Muck Soil Management for Onion Production
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Muck Soil Management for Onion Production

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Summary

1. **Muck Types.** Mucks which have a satisfactory reaction for onions, are ideally suited for the production of the crop. Testing the soil to determine the reaction before attempting to produce onions is strongly recommended (pages 3-4).

2. **Lime.** Its application is not advisable except for the very acid mucks, which group often do not produce well, even after liming (pages 4-5).

3. **Copper sulphate.** Light applications will generally prove markedly beneficial on those mucks which require lime, and on the less acid mucks on which the mature bulbs have poor color (pages 5-6).

4. **Sulphur.** Its use on "alkali" mucks will result in greatly increased yields, better maturity and better keeping quality of the crop (pages 6-8).

5. **Fertilization.** Use of commercial fertilizers is absolutely necessary for the production of good yields of onions. The fertilizer mixture and rate of application which is best adapted for the crop depends on several factors (pages 8-10).

6. **Drainage.** Proper drainage is essential for good yields. A uniform depth of water-level is desirable, with dams in the ditches to give satisfactory control of the moisture supply (pages 10-11).

7. **Cultural Methods.** Deep breaking, heavy rolling, fairly deep fall plowing in later years, shallow cultivation, and removal of weeds while they are small, are essential factors in onion production (pages 11-13 and page 17).

8. **Wind Injury.** Injury to onions can be lessened by wind breaks along the line fences, by barley interplanted between every three rows of onions, by increasing the content of organic fibre in the soil and by raising the water-level in the soil (pages 13-15).

9. **Varieties.** While several strains of the Yellow Globe variety of the American onion have constituted a very large part of the production in Michigan, trials with some sweet Spanish strains indicate an increased acreage of this type (pages 15-16).

10. **Seeding** and **Transplanting.** Early sowing of seed of high germination is essential for high yields. The use of transplants of the Spanish onion generally has resulted in an early crop of large onions (pages 16-17).

11. **Onion Diseases.** The four most important diseases: neck rot, smut, smudge, and downy mildew, can be largely prevented by proper soil management and the application of suitable fungicides (pages 17-18).

12. **Insects, Pests.** The four most important pests, the maggot, thrips, cut-worms and wire-worms can be largely controlled by proper soil management and the use of baits or insecticides (pages 19-21).

13. **Harvesting.** The harvest consists in the pulling, topping and curing of the onions until they are in condition to be kept in dry storage for several months without loss from disease or sprouting (pages 21-22).

14. **Storage.** The placing of the onions in a frost-proof dry storage sometimes prevents loss in cold autumn weather and permits holding the crop for favorable prices (pages 23-24).

MUCK SOIL MANAGEMENT FOR ONION PRODUCTION

PAUL M. HARMER

In the decade from 1920 to 1930, the acreage[1] of onions in Michigan increased from 1440 to 6700. In 1920, the State produced only 2.4 per cent of the total onions grown in the United States, but in 1930, the production had increased to 10.6 per cent. With so marked an increase in acreage, the possibilities of over-production and lower prices are also increased. It is not the purpose of this circular to further stimulate increase in acreage, but rather to encourage the proper management of the areas now under production that the grower may be able to produce at a lower cost per bushel and in that way to meet lower prices without loss.

Types of Muck Soils:

Muck soils, as a whole, are ideal for the raising of onions; first, because they are generally well supplied with moisture; second, because they are easily cultivated; and, third, because the soil is relatively loose and permits the bulbs to adjust themselves to the stand, with a consequent less need for thinning than if grown on mineral soil. All muck soils are not equally well adapted to the production of onions, however, and experimental investigations have showed a definite correlation between the soil reaction of the muck and its adaptation to the crop. From this standpoint, the muck soils of the State may be classified into three main groups:

1. Low-lime muck soils. Very strongly acid (pH 4.5 or less).[2]
2. High lime muck soils. Not acid to strongly acid (pH 4.6—7.0).
3. Alkali muck soils. Alkaline reaction (pH 7.1 or more).

Onions as a crop are rather sensitive to extremes of soil reaction. For that reason, the very strongly acid mucks of group 1 will not produce satisfactory crops until the intense soil acidity has been somewhat decreased by the application of lime. The alkali mucks of group 3 are likewise unproductive for onions until the alkaline condition has been corrected by the use of sulphur. It is therefore highly desirable that the soil reaction of newly reclaimed or unproductive muck be determined, before the growing of onions has been attempted.

[1]Data regarding acreage supplied by the Bureau of Agricultural Economics of the United States Department of Agriculture.

[2]The pH of a soil is a numerical method of expressing its reaction. A muck with a pH of 7.0 is not acid. An "alkali" muck has a pH greater than 7.0, while an acid muck has a pH less than 7.0. The pH of the muck soils thus far studied have ranged from 3.1 for the most acid one to 8.4 for the most alkaline.

Sampling the Muck Soil:

Samples of muck soil will be tested by your county agricultural agent or by the Soils Department of Michigan State College. In securing such samples, care should be taken to avoid old burn-outs, places where brush or refuse has been burned, old vegetable storage pits, trenches, tile lines, ditch banks, or any other place where some disturbing factor may have affected the soil reaction. Take the first sample in the surface layer at a depth of three to four inches. Since the soil reaction often changes somewhat below the surface layer, it is advisable to take a second sample with spade or posthole auger at a depth of about two feet. Keep the samples separate and properly labelled. If part of the field has been burned over at some time or if the muck varies considerably in different parts of the field, one or

Figure 2.—The intense acidity of muck areas supporting a growth of huckleberries or dwarf tamarack make their reclamation for the production of onions in many instances inadvisable.

two more sets of samples may be required. Draw a map of the field and locate points of sampling by number. Half pint samples are sufficient. These should be sent in moist condition in **clean** cans. A letter in an envelope attached to the package should give complete information regarding the muck, as to years under cultivation, drainage conditions, fertilization, crops grown, and yields.

SOIL AMENDMENTS

The Use of Lime—Lime should never be applied on muck for onion production unless the soil is very strongly acid. When applied on slightly or medium acid soils, it tends to delay maturity and to increase the proportion of "thicknecks." Onion seed sown on unlimed, very acid

muck may not germinate or, if it comes up, growth is likely to be slow and stunted. In some cases, it is not advisable to attempt the reclamation of such very acid areas.

Ground limestone or marl may be used for the correction of the acidity of these very acid soils. If a good quality marl is used, about one and one-fourth yards of marl should be applied in place of each ton of ground limestone required. The limestone should be fairly fine and the marl preferably screened, since an onion growing close to a lump of marl is likely to be a "thickneck." The amount of ground limestone needed will range from two to twelve tons per acre. While only three-fourths as much hydrated lime is needed to accomplish the same result as the ground limestone, its use generally cannot be recommended because of its greater cost.

Figure 3.—This area of high-lime muck, burned to a depth of about three feet, is likely to contain so much "alkali" that it would be unadvisable to attempt the production of onions on it for many years. Improvement of drainage and the growing of crops which can withstand the "alkali" is the best method of utilizing such areas.

If a large amount of lime is required to correct the acidity of a given muck, it is advisable to apply half of the amount and to disk it thoroughly into the soil, then to plow the muck deeply and apply the remainder and disk it well into the soil. If the lime requirement was high, it is often advisable to raise crops, such as hay, potatoes, and carrots, for a few years before onions are grown, until the lime has had time to act on the soil acids.

The Use of Copper Sulphate*—Experiments carried on at Michigan State College have showed a marked improvement in onions when copper sulphate is applied on low-lime muck which has already received a lime application. Benefits also have been secured on onions on some

*Because the exact role which copper sulphate plays in the nutrition of the plant is as yet unknown, it is grouped in this bulletin as a soil amendment rather than as a fertilizer.

medium acid and some slightly acid mucks, with no benefit observed on the alkali mucks investigated. The effects were evident in a higher yield, increased maturity, greater vigor of crop, and a much better color of the yellow onion varieties.

In general, a benefit from the use of copper sulphate can be expected on those onion fields which have an acid reaction, on which the tops have a tendency to die back from the tips during hot weather, and on which the mature bulbs of the yellow varieties have a yellowish-green instead of the desired yellowish-brown color. An application of copper sulphate at the rate of 50 pounds per acre will be sufficient to greatly benefit the crop on such areas. In most cases, it will be advisable to repeat the application the second year, after the application of the first year has been plowed down. The small amount required is quite

Figure 4.—Showing relative depth of color of yellow globe onions without (left) and with (right) copper sulphate applied to the soil. These onions were taken at random from the two treatments made on a well fertilized medium acid muck and photographed on the same plate without retouching.

difficult to apply uniformly; and, to overcome this, the copper sulphate, in the form of small crystals, can be safely mixed with the fertilizer. The dehydrated form of copper sulphate used for dusting purposes cannot be recommended because of its greater cost. Several of the fertilizer companies will supply fertilizer containing 100 pounds of copper sulphate per ton, at a cost practically the same as the two materials will cost before mixing.

The Use of Sulphur—Alkali muck is certain to give poor yields of onions, whether the alkali is due to the burning of the muck in recent years or in the remote past; to the presence of marl within a short distance of the surface or of lime applied on the surface; or, on spring-fed mucks, to the salts which have been deposited from the alkaline spring waters. Sulphur applied on such muck produces the following benefits on onions:

(1) Greatly increased yields, (2) earlier maturity, (3) increased root development, (4) increased disease resistance, (5) improved keeping quality, and (6) improved color of tops and bulbs.

The rate of application of sulphur required depends on the degree of alkalinity of the muck and on the depth to which the alkaline reaction extends. If the alkaline surface layer is underlain by a medium to strongly acid muck just below the ordinary plow depth, deep plowing and thorough discing will sometimes correct the condition without the use of sulphur. If the muck was originally high in lime content and has been recently and badly burned, it is not advisable to attempt to correct the alkaline condition with sulphur. Instead drainage of the muck should be improved and other crops more tolerant of alkali, such as sugar beets, mangels, cabbage, and carrots, should be grown for several years. If the muck was originally very strongly acid, the burning will not have produced an alkali soil.

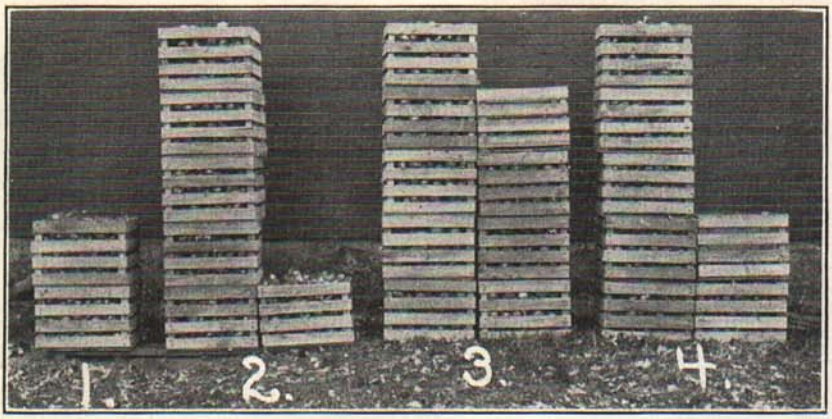

Figure 5.—Onions from equal areas of a uniformly well-fertilized alkali muck soil. From left to right the soil had received per acre in 1929 before planting, (1) no sulphur, (2) 500 pounds sulphur, (3) 1,000 pounds sulphur, (4) 2,000 pounds sulphur. In 1930, the 2,000 pounds of sulphur produced the highest yield.

On most alkali mucks, an initial application of 500 to 1000 pounds of sulphur flour is advisable, while a lapping back over a small portion of the field to double the application will give information as to the possibility of more being needed. The sulphur can be applied just before sowing the seed, but it is preferable to put it on a few weeks earlier and to disc it thoroughly into the soil every few days up to planting time. If a heavier application is found necessary, it is advisable to plow down the first before making the second application. Sulphur can be applied with most fertilizer and lime drills, but the drilling should be carefully watched, since sulphur does not feed down readily.

In addition to the alkali mucks, those which have a very slightly acid reaction are also benefitted by a sulphur application, unless the underlying muck is more acid. An application of 200 to 300 pounds per acre is generally sufficient for these soils, and, if desired, the sulphur can

be safely mixed with the fertilizer. As the mixture has a tendency to cake in storage, the mixing should be done shortly before the application is to be made.

FERTILIZATION

Muck soil is naturally infertile, but is generally highly productive when properly fertilized. Of the three important fertilizing constituents, nitrogen, phosphate, and potash, the last two named are required on practically all mucks for the production of onions, while nitrogen is generally required. The proper fertilizer analysis for the crop depends on the soil reaction of the muck, on the drainage conditions and on the time of sowing the crop. On the better drained and more acid

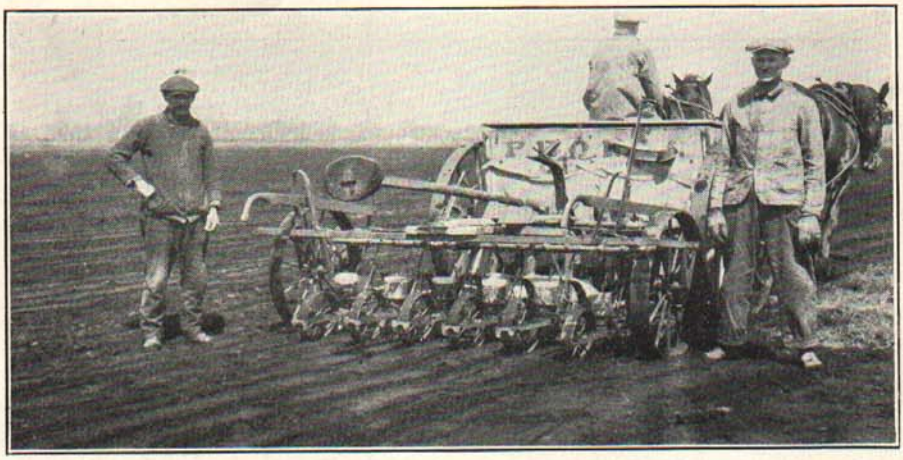

Figure 6.—A combination fertilizer drill and onion seeder. Six rows are sown, with the fertilizer applied in the row below the seed by the fertilizer drill ahead. Just behind the drill, a light float smoothes the surface of the muck ahead of the seeders. In some cases a garden tractor is used to sow three rows, the row fertilization and seeding generally being done in separate operations. On the larger farms nine-row and twelve-row outfits, tractor drawn, have additional seeders attached to sow a row of barley between every three rows of onions for wind protection.

mucks, a greater proportion of potash is needed in the mixture; while, on the poorer drained and the alkali mucks, somewhat more phosphate is required. Nitrogen in the mixture gives the early-sown onions a good start which generally results in a more rapid growth throughout the season. For late-sown onions the nitrogen can well be omitted except on very acid muck, alkali muck, or poorly drained muck.

While occasionally a newly reclaimed muck is sufficiently fertile that it will produce a good yield of onions without fertilization, the opposite is usually true. In many cases, these mucks were used as pastures or wild hay meadows for several years before they were broken up and, as a result, they are entirely depleted of fertility. For this reason, it is advisable to fertilize well for the first crop of onions if the muck has

Fertilizer, Lime, Copper Sulphate and Sulphur Recommendations For Onions on Muck Land.

Natural lime supply of muck	Type of Muck: Range in soil reaction	Type of Muck: Depth of muck (2)	Type of Muck: Length of time since reclamation	Condition of drainage	Application of ground limestone or marl (4) Rate per acre	Application of copper sulphate Rate per acre	Application of sulphur (3) Rate per acre	Fertilizer analysis (1): For early seeding of onions (6)	Fertilizer analysis (1): For late seeding of onions (6)	Annual rate of fertilization Pounds per acre: If applied broadcast or drilled with fertilizer distributor	Annual rate of fertilization Pounds per acre: Amount which may safely be applied in row 2 inches below seed (7)
High-lime....	Not acid to strongly acid...	Deep and medium.	Newly reclaimed (5).	Good	Application of lime-stone or marl likely to decrease yields	If tops die back from tips during hot weather or mature bulbs have poor color, apply 50 pounds	If soil is not acid or very slightly acid, 200 to 300 lbs is advisable but if medium or strongly acid, do not apply sulphur	2-8-16 3-9-18	0-14-14	1000-1500	400-600
High-lime....	Not acid to strongly acid...	Deep and medium.	Newly reclaimed (5).	Fair				3-12-15	3-12-15	1000-1500	600-800
High-lime....	Not acid to strongly acid...	Deep and medium.	Old muck.....	Good				3-9-18 4-8-28	2-8-16 0-14-14	800-1200	300-500
High-lime....	Not acid to strongly acid...	Deep and medium.	Old muck.....	Fair				3-9-18 2-8-16	3-12-15	800-1200	400-600
High-lime....	Not acid to strongly acid...	Shallow.....	.....	Good				3-12-15 3-9-18	3-12-15	800-1200	300-500
High-lime....	Not acid to strongly acid...	Shallow.....	.....	Fair				3-12-15	3-12-15	800-1200	400-600
Low-lime (4)..	Very strongly acid.....	All depths.....	.....	.....	2 to 16 tons...	50 pounds....	Sulphur not recommended	3-9-18 3-12-15	3-12-15	800-1500	Not recommended
"Alkali" (3)...	Alkaline.....	All depths.....	.....	.....	Lime not recommended	Not recommended	500 to 2000 pounds	3-12-15 3-9-18	3-12-15 3-9-18	800-1200	Not recommended

(1) Where two fertilizer recommendations are made for one soil condition, the first-named is preferred.

(2) In general, the depths of the muck referred to above as "shallow", "medium" and "deep" may be considered as designating depths less than two feet, two to three feet, and more than three feet, respectively.

(3) In addition to the fertilizer application, the "alkali" muck should be given a sulphur application of 500 pounds per acre or more. Improvement of the drainage may also be advisable. Muck which tests not acid or very slightly acid in the plowed layer by the Soiltex test will be benefited by a 200 lb. application of sulphur, unless the underlying soil at a depth of one to two feet is more acid.

(4) If the muck is very strongly acid, an application of ground limestone should be made and the land preferably cropped to rye, Hungarian millet or potatoes until the lime has been worked into the soil to considerable depth.

(5) After the "newly reclaimed" muck has been well fertilized for two or three years, it should be fertilized as recommended for "old muck".

(6) "Early" and "late" seedings of onions are relative terms depending on location and on weather conditions. In southern Michigan, seedlings before April 25 may generally be considered as "early" and after May 5 as "late", with the designation around the first of May depending on the air temperature and on the height of the water-level in the soil. The higher the water-level, the greater the need for nitrogen.

(7) The recommended rate of row application is based on the assumption that the rows will be 13 inches apart. If the rows are farther apart, the rate of row application should be reduced proportionately to avoid possible injury to germination of seed. Where the soil conditions make it unsafe to apply more than 300 or 400 pounds per acre in the row, enough should be broadcasted and disced in to bring the application to 700 or 800 pounds per acre.

not been well fertilized in previous cropping. After a reserve has been built up in the soil, the rate of fertilization can be somewhat decreased.

The rate of fertilization also depends on the method of application of the fertilizer. If the fertilizer is applied in the row, less can safely be applied than if it is broadcast on the surface and disced in or drilled broadcast uniformly over the field before seeding. Not more than one-third to one-half as much can be safely applied in the row as would be required if the entire application was made broadcast. To prevent any injury to the germinating seed, the fertilizer should be at least two inches away from and preferably below the seed. If row fertilization has not been practiced on a muck, it is advisable to try it out in a small way and observe results, before adopting it as a general practice. Row applications cannot be recommended for strongly acid or alkali mucks nor for areas which are likely to be droughty. On areas which may be badly swept by the wind, the row application is advisable, since it is not likely to be carried away. On the drier mucks which are being spring-plowed, it is sometimes advisable to plow part of the fertilizer down.

The Table on page 9 gives the fertilizer, lime, copper sulphate, and sulphur recommendations for the different types of muck when the soil reaction, the extent of drainage, and the age and depth of muck are considered. Recommendations of the analysis and rate of application per acre are given, both for broadcast fertilization either on the surface or drilled uniformly over the field, and for row fertilization. Generally the amount of fertilizer which can be safely put in the row is insufficient for the production of a good yield, and should be supplemented by enough fertilizer broadcasted before seeding to bring the total application to 700 or 800 pounds per acre. On the field which ordinarily requires 1000 pounds of a 3-9-18 mixture, it is frequently advisable to use one mixture for broadcasting and another for the row application. Thus, 300 pounds per acre of 3-12-15 in the row and 400 to 500 pounds of 0-8-24 broadcast, cuts down the cost of fertilizer per ton and also the amount required per acre.

DRAINAGE

The onion crop is quite sensitive to extremes of soil moisture. If the water-level is too near the surface, the "bottoming" of the onion is delayed, with the result that the crop will contain a large proportion of "thicknecks" at harvest. If the water-level is too low, the stand is likely to be poor in a droughty spring; growth will be slow and, following a droughty summer, the crop at harvest may contain too large a proportion of undersized bulbs.

In general, a water-level about two and one-half to three feet below the surface during the summer months produces best results. Even better yields may be secured with the water at a depth of only two feet, if the muck is so well tiled or ditched that heavy rains produce little or no fluctuation in water-level. A uniform water-level, permitting the onion roots to become adjusted to the supply of moisture, is highly desirable for this crop. When the muck is one which becomes too dry in droughty weather, the placing in the outlet ditches of dams

fitted with boards or flood gates, by which the water can be readily brought to the desired elevation, is a good form of insurance against crop failure. In such cases, it is necessary of course, that the ditches contain flowing water during droughty periods.

Distance between lateral tile lines or ditches depends on the nature of the substrata and the imperviousness of the muck. If ditches 40 rods apart cut into gravel or sand underneath the muck, the drainage may largely be taken care of by this underlying coarse layer, sometimes to the point of causing droughtiness of the muck. If the muck at a depth of two to three feet is tight and impervious to water, as occasionally happens, tile lines as close as 12 to 16 feet may be required. On most mucks, tile lines four to eight rods apart or ditches eight to twenty rods apart will provide satisfactory drainage.

Figure 7.—The most successful grower is the one who has the water supply in his muck at his control. This picture shows one of the most efficient types of dams, constructed of interlocking sheet steel piling driven well into the muck and reinforced by rock piled on the lower side.

In laying tile in muck, the ordinary unglazed clay tile is recommended, concrete tile sometimes decomposing within a few years. It is generally advisable not to use tile smaller than five inches in diameter. If the muck is newly reclaimed, the tile should be placed at a greater depth than will be desired later, since new muck settles on the average about one-fourth the distance between the surface and the tile line within a few years after reclamation.

CULTURAL METHODS

Breaking:

In the first or later breakings of muck soil for onion production, the plowing should be deep enough to turn the heavy sod, brush, or other vegetation down to a depth of 12 to 15 inches. Onions grown on

shallow-broken muck are almost certain to be a failure if the season is droughty. New muck should preferably be broken in early summer, so that the land can be fallowed for the remainder of the summer. If the breaking has been properly done, the furrows have been laid flat, with the sod down, and a layer of muck free from sod left on the surface for the preparation of the seed bed. Generally all sods can be killed and the muck brought into condition by the summer fallow, so that onions can be sown the following spring; but, in some cases, the muck is so raw that it is advisable to grow other crops, such as potatoes, cabbage, corn and turnips, until the soil is more decomposed. Following breaking, no plowing should be done for two years, in order that all sods may be well decomposed before they are brought up to the surface.

Figure 8.—The double-disc and roller are important in the preparation of the seedbed. On this rather wet muck, the farmer took no chances on having his tractor mired, as can be seen from the extensions on the tractor wheels. On a drier muck, a heavier roller, or cultipacker and float, would have given more satisfactory results.

In later handling of the muck soil, fall plowing generally gives better yields than does spring plowing. However, on well decomposed mucks which tend to weather to a powder during the winter months, it is better to delay the plowing until spring so that the less weathered muck will be on the surface and thus prevent blowing.

Preparing the Seed Bed:

If the muck area is well drained and the muck is loose and fibrous, the heavy, 30-inch concrete roller[1] gives very beneficial results, especially if a sod has been plowed down or if the spring or summer are droughty. The use of such a roller, if only on occasional years, pays well for the investment, unless the drainage is poor or the muck is

[1]For information regarding the construction of a concrete roller, see May, 1924, issue of the Michigan Quarterly Bulletin which may be secured by writing the Bulletin Room, M. S. C., East Lansing, Mich.

exceptionally heavy. The use of the roller on spring plowing just before seeding tends to thoroughly firm the soil, and in that way increases the movement of capillary moisture and reduces the chances of injury to the young onions by late frosts. In the absence of the heavy roller, the cultipacker, well weighted down, serves to some extent as a substitute.

The disc harrow is probably the most effective implement for the preparation of the seed bed. The double disc, tractor drawn, is ideally suited for muck soil, and when it is followed by the roller and finally by the float, the soil is left in good condition for uniform seeding and straight rows. Care should be taken, however, not to float the muck too far ahead of the seeding, since the smoothly floated muck tends to drift badly with the wind.

Figure 9.—The effects of the 30-inch concrete roller is evident on this rather fibrous muck. Note that the roller produces considerably more compaction than do the tractor wheels. Three or four good horses can handle a five-foot roller of this type.

PREVENTION OF WIND INJURY*

Injury by strong winds, sometimes by the removal of the muck covering the seeds but generally by the blowing of particles of soil which strike and bruise the young onions, is responsible for a considerable loss to onion growers each year. Prevention of such injury can be accomplished by a combination of several methods:

1. Growing tree windbreaks along line fences and ditches.
2. Use of fences of slats, boards, or burlap, or of strips of winter or spring rye.
3. Use of interplanted crops, such as barley.
4. Increasing supply of organic fiber in soil.
5. Raising water-level in soil by damming ditches.

*A more detailed discussion can be found in Circular 103 (Revised) "Prevention of Wind Injury to Crops on Muck Land," which can be secured by writing Bulletin Room, M. S. C., East Lansing, Michigan.

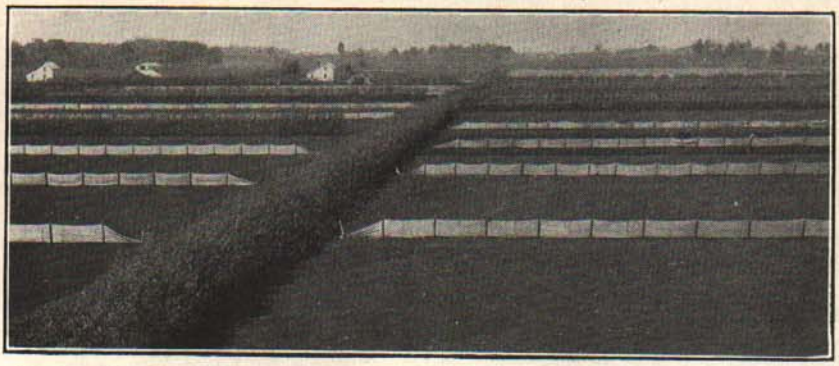

Figure 10.—On these onion fields a combination of green willow (two year growth) and burlap is being used to prevent wind injury. This willow grows very rapidly, often reaching a height of 18 feet in four years. The burlap is not good for more than two years use and generally cannot be recommended because of its cost.

In beginning the cultivation of a newly reclaimed muck soil, most muck farmers feel that the muck is sufficiently raw so that it will never blow. In three or four years, however, decomposition has progressed so rapidly that the muck may be blowing badly. The early planting of trees along the line fences will tend to check the sweep of the wind across the broad flat areas. On the smaller fields in which rows of trees would cause a loss of a disproportionate portion of land, fences of slats, boards, or old fertilizer bags can be utilized to take the place of the trees, insofar as possible. Strips of four or five drill rows of winter rye can be sown in the fall in a north and south direction at intervals of 50 feet to 100 feet and the onions sown parallel to these strips in the spring. Spring rye can be substituted for the winter rye with nearly as rapid growth. The chief objections

Figure 11.—Barley, sown between every three rows of onions, is one of the best protections against wind injury. In cold spring weather, the onions will grow faster with the barley present, since it protects them from the chilling winds.

to rye are that the drifting muck tends to form ridges where the strips are located and the winter rye also harbors insect pests. If the muck is quite dry, however, such rye strips are insufficient to entirely prevent wind injury. For that reason, it is generally advisable to sow barley, interplanted between every three rows of onions, on every onion field which is in any danger of being swept by the spring winds. Such barley must be removed by the wheel hoe, of course, as soon as the onions are large enough to serve as their own protection. Ordinarily, the barley is about 10 inches tall at this time and will not have to be carried off the field to permit cultivation.

The growing of green manure crops to be plowed down tends to decrease the blowing of muck by adding organic fiber to the soil. The crop is also likely to show a marked increase in yield as a result of

Figure 12.—A good stand of good size onions is necessary for a high yield. This Michigan field was selected by a group of growers as the best in three states, Indiana, Ohio, and Michigan, in 1931. The variety is Brighams Long-keeping Yellow Globe.

the green manuring. In many seasons, a good crop of rye can be grown in the fall after an early crop of onions have been removed. On muck which is to be left fallow after early fall plowing, a seeding of oats will protect the soil from drifting during the winter months, yet will not interfere with the cropping in the spring.

VARIETIES

Practically all of the onions produced in Michigan are of the American type and are grown from seed. Most of these are yellow globe varieties, the more important of which are Southport Yellow Globe, Yellow Globe Danvers, Mountain Danvers, Brigham's Long-Keeping Yellow Globe, and Downing's Yellow Globe. The two last-named strains of yellow globe have been developed by two Michigan growers and have become

popular with growers and buyers because of their good keeping qualities in storage. Limited variety tests have indicated that the Brigham onion is one of the best on the better-drained and acid mucks, while the Downing onion has proved better on the poorer drained and on alkali mucks. The Mountain Danvers is probably the earliest of all of the above named varieties.

In addition to the yellow varieties, small acreages of white and of red onions are grown. Of these, the Southport White Globe and the Southport Red Globe and Red Wethersfield, a flat onion, are practically the only varieties grown.

Within recent years considerable interest has been aroused in the possibilities of producing the sweet Spanish type of onion in Michigan. These onions, both from seed and transplants, have been grown in small acreages. The chief objections to the Spanish onion have been the need of a long season in the production of the crop from seed, the cost of setting of transplants, and the fact that the onions were inclined to be soft and did not keep well in storage. Within the last two years, the Riverside strain of Valencias has been found by some growers to mature better and to keep better than varieties previously grown. Attention should be called to the fact that Riverside Valencias, when grown from different sources of seed, will vary somewhat in these desirable qualities.

SEEDING AND TRANSPLANTING

In general, the earlier the seeding of onions the higher the yield. In southern Michigan, seeding between April 10 and 25 is considered desirable, although the time may be advanced to the first of April or delayed to May 10 if weather conditions warrant it. Late seeding will often result in a considerable proportion of "thicknecks" in the crop at harvest. When transplanting is employed, it is generally delayed for 10 days to two weeks later than seeding.

The proper rate of seeding of onion seed per acre depends on several factors. A uniform stand of from 6 to 12 plants per foot of row is generally considered satisfactory, a good stand being dependent on the size of the matured bulbs desired. To secure this stand, a seeding of from 12 to 20 seeds per foot of row is necessary, the number required depending on the percentage of germination, the vitality of the seed, the depth of seeding, the moisture supply, and the probable amount of insect injury. With seed of good germination and rows 13 inches apart, this requires from three to four and one-half pounds of seed per acre, the rate per acre being to a considerable degree dependent on the size of the seed.

The proper depth of seeding depends largely on the type of muck on which the crop is to be grown. If the muck is heavy and inclined to form a tight crust, seeding at a depth of one-half inch is preferable, especially if the soil is well supplied with moisture. On the better drained, more open mucks, seeding three-fourths inch to one inch deep is likely to give better results, the important point being the placing of the seed in moist soil. On excessively drained mucks and on areas which are likely to be badly swept by wind after seeding, a depth of an inch and a quarter to an inch and a half is sometimes advisable.

The use of transplants gives the advantage of an earlier crop, which in some years brings good returns. Production of these by seeding in the greenhouse in February or early March gives satisfactory results, but most of the transplants thus far used in Michigan have been secured from southern growers. Consideration should be given the fact that this importation of plants may introduce serious soil-borne diseases and insect pests of onions and other crops, such as nematodes or thrips. For the same reason, care should be taken in raising the plants in the greenhouse or the hot bed that the soil is fresh and the house free from insects.

In the transplanting of the sweet Spanish onions either from the greenhouse or from shipments from southern States, the plants are set either by hand or machine, generally in rows 14 or 16 inches apart. The plants are usually transplanted to the field when they are four to six inches high, being set into the soil about one and one-half inches. The spacing of the plants in the row ranges from three to six or more inches apart.

CULTIVATION AND WEEDING

Clean cultivation should be the general practice in onion fields. In most cases, onions are grown year after year on the same field. Destruction of all weeds while they are small and their removal from the field if they are bearing seed, will result in reduced costs of weeding in future years. Sometimes a crop is lost through unfavorable climatic conditions, disease or insect pests, or poor seed, and such land is frequently allowed to become foul with weeds during the remainder of the summer. Such practice results in an increased cost of weeding for several years and could be averted by the growing of a green manure crop, such as oats, rye, or Hungarian millet, which, plowed down, would be likely to result in increased yields of onions for several years.

Cultivation is required on most onion fields only for the destruction of weeds. This is accomplished by the use of the wheel hoe to remove the weeds between the rows and by hand weeding to remove the weeds in the row. Since hand weeding is considerably more expensive, it is obvious that the expense of weed control can be somewhat reduced by careful wheel hoeing.

In general, cultivation of onions should be shallow, a compact soil being more desirable than a loose one. On mucks which are very acid, however, and on which the acidity may be so intense that it is affecting the crop in some spots in the field, fairly deep cultivation will sometimes decrease the injury, apparently by reducing evaporation of moisture and thus decreasing the concentration of soil acids.

ONION DISEASES

The following discussion regarding onion diseases is based largely on the recommendations of Dr. Ray Nelson, of the Botany Department at Michigan State College.

Neck Rot—This disease begins as a softening of the tissues, generally around the neck of the bulb, but sometimes around the roots or

in wounds. It appears as a gray mold on the surface and as black kernel-like bodies, which are usually on the surface of the outer skin. The disease attacks onions which are not properly matured and field-cured or which are brought into the storage while wet. It is generally most severe in poorly ventilated storages.

Control measures include proper drainage, proper fertilization, and early seeding in order to secure well matured bulbs. The use of sulphur on alkali muck will prove beneficial in this respect. Care in handling the crop to prevent injury to the bulbs, and rapid curing and properly ventilated storages will largely prevent the disease.

Onion Smut—While this disease is a cool weather disease and is, therefore, limited to the onion districts of the northern States, it has only recently seriously threatened the onion industry in Michigan. Thus far, it has been found in three onion districts, in two of which it is rapidly spreading. The disease lives in the soil for years and attacks the young seedlings, destroying leaves and bulbs, the normal parts being replaced by a dark brown or black powdery mass of dusty smut spores. The plant usually is much stunted and dies slowly, due to the shriveling and drying up of the diseased parts. The seedling is susceptible to the disease for only a few days in its growth and only while the temperature of the surface soil remains fairly cool.

Smut can be controlled by the application of a formaldehyde solution to the soil as a drip at the time of seeding. One pint of formaldehyde to 15 gallons of water, will give practically complete control. The tank for applying the solution is attached to the seed drill and the solution applied in the furrow on the seed at the rate of 16 gallons per 3,000 feet of row. If formaldehyde is not used, transplants from smut-free soil or sets may be grown, with little or no smut injury.

Onion Smudge—The disease appears as a dark green or black smudge on the bulb or neck of the onion. It is most conspicuous and serious on the white varieties, while the colored varieties are resistant. Rotation, where practical, is recommended. Thorough and rapid curing of the bulbs will reduce the disease to a minimum in storage.

Downy Mildew—Under favorable weather conditions, this disease has caused marked damage in some sections. The disease ordinarily appears late in the season, under the influence of warm days and cool nights, especially under moist conditions. It usually starts from a few points, and spreads rapidly over the field, attacking and resulting in a premature dying of the tops, a condition often mistaken for early maturity. The fungus can be recognized as a violet-colored mold on the diseased leaves in the early morning while the dew is still present. The disease results in a decreased yield of undersized onions, which fail to keep well in storage.

As the fungus winters over in the refuse from diseased plants, destruction of all diseased tops, together with crop rotation and improvement of drainage, if needed, are the best means of control. The disease can be prevented by spraying before its appearance with a 4-4-50 Bordeaux mixture to which sufficient fish-oil soap has been added to make the spray adhere to the leaves. Since several sprayings are required and because the appearance of the disease cannot be foreseen, this method has not been generally adopted.

INSECT PESTS*

The following recommendations for the control of insect pests of the onion are largely based on the control measures advised by Professor R. H. Pettit of the Entomology Department of Michigan State College.

Onion Maggot—The most important and least expensive means of controlling the onion maggot is the destruction of all cull or waste onions, since these constitute the breeding places for the early maggot

Figure 13.—A home-made distributor for corrosive sublimate treatment for maggot control. The tank attaches to a wheel-hoe frame and is of galvanized sheet iron reinforced with angle iron, the inner surface of the tank being covered with asphaltum paint. Dimensions of tank 20 x 20 x 8 inches, with one edge removed to give an 8 x 8 inch base, and the opposite edge removed to give a 6 x 8 inch opening in top. Capacity of tank 12 gallons, sufficiently large for treatment of a row 50 to 60 rods long. The distributing pipe ends in a piece of rubber tubing on which is attached a screw clamp by which the flow is regulated. A pinch clamp is used to close the rubber tubing when flow is not desired. The distributing pipe must be in line with the axles of the wheels and the lower end in plain view of the operator so that the flow can be directed on the onion row. Inset shows distributing pipe with rubber tubing and clamps attached. Three-inch sheet iron rims on wheels facilitate the handling of the machine while a cheese-cloth strainer prevents clogging of the distributing tube.

fly. Where onions are left in the field, the land should be plowed fairly deep, while all piles of waste onions in the field or storage should be either burned or buried under at least a foot of compact soil. Since the

*For a more detailed life history and methods of control of insect pests, the reader is referred to Special Bulletin No. 183, "Common Pests of Field and Garden Crops," which can be obtained by writing the Bulletin Room, Michigan State College, East Lansing.

adult fly travels quite a distance, it is essential that this means of control, to be most effective, should be extended throughout the neighborhood.

The use of a corrosive sublimate solution, one ounce in 10 gallons of water, applied in a small stream on the onion row for four or five applications eight to ten days apart, beginning when the plants show nicely above ground, has been found very effective in fields which are generally badly attacked. Because the solution is deadly poison, extreme care should be used in handling it. Since it attacks metals and as a result loses its effectiveness, the distributor, if metal, must be painted inside with asphaltum or duco paint.

A third method of treatment, slightly less expensive than the corrosive sublimate method, is the application under pressure of a home-made Bordeaux oil emulsion spray made according to standard directions. (See page 10, section 23, Special Bulletin 174.)[1] From four to five applications, a week to ten days apart, should be made, beginning when the onions are about an inch above ground. A stream of the spray is directed on the onion row, preferably with a garden tractor with spraying attachment.

Onion Thrips—These tiny jumping insects attack the onion tops during periods of hot, dry weather, but are largely controlled by nature in seasons of normal rainfall. They feed upon a large number of other plants and winter over in grass, leaves, or rubbish. Since there are five or six generations per year, control is difficult; the spray used is one pint of nicotine sulphate and two quarts of penetrol in 100 gallons of water. Two applications six or seven days apart should be made with a pressure spray, preferably during the hottest part of the day and when there is little air movement. If all refuse has been carefully plowed under, the attack will be at first confined to the edges of the field. Burning of the grass along the fence rows in the early spring and the early spraying of strips of the onions a few rods wide around the edge of the field are desirable means of early control, but the crop should be watched closely for the presence of thrips, especially on the higher places in the field, and the whole field should be sprayed before the tops have been greatly injured.

Cut-worms—The cut-worm can be fairly easily controlled by the application of a poison bran mixture made up according to the standard formula.[2] The bran should be scattered broadcast by hand as finely as possible preferably in the evening, in the area in which the cut-worms are working. Lumps of the mixture may prove fatal to wild birds and poultry.

Wire-worms—Attacks from wire-worms are often very serious on new breaking. If there are scattered living sods left in the field, the injury may be very slight the first year after breaking; but, with the

[1]Special Bulletin 174 (Revised), "Spraying Calendar," can be secured without charge by addressing Bulletin Room, Michigan State College, East Lansing.

[2]Dissolve one pound of ordinary lye in one quart water and when dissolved, add slowly to the lye water three pounds white arsenic, with constant stirring until it is all dissolved. Dilute this poison with water to 10 gallons and stir it into 150 pounds bran placed in a water-tight barrel. From 3 to 5 gallons more water may be needed to secure the proper consistency. Finally, stir into the mixture four ounces of banana oil.

complete killing out of all sods by the second year, the injury is likely to be more severe. In the third year and in later years, injury will be much less, since the wire-worm emerges as the click-beetle, which generally flies to sod land before laying its eggs. The application of poison or salt cannot be recommended, due either to expense or ineffectiveness. The writer has had some success in preventing destruction of the onion by substituting a more desirable food. A mixture of wheat and barley in equal parts, with one and one-half pounds radish seed added to each bushel of the grain mixture, is sown between each two or three rows of onions, as described for wind protection on page 15. The wheat is preferred to onions by the wire-worms which attack it shortly after it is up. After the radishes have become good size, some of the wire-worms will attack and sometimes burrow into them. In that case, it is advisable to pull and remove the radishes. The barley remains to serve as a protection from wind. If the wire-worm attack is severe, it is necessary to make a second and possibly a third sowing of the wheat, in rows adjoining the earlier seeding, several days before the earlier seeding must be removed to prevent shading of the onions.

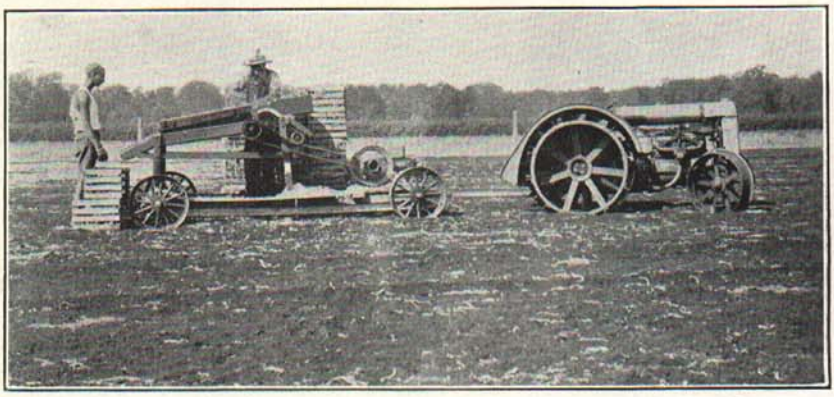

Figure 14.—On some onion fields, the onions are pulled into crates, where the maturing is completed, the crates are then gathered in groups in the field and the topping is done with a machine topper, which is hauled from place to place by team or tractor. As they leave the rollers, the onions pass over a one and one-fourth inch rack to complete their grading.

HARVESTING AND GRADING

Harvesting of the onion crop begins after the tops have fallen over and started to mature and the neck of the onion has become sufficiently dried out so that it may be easily pinched together. The onions at this stage of maturity are pulled, and six or eight rows laid together in one windrow, so that the tops lie over the bulbs and protect them from light frosts and sun scald. After the tops have become well matured in the windrow and the necks are dried out, the onions are topped, generally with hand shears, but sometimes with a machine topper. If weather conditions will permit leaving the onions in the ground until the tops are fully matured, they may be topped by hand directly from

the row. The topped onions are usually placed in crates and the crates stacked in the field to permit further curing of the crop. As protection from sun and frost, the top crates are covered with onion tops. When sufficiently cured, the onions are hauled in the crates to the storage or are put over the grading rack and bagged for shipment.

When the topping is to be done by machine, the onions are often left in the ground until quite well matured, then pulled and placed in crates to get well cured out before topping. Onions with tops that are not well dried out generally do not top well by machine.

In cases of late seeding or of wet or alkali muck, the proportion of immature onions is likely to be large. These are almost certain to sprout in storage, consequently the rejection in topping of all onions with thick, juicy necks is advisable. If the season is late, with danger of wet or freezing weather, it is sometimes possible to top those onions which are mature, and to sort out those which would cure out later, and complete their curing with artificial heating in storage.

Figure 15.—These onions were hand-topped from the row and their curing then completed in crates. This picture, taken in the same Michigan field shown in Figure 12, shows the topped onions being graded and weighed into 50-pound bags.

The grading of onions in Michigan has thus far been limited to the passing of the crop over a one and one-fourth inch grading rack to remove the small onions. A few growers have developed special markets for large onions over two and one-half or three inches. Better grading methods are likely to be demanded by the consuming public within a few years, while federal inspection at the shipping point is proving of great benefit as a protection for the shipper.

STORAGE

Holding the onion crop in dry storage has been found by many growers to give paying returns in a majority of the years in which the price at harvest has been low. In certain localities, the presence of a storage has resulted in increased prices offered for the crop at harvest, so that the storage paid well, even though in some years it remained empty.

A well constructed onion storage protects the crop against sudden temperature changes. Double doors and insulated walls help to maintain a uniform temperature throughout the building. The temperature should remain as nearly as possible between 29° and 34° Fahrenheit during the period of storage. This is likely to require some artificial heat in cold weather, but care should be taken that the temperature is not raised too high. A variable temperature encourages sprouting and consequent loss of onions. When the crop is put into storage, the temperature should be lowered to the desired point as soon as possible, by the opening of doors and ventilators on cool days. On warm days, doors and ventilators should be kept closed, if the humidity inside will

Figure 16.—A 60-car storage constructed of glazed block tile. Built on a siding, the onions are loaded directly from the storage into the car. On the farther side the covered driveway offers protection for loads in inclement weather, as well as storage for empty crates.

permit it, in order to prevent a rise in temperature in the storage, with consequent sprouting of onions. Thermometers should be kept at hand so that temperature changes may be noted. In the absence of sufficient thermometers, a very thin crust of ice on pans of water set around in the storage is a fairly safe guide in maintaining the proper temperature.

The storage should also be fairly well ventilated so that a relatively low humidity can be maintained. A high humidity is likely to produce sprouting and neck rot if the crop is not thoroughly mature. The crop is stored in crates and the crates are stacked nearly to the roof. The stacks are preferably arranged in groups of about six on a side, so that ventilating spaces are left between the groups. The less cured out the crop that is put in storage, the greater the need for ventilation.