop.

sale of the smaller crop of 1912 was greater than the cash sale of either the 1911 or 1913 crops. These figures were taken from the American Agriculturist Onion Crop Report. Other things being equal, the money value of a small crop is greater than the money value of a large crop.

CHAPTER X

ONION PESTS

INSECTS

Onion Maggot, *Phorbia ceparum*, by Meigen, and *Pegomya cepetorum*, by Meade. This insect has been known and widely distributed from time immemorial. It was first described by Meigen in 1830. It has been imported into the United States probably through some shipment of its food. It is often called the Imported Onion Maggot to distinguish it from other maggots which also feed on the onion. The onion maggot is well named, since it feeds on no other food plant than the onion.

Economically, it is one of the most destructive pests of onions. It is widely distributed throughout the United States, being present wherever the onion has been grown for any length of time. Where not controlled, it has been known to drive the onion grower out of business. It has been particularly destructive during certain seasons. Severe attacks occurred in 1854 and 1863 in the middle and Eastern states. Again in 1904 from one fourth to one third of the crop was taken in many places.

The onion maggot is the larva of a fly and is about one fourth of an inch in length when full grown. It is of the Dipterous family *Anthomyidae*. The insect passes the winter stage partly as a pupa in the ground, and partly as adults in barns, farmhouses and other sheltered localities. If in the pupa stage, it emerges during the first few warm days of spring. Unless planted late to avoid the maggot, the onion plants are usually just above the ground when

from two to six eggs are laid singly on a part of the plants in the field. The eggs are laid at the surface of the ground between the sheath or collar and in the crevices between the leaves. They are white and smooth in appearance and perceptible to the naked eye. Varying with the temperature the eggs hatch in a week or ten days.

After hatching, the maggots or larvae burrow into the onion. Figure 29 shows the method of attack. They begin to feed immediately, and in most cases the injury leads to the rapid decay and death of the plant. The maggot feeds within the epidermal tissue of the plant. The cylindrical root is nearly cut apart and the plant wilts to the ground, as shown in Figure 30. From one to four maggots are found in each plant attacked. Several sizes may be found in the same plant, but they attain full growth in about two weeks. The maggot pupates in the surrounding ground, or sometimes within the onion. In another two weeks the fly emerges to lay eggs for the second brood. The fly resembles our common house fly, but is considerably smaller and more distinctly gray in color. The second brood appears about the middle of

Figure 29. At Left: Onion Plant Attacked by Maggots. At Right: Plant Exposed Slightly Showing Maggots

Figure 30. Effect of Attack by Maggots.

June in this locality and is the most destructive. Three broods usually occur in Northern climates, but the number varies with the weather conditions and locality.

The **Seed Corn Maggot**, *Pegomya fusciceps*, by Zett. The insect not only attacks corn and cole crops, but also the onion. The species is widely scattered and has been known for a long time. It came into prominence about 1902 and has greatly increased since that time. It is closely related to the onion maggot and has a similar life history. The treatment is the same.

The **Black Onion Fly**, *Trixtosa flexa*, by Wiedmann in 1830. The Black Onion Fly is often confused with the onion maggot and the seed corn maggot. A strong lens is needed to distinguish them. It is present in all of the Northern onion growing states, with the possible exception of New England. The insect is entirely black, with the exception of three narrow white stripes on the wings. The life history is the same as that of the onion maggot, with

the exception that the fly continues to live in onions in storage. When attacking storage onions, bisulphide of carbon can be used as a fumigant, one pound to each two hundred cubic feet of storage.

The **Barred-Winged Onion Fly**, *Choetopsis oenea*, by Wiedmann. This species will breed in decomposing vegetation normally. It attacks the onion less frequently than the first three species named. The fly belongs to the family *Ortalidae* the same as the black onion fly, and has a life history practically the same as the onion maggot, with the exception that the maggots pass the winter in the onions. All unmarketable bulbs should be destroyed and the storage should be treated with bisulphide of carbon the same as for the black onion fly.

Control for Maggots. Methods of prevention are the best in the control of various kinds of maggots. The removal of the crop remnants, infested plants and the rubbish are of first importance. Where the insect has gained a foothold, manure and onion refuse should not be applied to the land, since the organic matter affords an excellent breeding place for the larvae. The habit of scattering decayed bulbs on or near onion ground, as shown in Figure 31, is pernicious.

Figure 31. Decayed bulbs scattered out form an ideal breeding place for the larvae of the maggots.

A generous application of fertilizer has been found to be beneficial in many cases. It imparts vigor to the plants, assisting in the recovery of the partially injured ones; the rapidly growing bulb has greater resistance to the attacks of the larvae; and the salts of the fertilizers have an action on the insect itself. The Indiana Station reports successful results with the use of from 400 to 600 pounds of kainit and 200 pounds of nitrate of soda. The New Jersey Station recommends 600 pounds of kainit and 200 pounds of nitrate of soda. A partial substitution of salt in the fertilizer will give the desired action upon the insect itself. The fertilizer should be drilled in shallow, close to the row, or applied broadcast alongside the row having the soil turned away with a hand-plow, and later turned back. The application is more effective if applied after or just before a rain that has wet the ground pretty thoroughly. A few radishes, beets, cabbages, turnips or cauliflower, growing in or about the onion patch serve as a trap crop to catch many of the seed corn maggots.

The **Onion Thrips**, *Thrips tabaci*, by Lind. The Onion Thrips is also known as the onion louse and causes what is commonly called the white blast, white blight and silver top. Dry weather will bring on the pest. A severe attack will render many of the bulbs unmarketable by causing thicknecks or scullions and sometimes completely destroys large areas. The whitened appearance of the leaves is caused by the extraction of the vital juice, first by rasping, followed by suction. Figure 32 shows an infested field. The insect making the attack is of microscopic dimensions and, unless carefully examined, only the devastations following the attacks will be noticed. The stem loses its upright appearance, the leaves become twisted, crinkled and curled, finally dying down prematurely.

Figure 32. Field Infested with Thriss. Defective bulbs compared with Normal Bulbs.

The life history of the insect has not been fully worked out on account of its minute size. The female deposits her eggs just beneath the epidermis of the leaf or stem by means of a saw-like organ. In a few days the egg hatches and the young larvae begin to feed. They suck the juices the same as the adults and are full grown in one or two weeks. Finding a suitable place to transform, they change to the nymph stage and grow to the adult size. With a warm temperature it will require about three weeks in all from the time of laying the egg for the insect to become fully grown. It is probable that six or more generations occur during a single season.

Control of Thrips. The onion thrips suffers from several means of natural control. A sudden and driving storm as well as wet weather in general takes large numbers of the insects. Several species of the lady-bird,

the insidious flower bug and other insects are means of natural control.

The onion thrips feeds on many other plants beside the onion. There is always danger of infection from other crops, and, of course, where all crops that are grown in a particular locality are subject to attack, it would seem to make little difference if the land were rotated. Care should be taken, however, in the selection of crops and more particularly in keeping the onion refuse cleaned up from the fields. All rubbish about the fields should be cleaned up, since most any protected place on the surface of the ground provides shelter over winter.

The potato, sweet potato, peas, beets and spinach, although attacked, are not materially damaged, and can be used as alternates in rotation. Early planting is of great benefit and it is of advantage to stimulate growth by means of fertilizers and manures.

Spraying the crop with nicotine sulphate has been found to be very successful. (Department of Agriculture Year Book 1912.) The following combination is easiest to make and is the most successful to use:

Nicotine sulphate.....	3.2 ounces
Cresol soap.....	3 pints
Water.....	50 gallons

The cresol soap should be eighty-five per cent pure in order to secure the best results and is added as a sticker and spreader. A good quality of whale oil soap gives good results, but must be shaved into small particles and heated before a solution is formed. If whale oil soap is used it should be mixed according to the following formula:

Nicotine sulphate.....	4.3 ounces
Whale oil soap.....	4 pounds
Water.....	50 gallons

A two or four-row attachment with ample hose length should be made for the sprayer and carried in the hands. The spray should be applied with as much force as possible. Provisions must be made in planting the rows to leave a space for a horse drawn sprayer, but, if the barrel type is used, it can be drawn in any field. When once begun, the spraying should be continued at intervals of from seven to ten days, until three or four weeks previous to harvest time. On account of the minute size and its method of hiding in the sheath of the onion it is rather difficult to control the thrips by spraying. The remedial measures should be used early, so as to act as a preventive rather than a cure.

Cutworms. There are several species of the cutworm that attack the onion, and at times they become very destructive. The insect remains over winter mostly in the egg stage in weeds, grass and rubbish. It hatches out and begins to feed early in May, continuing until sometime about the middle of June. At that time the larva burrows in the ground, later coming out as a moth to lay its eggs. Its method of attack is to cut off young plants at the surface of the ground, frequently destroying more than they consume.

Control of Cutworms. Fall plowing and disking will destroy many of the insects by turning them up to the weather. Clean cultural methods are essential. When present they can be controlled by the use of poisoned baits. To a bushel of bran, one pound of arsenic or Paris Green is added and mixed thoroughly into a mash with eight gallons of water, into which has been stirred half a gallon of sorghum or other cheap molasses. After the mash has stood for several hours it should be scattered in lumps about the size of marbles over the fields where the injury is beginning to appear. Since the cutworms are active over night, it should

be scattered late in the day. Where they are migrating from one field to another the bran should be spread evenly and continuously at the margin. For this purpose an onion drill can be used, mixing the bran and poison without sorghum and water.

Wireworms. There are several forms of wireworms that attack the onion. They are elongated, wirelike creatures that work their injury by the destruction of the roots, and are very hard to treat. The life histories of the different genera have not been thoroughly worked out. They do their greatest damage to the crops that follow grass.

Control of Wireworms. Exposure to the weather by fall plowing, together with careful selection of crops following grass, is perhaps the best control.

DISEASES.

Onion Smut has been known in European countries for a long time. It was first reported in the New England States in 1865. It is now prevalent in many parts of the United States, particularly in the older onion growing sections. The fungus is known as *Urocystis cepula*. It attacks the leaves of the young and tender seedling. One thing peculiar about the onion smut is the fact that transplanted seedlings cannot be attacked, nor is the onion troubled after it has once gotten a start, the explanation being that the smut threads can penetrate only a very tender growth. The spores retain their vitality possibly for twenty years in the soil. If once the soil has become infected, crop rotation is of little benefit. Mother bulbs, planted for seed purposes, are never attacked, consequently the spores of the fungus are not carried by seed unless through accident. The great mode of dissemination is by means of infected bulbs. The spores are also transported from field to field by means of the wind, tools, crates, insects, water, and the

feet of horses and workmen. Infected bulbs, spread out upon the land for their manural value, provide an ideal method for the extension of the disease.

The young and tender seedling is attacked below the surface, just after coming out of the ground. Figure 33 shows diseased and healthy specimens. Great numbers of plants are killed; others produce mis-shapen bulbs, each one containing millions and even hundreds of millions of smut spores. The spores are developed in powdery masses, appearing as narrow elevations on the surface of the bulb. Unless the disease is checked, a crop cannot be profitably grown in the same field for five years after the first attack.

Control of Smut. Several preventive measures can be taken. Flowers of sulphur, for-

Figure 33. At Left: Onion Plants Infected with Smut. Notice the infected layer in plants five and six. At Right: Healthy Specimens.

malin or ground quicklime can be applied with good effect. The formalin treatment is perhaps the best. A solution of one pound of 40% formaldehyde and from twenty-five to thirty-three gallons of water is made and applied at the time of seeding by means of a drip attachment to the drill, at the rate of from 500 to 700 gallons per acre. This insures a layer of soil near the seed which is disinfected, and permits the growth to go past the smut infection stage before the fungus can occupy that part of the soil. Ground quicklime or stonelime, preferably the former, can be used for smut at the rate of seventy-five to one hundred and twenty-five bushels per acre just before seeding. If broadcast, it should be harrowed in; but, if drilled, harrowing will not be required.

Onion Mildew. Onion mildew has been a well known disease in European countries for a long time. The attacks have been severe upon the plantations of the Bermuda Islands. In the United States it is pretty well scattered throughout the country. It is also known as downy mildew, onion blight, onion mold, white blast, onion rust and in some places improperly called onion smut. The fungus responsible for the disease is *Peronospora schleideniana*. The spores of the fungus germinate upon the surface of the leaf, if moisture is present. The disease spreads rapidly on the leaf and from plant to plant. Moist humid conditions are essential to its development. Onions on low sheltered ground are more likely to be attacked. The disease makes its start in spots in the field, giving the plants attacked a bleached appearance. A more careful examination reveals a dense moldy growth. The leaves of the plant break over, appearing as though scalded with boiling water. New leaves are sent out and, if the weather is favorable, the plants will look as thrifty as ever in a week or ten days. Should the weather be favorable to the fungus, the new

leaves will be taken as fast as formed. Onion plants are most likely to be attacked just after the bottoms begin to form. Attack by thrips weakens the plant and renders it more susceptible to onion mildew.

Since the disease makes its appearance after the crop starts to bulb, many growers believe that the dead tops are a result of the natural dying process. This is especially true if the crop is attacked late in the season. Furthermore, the bulbs are not disfigured and the damage can not usually be measured by the naked eye. The yield is, of course, reduced. If seed onions are attacked, the vitality and germinating powers of the seed are lowered.

Control of Mildew. Clean culture is one of the best methods of control. Burn all onion tops or scatter them on ground not used for onions. As the disease is also carried by bits of leaves or stems in the seed, the chances of its spreading are reduced, if the seed is perfectly clean. A system of crop rotation should be practiced, since the spores last but two or three years in the soil. Tall weeds or shrubbery on the borders of the field should be removed, so as to permit a free circulation of air, thus assisting in the evaporation of rains or dews.

Systematic spraying with Bordeaux mixture, commencing about the first of July, will control the disease. After the crop is attacked, spraying will be of no benefit except to protect the new growth of leaves. Spray every ten days or two weeks. Standard Bordeaux mixture is used, four pounds of quicklime, four pounds of copper sulphate, properly mixed with fifty gallons of water. The spray is applied with the same kind of apparatus as that described on page 86 for thrips.

Dry or Black Neck-Rot is a serious disease attacking the white onion. The reason for attacking this

variety lies in the method of harvesting. The white onions are harvested before the tops are cured, in order to preserve the color. The neck of the onion being still green, the fungus has a favorable opportunity to enter. The onion, when once infected, is destroyed. Figure 34 shows a diseased specimen. The disease becomes worse where the white onion is cropped continuously.

Control of Dry or Black Neck-rot.

Neck-Rot. The best suggestion at present in the way of a preventive is to put the crop under cover immediately upon topping and fumigate with formaldehyde gas. Twenty-three ounces of potassium permanganate should be used with three pints of formalin for each thousand cubic feet of space fumigated. Place one of the materials in a flat bot-

Figure 34. Dry or Black Neck-rot.

tomed dish and generate the gas by adding the other just before retiring. A tight oiled tent of canvas may be used for this purpose. The gas will kill the spores. Although this method has been used with success, further experimentation is necessary.

Heart-Rot is a bacterial disease of the onion that invades the center of the bulb, following topping. Should the outside layers of the bulb become infected first, it is called "slip-rot." It ends in complete destruction of the

bulb through a soft rot. Wet weather at the time of harvesting is the principal cause.

Control of Heart-Rot. Prompt pulling and care in curing the crop is the best control.

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