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 3-5).

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

3. **Copper Sulphate.** Light applications will prove markedly beneficial on those mucks which require lime, and also on most slightly, medium and strongly acid mucks (page 6).

4. **Sulphur** and **Manganese Sulphate.** Their use on alkaline mucks will result in greatly increased yields, better maturity, and better keeping quality of the crop (pages 7-9).

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 9-11).

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 11-13).

7. **Cultural Methods.** Deep breaking, heavy rolling, fairly deep fall plowing, shallow cultivation, and removal of weeds while they are small are esential factors in onion production (pages 13-14 and 19-20).

8. **Wind Injury.** Injury to onions can be lessened by wind breaks along the line fences, by grain 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 15-17).

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 in recent years have resulted in an increased acreage of this type (page 17).

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 18-19).

11. **Onion Diseases.** The five most important diseases, neck rot, smut, smudge, downy mildew, and root knot, can be largely prevented by proper soil management or by the application of suitable fungicides (pages 20-22).

12. **Insect Pests.** The four most important pests, maggots, thrips, cut-worms, and wire-worms, can be largely controlled by proper soil management and the use of baits or insecticides (pages 22-25).

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 25-26).

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 26-27).

MUCK SOIL MANAGEMENT FOR ONION PRODUCTION

PAUL M. HARMER

Within a relatively few years, the onion crop in Michigan has changed from one of minor importance to our most important muck crop. In the fifteen years from 1920 to 1934, inclusive, the acreage[1] of onions in this State increased from 1,440 to 8,720. In 1920, the State produced only 2.4 per cent of the total onions grown in the United States, but in 1934, the production had increased to 14.6 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 so that the grower may be able to produce at a lower cost per bushel and in that way 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. With a good system of soil management, onions may be grown almost continuously on the same field for many years without appreciable decrease in yield. 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. Alkaline 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 alkaline mucks of group

[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 alkaline 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 3.0 for the most acid one to 8.6 for the most alkaline.

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 is attempted.

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 mucks which are naturally well supplied with lime and which are therefore not very acid, it may delay maturity and increase the proportion of "thick-

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

necks". 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 advisable not to attempt the reclamation of such very acid areas.

Ground limestone, marl, sugar beet lime, or wood ashes may be used

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SAMPLING MUCK SOIL FOR SOIL REACTION TESTS: In securing samples for testing, care should be taken to avoid old burnouts, places where brush or refuse has been burned, old vegetable storage pits, trenches, tile lines, ditch banks, or any other place at which some disturbing factor may have affected the soil reaction. Scrape off the surface and take the first sample at a depth of four to six inches. Since the soil reaction often changes somewhat below the plowed layer, it is advisable to take a second sample with spade or posthole auger at a depth of 18 to 24 inches. Care should be taken that none of the plowed layer falls into the second sample. Keep the samples separate and properly labeled. If part of the field has been burned over at some time or if the muck or the native vegetation varies considerably in different parts of the field, more than one set of samples may be required. If the land is properly drained and has been broken deeply for the first time, yet the properly fertilized first crop has been a failure,

for the correction of the acidity of these very strongly acid soils. If a good quality marl is used, from one and one-half to two 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 "thick-neck". The amount of ground limestone needed will range from two to twelve tons per acre. While from two-thirds to 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.

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 disc it thoroughly into the soil, then to plow the muck deeply and apply the remainder and disc it well into the soil. If the lime requirement is 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.

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

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it is advisable to include a third sample taken just above (8 to 12 inches deep) the buried sod, since it sometimes happens that the buried surface layer is sufficiently alkaline as to interfere with root development of onions, although the samples taken at depths of four inches and twenty inches may give no indication of this condition. Draw a map of the field and keep it for your own information; locate the points of sampling by number (1, 2, 3 etc.) and number the samples [1A (above), 1B (below), 2A, 2B, etc.] accordingly. Half pint samples should be sent in moist condition in clean cans. Complete information regarding the muck, as to location in state, depth, years under cultivation, drainage conditions, fertilization, yields and condition of crops grown in the past years, as well as names of crops to be grown, should be sent in a letter attached to the package. Address Muck Specialist, Soils Dept., M. S. C., East Lansing. In the busy part of the year, reports on the samples may be delayed from three to six weeks.

The Use of Copper Sulphate[1]—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 all very strongly and medium acid and on most slightly acid mucks, with no benefit observed on the alkaline mucks investigated. Mention should be made of the fact that no bad effect will be produced from the application of copper sulphate in the amounts recommended, even if applied on parts of a field which show no need for its application. The benefits will be much more evident in a hot dry rather than a cool wet season and greater on a well drained muck than on one having poor drainage.

Fig. 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.

The effects from the use of copper sulphate are evident in a higher yield, increased maturity, greater vigor of crop, and a much better color of the yellow onion varieties. In general, a marked benefit 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 initial application of copper sulphate at the rate of 50 pounds per acre will be sufficient to greatly benefit the crop on such areas. In succeeding years, an annual application of 25 to 50 pounds per acre should be made until a total of 150 to 200 pounds have been applied. The small amount required is quite difficult to apply uniformly; and, to overcome this, the copper sulphate, in the form known as "snow," can be safely mixed

[1]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.

with the fertilizer. The dehydrated form, used for dusting purposes, cannot be recommended because of its greater cost. Most of the fertilizer companies will supply fertilizer containing 50 or more pounds of copper sulphate per ton, at a cost practically the same as the two materials will cost before mixing.

The Use of Sulphur—Alkaline muck is certain to give poor yields of onions. The poor yields occur whether the alkalinity 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 lime applied on the surface, or to the salts which have been deposited from the alkaline spring waters on springfed mucks. Sulphur applied on such muck produces the following benefits on onions:

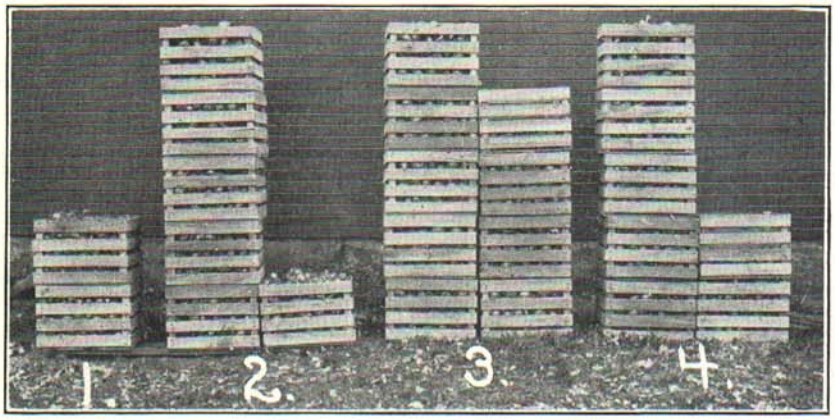

Fig. 5. Onions from equal areas of a uniformly well-fertilized alkaline muck soil. From left to right the soil had received per acre in 1929 before planting, (1) no sulphur, (2) 500 pounds sulphur, (3) 1,000 pounds sulphur, (4) 2,000 pounds sulphur. In 1930, the 2,000 pounds of sulphur produced the highest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

(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 alkaline soil.

On most alkaline mucks, an initial application of from 250 to 1,000 pounds of sulphur is advisable, while a lapping back over a small por-

tion of the field to double the application will give information as to the possibility of more being needed. If a heavier application is found necessary, it is advisable to plow down the first before making the second application. Finely ground sulphur can be applied shortly 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 coarser sifted crude sulphur is used instead of the flour, it is advisable to apply it several months before cropping. If the alkalinity extends to a depth of eight inches or more, it is advisable to plow shallow for a couple of years following a moderate sulphur application, unless a second application is to be made. Sulphur can be applied with most fertilizer and lime drills, but the drilling of sulphur flour should be carefully watched, since it does not feed down readily.

In addition to the alkaline mucks, those which have a very slightly acid reaction are often benefited by a light sulphur application, unless the underlying muck is more acid. An application of 100 to 200 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, home mixing should be done shortly before the application is to be made.

The Use of Manganese Sulphate—Although manganese salts have been found beneficial to onions on some alkaline mucks, the use of sulphur, rather than manganese sulphate, has in the past generally proved more economical and more permanent in its effect. Alkaline mucks, as a group, naturally contain manganese in sufficient amount but unavailable to the crop, the acid produced from the sulphur applied correcting that unavailability. In the absence of a sulphur application, the application of manganese sulphate at the rate of 200 pounds per acre generally will result in a fair yield on a slightly to medium alkaline muck which would otherwise produce a crop failure.

On strongly alkaline muck which has just received an application of sulphur, an additional application of 100 to 200 pounds per acre of manganese sulphate is sometimes advisable. This should be applied just before seeding and can be mixed in the fertilizer. On strongly alkaline muck on which a fairly heavy application of sulphur has been plowed down rather deeply, so that the succeeding crop may suffer somewhat from the upturned alkaline soil, the use of 100 to 200 pounds per acre of manganese sulphate may be the means of saving the crop in early growth, until the roots can penetrate into the sulphured layer.

Occasionally, a muck is cropped to onions for the first time without the precaution of a determination of the soil reaction, with the result that the onion growth shows part or all of the field to be alkaline. Since the growth gives no indication of the presence of "alkali" until the plants are about a month old, it is then impossible to apply sulphur and get it sufficiently worked into the soil so that the toxic condition will be corrected. Beneficial effects can be secured by the application of 200 pounds of manganese sulphate as a top dressing over the crop. Still better, a manganese sulphate solution[1] run directly on the onion

[1]The manganese sulphate solution can be made by dissolving the fairly fine ground material at the rate of one pound in 20 gallons water containing one-fourth pint of commercial sulphuric acid. On page 23 is shown a tank that can be used for applying the solution to the crop. The application is equivalent to approximately one gallon per 80 feet of row, when rows are 13 inches apart.

row at the rate of 25 pounds of manganese sulphate in 500 gallons of acidified water per acre will produce a renewed unright green growth of the curled yellow tops within a few days after the application. In addition, 100 pounds per acre can be applied broadcast immediately, or a second application in solution can be made within a couple of weeks if the first does not produce marked improvement. With this treatment the crop yield is not likely to be large, and for permanent benefit, sulphur should be applied before the next crop is grown.

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

Fig. 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 smooths 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.

on practically all mucks for the production of onions, while nitrogen is sometimes required. The proper fertilizer analysis for the crop depends on the soil reaction, age, and depth of the muck, on the drainage conditions, and on the time of sowing the crop. On the better drained and more acid mucks, a greater proportion of potash is needed in the mixture, while, on the poorer drained and the alkaline mucks, somewhat more phosphate is required. Nitrogen in the mixture gives the early-sown onions on old muck a good start which generally results in a more rapid growth throughout the season. On well drained new muck, however, the nitrogen often is not required. For late-sown onions it likewise can well be omitted, except on very acid muck, alkaline muck, or poorly drained muck.

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 safely applied in row 2 in. below seed (7)
High-lime	Not acid to strongly acid	Deep and medium	Newly reclaimed(5)	Good	Application of limestone or marl likely to decrease yields	If tops die back from tips during hot weather or mature bulbs have poor color, apply 50 lbs.	If soil is not acid or very slightly acid, 100 to 200 lbs. is sometimes advisable, but if medium or strongly acid, do not apply sulphur	0–10–20 2– 8–16	0–12–12 0–10–20	800–1200	400–600
				Fair				3–12–15	3–12–15	800–1200	600–800
High-lime	Not acid to strongly acid	Deep and medium	Old muck	Good				2– 8–16	0–10–20 0–12–12	700–1200	300–500
				Fair				2– 8–16	3–12–15	700–1200	400–600
High-lime	Not acid to strongly acid	Shallow		Good				3–12–15	3–12–15	700–1200	300–500
				Fair				3–12–15	3–12–15	700–1200	400–600
Low-lime (4)	Very strongly acid	All depths			2 to 12 tons	50 pounds	Sulphur not recommended	3–12–15	3–12–15	800–1200	Not recommended
Very high (3)	Alkaline	All depths			Lime not recommended	Not recommended	500 to 2000 pounds	3–12–15	3–12–15 2– 8–16	700–1200	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 alkaline muck should be given a sulphur application of 500 or more pounds per acre. Improvement of the drainage may also be advisable. Muck which tests not acid or very slightly acid in the plowed layer will be benefited by a light 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 several 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, seedings before April 25 may be generally 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 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.

Although occasionally a newly reclaimed muck is sufficiently fertile that it will produce a fair 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 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 then disced in or if it is drilled broadcast uniformly over the field before seeding. Not more than one-half as much can be safely applied in the row as would be required if the entire application was made broadcast. To secure best results and at the same time to prevent any injury to the germinating seed, the fertilizer preferably should be applied directly below the seed and not less than two inches from it. 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 alkaline 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 drier mucks which are being spring-plowed, it is sometimes advisable to plow part of the fertilizer down.

The Table on page 10 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 600 to 800 pounds per acre. On the field which ordinarily requires 900 to 1,000 pounds of a 2-8-16 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 or 2-8-16 in the row and 300 to 500 pounds of 0-8-24 broadcast, cuts down the cost of fertilizer per ton and also the amount required per acre.

In making these recommendations, it has been impossible to include all analyses of the same or similar ratios which might be used. Thus 600 pounds of 0-20-20 would contain the same amount of each fertilizing constituent as 1,000 pounds of 0-12-12, and 1,500 pounds of 2-8-10 might be used instead of 1,000 pounds of 3-12-15.

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 fluctuation in the 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 the droughty periods.

Fig. 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.

For best results a new muck should be properly drained for at least a year preceding cropping to onions, in order that water channels may become established in the soil and decomposition of the raw muck will have begun. In establishing the drainage system, the proper distance between lateral tile lines or ditches will depend both on the nature of the substrata and on 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.

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 about 12 inches. Breaking to a depth of 15 and even 18 inches is advisable when the field is "hummocky". Onions grown on shallow-broken muck are almost certain to be a failure if the season is droughty. New muck preferably should 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.

Fig. 8. The double-disc and roller are important in the preparation of the seed bed. 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 exceptionally heavy. The use of the roller on spring plowing before

Fig. 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.

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.

[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.

PREVENTION OF WIND INJURY[1]

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 rye or barley.
4. Increasing supply of organic fiber in soil.
5. Raising water-level in soil by damning ditches.
6. Compaction of soil by very heavy rolling.

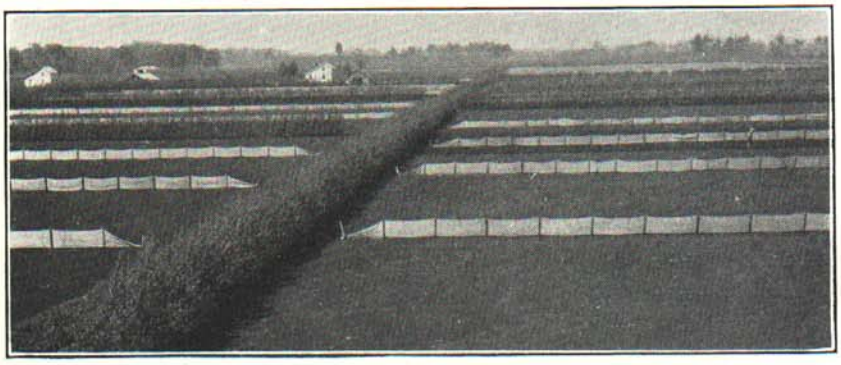

Fig. 10. On these onion fields a combination of green willow (two year growth) and burlap is being used to prevent wind injury. This willow grows very rapidly, often reaching a height of 18 feet in four years. The burlap is not good for more than two years use and generally cannot be recommended because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

[1]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, Mich.

objections to winter rye are that the drifting muck tends to form ridges where the strips are located and it also harbors insect pests. Further, if the muck is quite dry, such rye strips are insufficient to entirely prevent wind injury. For that reason, it is generally advisable to sow rye or barley, interplanted between every three rows of onions, on every onion field which is in any danger of being swept by the spring winds. Of these rye is more resistant to freezing than is barley. Such grain must be removed by the wheel hoe, of course, as soon as the onions are large enough to serve as their own protection. Ordinarily it is about 10 inches tall at this time and in warm, dry weather will not have to be carried off the field to permit cultivation. On fields on which spring rye or barley reach a height requiring cutting before the onions are able to withstand the wind, the use of the slower growing winter varieties is sometimes advisable.

On well decomposed mucks 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 the green manuring. In many seasons, a good growth of rye can be grown in the fall after an early crop of onions has 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. Both Sudan grass and soy beans are excellent green manure crops and are likely to make up for the loss of a crop in increased yields in future years.

VARIETIES

A large proportion of the onions produced in Michigan are of the American type and are grown from seed. A relatively small acreage is grown from sets, with the idea of securing early maturity of the crop. Most of the onions produced are of the 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 alkaline 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 developed 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 fairly 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 few 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.

PRODUCTION OF SEED, SETS AND TRANSPLANTS

A considerable number of the onion growers of the state are producing part or all of their seed from bulbs of their own raising. This practice is desirable when the grower has difficulty in securing a variety adapted to his climatic and soil conditions. In addition to careful selec-

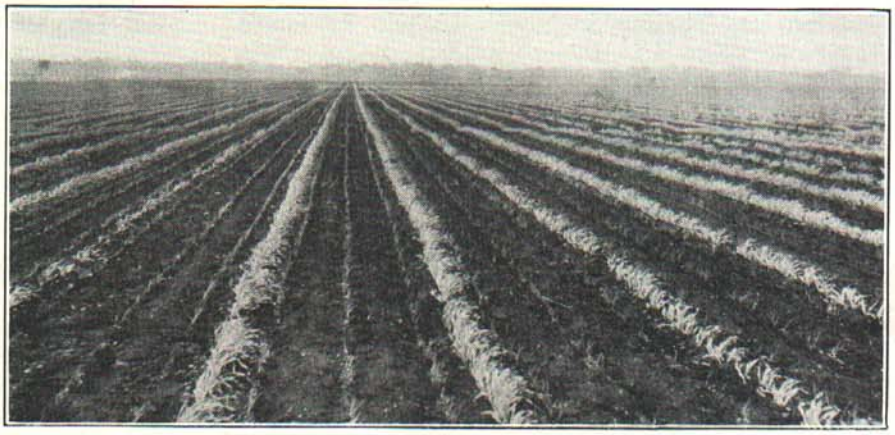

Fig. 11. Grain, sown between every three rows of onions, is one of the best protections against wind injury. In cold spring weather, the onions will grow faster with the grain present, since it protects them from the chilling winds.

tion of bulbs of the desired type, the keeping quality can be improved by the planting of only those bulbs which show no evidence of sprouting.

In the latter part of April or early May in southern Michigan, the bulbs are set out, from six to eight inches apart in the row, with rows about two feet apart. Although better yields of seed may be secured on a good loam soil, good yields can be obtained with proper planting on muck. The bulbs should be set in compact muck so that there is two to three inches of soil above the bulps. Since the muck planting is likely to be adjacent to onion fields, particular care should be given the bulb planting to protect it from maggots and thrips. An application of 300 to 400 pounds per acre of a 2-8-16 fertilizer mixture is also advisable. The seed balls should be harvested when the seed cells start to open, since a delay is likely to cause a loss from shattering. If convenient the picking can be made two or three times as the balls mature. The balls should then be dried rapidly in a room having plenty of air circulation, so that they will not mold with resulting injury to the vitality

of the seed. In small quantities the seed can be rubbed out of the balls when dry, and then cleaned with a fanning mill. In larger quantities it can be threshed with clover huller or better with special machinery for that purpose.

Onion sets are produced by the close sowing of onion seed. From 25 to 35 pounds of seed per acre should be sown, the amount depending on the percentage germination and size of seed. Insufficient stand will result in the production of sets larger than three-fourths inch in diameter, which larger sets may develop seed stalks instead of bulbs. Thus far it has been difficult to produce sets from the sweet Spanish onion, for lack of which transplants are sometimes used.

Production of sweet Spanish transplants by seeding in the greenhouse in February or early March gives satisfactory results, but some of the transplants 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 and plants kept free from insects.

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 rates per acre being to a considerable degree dependent on the size of the seed. Where large onions of the sweet Spanish type are desired from seed, from two to three pounds per acre should be sown.

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.

Although onion sets are used to considerable extent in the production of the bulb crop in some sections of the country, the practice has never widely been adopted in Michigan. A small proportion of the farmers have a few acres planted to sets, largely because the crop matures earlier than when grown from seed and the labor of harvesting is thus spread over a longer period of time. Although yields are sometimes higher, factors such as insect pests and weather conditions frequently result in low yields of the crop produced from sets.

The sets are generally planted two to four inches apart in the row, with the rows 13 to 16 inches apart. The set bulbs are entirely covered, with soil firmed over them, but they should not be planted too deep. The sets are planted the last part of April in southern Michigan.

Fig. 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 use of sweet Spanish transplants gives the advantage of an earlier crop, which in some years brings good returns. 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 to 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 the removal from the field of all weeds 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 Sudan grass, 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, and by the use of the scufflehoe later in growth.

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 alkaline muck will prove beneficial in this respect. Care in handling the crop to prevent injury to the bulbs, and rapid and thorough curing in the field, together with storage in properly ventilated storages will largely prevent the disease.

Onion Smut—Although 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 smut fungus 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 formalde-

hyde 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.

Downy Mildew—Under favorable weather conditions, this disease has caused marked damage in some sections. The mildew ordinarily appears late in the season, under the influence of warm days and cool nights, especially under moist conditions. It may become destructive at any time if the temperature and moisture conditions favor the spread and development of the causal fungus. The disease was serious in many fields in 1935, and it was accompanied by a severe scalding of the onion tops, due to the hot, very humid weather of late July. The mildew 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 seen in the early morning while the dew is still present, as a violet-colored mold on the leaves. The disease results in a decreased yield, with a large proportion of undersized onions, which fail to keep well in storage.

There is considerable evidence that the mildew fungus is seed borne and an outbreak of the disease may follow the use of infected seed. Seed should be obtained from sources free from mildew. 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 Bordeaux mixture containing fish-oil soap as a spreader. Since several sprayings are required and because the appearance of the disease cannot be foreseen, this method has not been generally adopted. The use of disease-free seed, destruction of all crop refuse and rotation of crops are the practical means of combatting this disease.

Root Knot—Root knot (nematode disease) attacks many different kinds of plants including the onion. Only in recent years has it become important in Michigan on plants grown out of doors. Climatic conditions are not generally favorable for the overwintering of nemas but they do survive in the roots of perennial plants, in warm greenhouses, and in muck soils where the shallow freezing does not destroy them. Root knot is increasing in importance in Michigan, and some instances of serious injury to celery, carrots, parsnips and other crops on muck have been observed. It is fairly frequently found in the onion fields of Ohio and was located in two onion fields in Michigan in 1934, in one of which it reappeared in 1935. It can be carried from one field to another on cultivating implements and on shoes.

The disease can be detected by the characteristic galls or swellings which occur on the roots of infested plants. These galls are usually about the size of a pea or smaller and are round or somewhat elongated.

They occur most abundantly on the smaller roots. The microscopically small nemas penetrate the roots from the soil and their presence in the root tissue causes the cells to enlarge and form the galls. Infested plants are usually dwarfed and unthrifty, the degree of injury being dependent upon the number of galls that are present. If soil and climatic conditions are favorable for the growth of onions, yet they are stunted and fail to develop normally, examination should be made for the presence of this disease.

Root knot can be controlled by practices which aim to starve out the nemas or to reduce their number. Fallowing and rotation with crops which are immune from or very resistant to the disease must be used to prepare infested soils for the growing of susceptible crops. Some plants which may be used in the rotation include: Corn, rye, some varieties of oats, iron cowpea and perhaps other legumes. The nematodes attack many kinds of weeds and the maintenance of a weed-free fallow is essential. Fallowing and a two or three year rotation with immune crops should provide an effective program for the control of this disease in Michigan. Late fall plowing to permit greater penetration of frost in muck probably will aid in their control. Plants infested with nematodes in the greenhouse should not be transplanted to the field.

Fig. 13. Showing onion roots affected with root knot (nematode disease). Note the dwarfed growth of tops, restricted root development, and characteristic knot like swellings of the roots. Crop sown in early April, plants photographed June 24.

INSECT PESTS[1]

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

[1]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.

Onion Maggot—The most effective 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 fly. Where onions are left in the field, the land should be plowed fairly deep, while all piles of waste onions in adjoining fields or around storages should be either burned or buried under at least a foot of compact soil. Since the adult fly travels quite a distance, it is essential that this means of control, to be most effective, should be practiced throughout the neighborhood.

Fig. 14. 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.

The use of a corrosive sublimate solution,[1] 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

[1]To make up a stock solution, dissolve one pound of corrosive sublimate in four gallons of hot water in a wooden container. Use one quart of this stock solution in water to make up 10 gallons of field solution, sufficient for one application on about 800 feet of row.

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 or other satisfactory spreader 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. A spray, applied with a power sprayer at the rate of 100 to 150 gallons per acre per application, is necessary for satisfactory control. 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 complete killing out of all sods by the second year, the injury is likely to be more severe. In the third and 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

[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 of 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 three gallons cheap molasses and enough water to make 10 gallons and stir it into 150 pounds bran placed in a water-tight barrel. From three to five gallons more water may be needed to secure the proper consistency. Finally, stir into the mixture four ounces of banana oil.

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 is sown between each two or three rows of onions, as described for wind protection on page 16. The wheat is preferred to onions by the wire-worms which attack it shortly after it is up. 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.

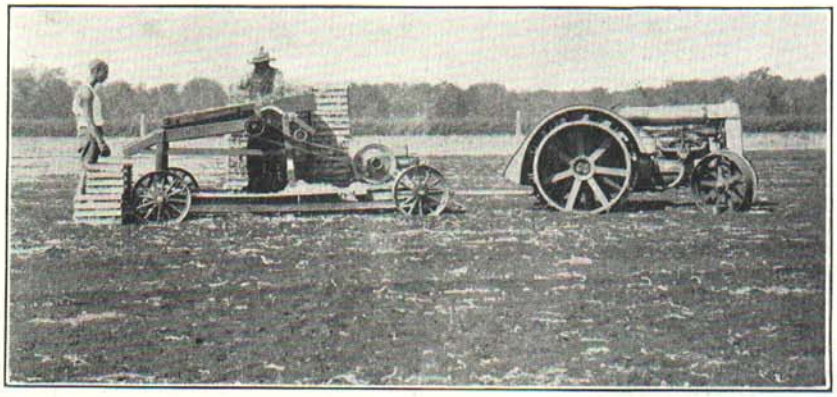

Fig. 15. On some onion fields, the onions are pulled into crates, where the maturing is completed, the crates are then gathered in groups in the field and the topping is done with a machine topper, which is hauled from place to place by team or tractor. As they leave the rollers, the onions pass over 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 may be 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 alkaline muck, the proportion of immature onions is likely to be large. These are almost certain to sprout in storage, consequently, in topping, the rejection 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 later, and complete their curing with artificial heating in storage.

Fig. 16. 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 permit it, in order to prevent a rise in temperature in the storage, with con-

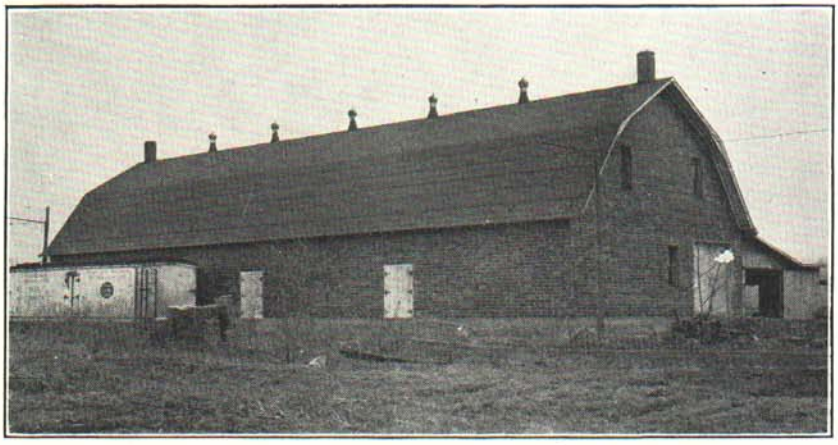

Fig. 17. A 60-car storage constructed of glazed block tile. Built on a siding, the onions are loaded directly from the storage into the car. On the farther side the covered driveway offers protection for loads in inclement weather, as well as storage for empty crates.

sequent 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 on the floor of 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.