EXTENSION BULLETIN 307

Conservation of Michigan's Muck Soil

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SUMMARY

1. Conservation of Michigan's muck soil resources should embrace a development program for the large unreclaimed muck acreage of the state, a plan of conserving the mucks which have recently been brought under cultivation, and a procedure whereby any already badly depleted mucks may in some measure be restored to their original state of productivity.

2. For a muck area about to be reclaimed, a careful study should be made before the expense of reclamation is undertaken. This study should determine: First, whether there will be a demand for the crops which might be produced on that area when reclaimed; Second, whether the type of muck is adapted for producing satisfactory yields of those crops; and Third, if drainage is undertaken, what depth of outlet ditch will give satisfactory but not excessive drainage for these crops.

3. Depletion of our older muck soils has been largely due to three agents of destruction: (a) excessive chemical decomposition; (b) fire; and (c) wind. A fourth, water erosion, sometimes has removed the surface material of our older well decomposed mucks.

4. Practical methods of restoration of depleted mucks and of minimizing future depletion include:

a. Adoption of a method of water control with maintenance of as high a water level in the soil as the root systems of the crops being grown will permit. This generally requires a dam or series of dams with adjustable gates and sometimes one or more pumps.

b. In cases of sheet erosion on well decomposed mucks with considerable slope, depletion can be reduced by construction of diversion ditches and sometimes also of lateral ditches or tile lines at right angles to slope.

c. Use of windbreaks and interplanted grain for wind protection.

d. Addition of organic matter in form of mature vegetative growth containing as much fibrous and woody tissue as possible for wind protection and soil improvement. Use of manure and green manure may hasten soil decomposition.

e. Heavy compaction of excessively drained soils.

f. Conservative addition of various plant food materials which may have been largely removed by wind erosion and cropping

methods. Excessive applications of fertilizer may hasten soil decomposition.

5. Burning of muck soils should be prohibited by State law. Immediate action is necessary in controlling accidental burning, by encircling burning area with ditches down to deep, wet muck, the use of water for flooding, of disks for eliminating burning pockets and of scoops for removing small burning pockets to upland.

6. Installation of a set of measuring wells—as a part of a water control system—is advisable in order to know exactly where the water level is in different parts of a farm, as insurance against possible damaging effect of excessive moisture.

Conservation of Michigan's Muck Soil

By PAUL M. HARMER[1]

The agricultural value of most Michigan muck soils is comparatively high. The high water-holding capacity of muck—which enables it to carry a crop through a severe drouth and yet produce good yields; its relatively high nitrogen content; and the ease of its cultivation all tend to make reclaimed muck a highly desirable soil.

Experimental investigation has still further enhanced its value to agriculture. It has been proved that with proper water control, proper fertilization, and good soil management practices any crop produced in the same locality can be grown successfully on good muck soil.

The life of muck soil, as compared with mineral soil, is relatively short. From the moment of the first step toward its reclamation, muck soil begins to waste away. Records frequently show its depth to have decreased as much as 1 foot within the first 5 years following reclamation, with a more gradual settling in later years. Instances have been reported in Europe—as well as several in Michigan—in which deep muck has decreased several feet in thickness in the 50 years following reclamation. In several other cases, known to the writer, shallow muck has ceased to be muck at all, after a relatively few years of intensive farming.

The total muck area in Michigan has been estimated by various investigators as between 4 and 5 million acres. In other words, approximately 1 out of every 8 acres of the land area of the state is muck soil. Although this acreage is much greater than that of states to the south and east of Michigan, because of one factor or another a considerable part of our muck soil can never be reclaimed, or will not be in the immediate future.

Under present conditions, some types of this muck are unsuited for crop production. In addition, external economic factors may combine to prevent reclamation, such as an excessive cost of drainage, remoteness from markets, and—in some sections—lack of the necessary labor required for the production of special crops. It is true

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[1]Extension Specialist (Professor) in Soil Science. The author desires to acknowledge the criticisms and suggestions of Dr. N. K. Ellis, formerly muck soil specialist at Purdue University and now head of the Purdue Horticulture Department; G. A. Thorpe, F. W. Trull, L. J. Bartelli, and C. A. Engberg of the U.S. Soil Conservation Service; L. R. Schoenmann of the Michigan State College Conservation Department; and several members of the Michigan State College Soil Science Department.

that only a small percentage of Michigan's muck soil has been brought under cultivation, yet in some of the southern counties the larger part of the more desirable muck has already been reclaimed.

Internal soil factors must, of course, be considered in determining whether it is sound, economically, to develop a given muck area. They include the prospective life of the muck, the degree of acidity or alkalinity of the soil, and the nature of the material underlying the muck.

The life of a muck is largely dependent on its depth. If a muck is less than 2 feet deep, and underlain by marl or a coarse sand or gravel, it generally is not advisable to reclaim it for special crops. If the underlying material is a clay loam, drainage may be advisable, at least for general crop production. If the muck is 3 or more feet in depth—and the soil pH in the upper 2 feet is not lower than 4.4—reclamation is advisable, providing the external factors mentioned are favorable. (The soil pH may be somewhat lower if blueberries are to be grown.)

The most important agents of destruction which enter into the loss of muck soil are chemical decomposition, fire, and wind. A fourth, and much less important one, is water. Water may cause some sheet erosion and gullying on the older, well decomposed mucks, and occasionally excessive deposition on the muck of mineral soil from surrounding uplands.

Chemical decomposition, without doubt the most important, is active from the moment that the muck is reclaimed. Fire consumes many thousands of acres of muck each drouthy summer. In other deposits, within a few years after reclamation, wind begins removing the best part of the muck, the surface soil of the cultivated field.

CHEMICAL DECOMPOSITION

Our muck soil has been formed by the gradual accumulation, throughout the past ages, of the remains of water-loving vegetation. This accumulation for the most part is due to the presence of water. Water retards complete oxidation of the organic matter by preventing the air from coming in contact with these vegetative remains. In extremely acid deposits, the water's preserving influence is augmented by the soil acids, which prevent the somewhat sterile muck from becoming infected with many of the organisms that cause decomposition.

EFFECT OF DRAINAGE

The first effect of drainage, then, is to permit the air to enter the muck, and the processes of oxidation and decomposition to begin. In general, the greater the amount and depth of such drainage, the greater will be the rate and depth of decomposition—and consequent loss of soil in that muck area.

Unfortunately for many of the muck farmers in our state, the early drainage engineers knew how to remove the water rapidly from the muck soil areas, but failed to realize the moisture require-

Fig. 1. Dam constructed to maintain water level in a large muck area. Note the use of interlocking sheet steel piling, which is driven deep to extend well out into the bank on each side. It is also driven across the ditch below the bottom of the gates. Concrete piers, concrete apron in the bottom of the ditch, angle iron braces welded into position, and four redwood gates complete the construction.

ments of the crops those areas were to produce. As a direct result, not only have the crops suffered for lack of moisture in drouthy seasons, but the loss of muck through decomposition processes has been far more rapid than was necessary for satisfactory crop production.

Care should be taken in the future not to drain much in advance of the actual need for muck land—not only because of the unnecessary soil decomposition, but also the expense of reclamation without return on the investment. An example of needless expenditure of public and private funds can be seen in the original drainage of the large Seney marsh in Schoolcraft county. That drainage was later abandoned, and the area reflooded for game refuge purposes.

It should be noted that in the drainage of a new muck area the income from a native growth—such as ash, elm or cedar; coarse marsh grass (of value for packing purposes); or fruit such as the wild swamp blueberry (often incorrectly called "huckleberry")—may be lost through dying out.

In new reclamation projects, it is advisable not to drain excessively. The presence of gravel or sand immediately underlying the muck should be taken in consideration, since the presence of such coarse material is likely to aggravate a drouthy condition. Increase in the width of a ditch, to accommodate the necessary volume of water, is

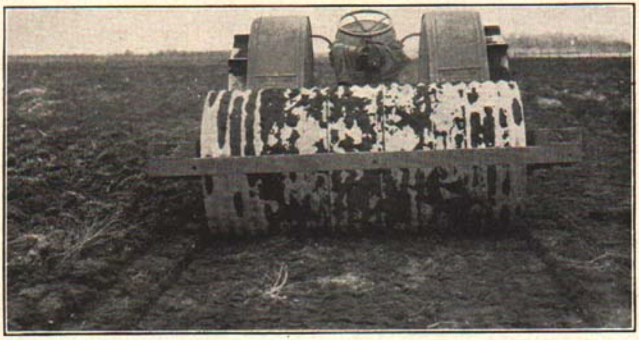

Fig. 2. The use of a heavy concrete roller on excessively drained muck land compacts the underlying muck as well as the surface, and, by keeping the air out, helps to decrease an excessive rate of decomposition. Its use is especially desirable on loose, peaty mucks.

often preferable to an increase in depth. In addition a planned system of dams is frequently advisable.

By far the most effective method of decreasing these processes of decomposition in excessively drained muck areas lies in the damming of the outlet ditches. (Fig. 1.) This has already been done in several of the important muck areas of the state, with beneficial results to the crops produced. Heavy rolling of these excessively drained mucks also tends to restrict decomposition by compacting the soil, and thus keeping out the air. (Fig. 2.)

If there is sufficient flow of water in the outlet ditch throughout the dry summer a dam or series of dams, properly installed, generally

Fig. 3. The master dam in the main Chandlers Marsh drain, 3 miles north of East Lansing. It is constructed of a 7-foot tube of corrugated sheet iron 28 feet long, with tube filled over with soil to form a bridge. Some clay is necessary in the fill to prevent seepage and possible undermining. The dam is open in the early fall (photographed September 26, 1950) to lower the water level, and give more drainage for the extensive sugar beet acreage on the muck above. Note the weed growth below the dam (foreground), and the weed-free channel above.

Fig. 4. View of secondary dam and bridge in the Chandlers Marsh drain, nine-tenths of a mile above the master dam shown in Fig. 3. This photograph was taken from the upper side, in late summer, before the retaining planks had been removed to lower the water level.

is highly effective in controlling water levels. At the same time, the rate of decomposition is also controlled in those areas. Such a flow usually means that the stream is fed by springs farther up in the drainage districts.

A system of dams for effective water control (Figs. 3 and 4) is the best means of preventing excessive decomposition, and most conducive of optimum crop yields. At the same time, it may tend toward a more rapid filling of the ditches—coupled with a greater growth of weeds in the ditch—than if no dams were present. For that reason the dams should have ample sized gates, which can be opened in the fall. If the ditch tends to become choked with water cress and other broad-leaved weeds, a spray of 2-4,D in late summer will destroy them. A more rapid washing away of any sediment which has accumulated while the gates were closed is then possible in high water.

Quite often a muck located near high hills is so underlain with springs that satisfactory drainage can be obtained only at rather large expense. Occasionally these springs—which originate in the hills—lie so deep at the border of the muck area that it is impossible to intercept them with a deep cut-off ditch. Completion of the outlet ditches may leave such muck very soggy, even comparatively close to the ditch, because of upward pressure of the soil water from the springs. Under those conditions extensive tile lines are necessary to effect satisfactory drainage. It is advisable to explore the situation thoroughly on such muck areas in deciding on the practicability of reclamation.

A constant supply of water in the main ditch throughout the year greatly enhances the value of a muck farm. Where the supply is not adequate to maintain the proper level in a system of water control, occasionally it is possible to obtain water from some nearby lake; or by diversion from some other drainage ditch. Pumps, and sometimes a series of special dams, may be necessary to obtain sufficient head of water from such sources to affect the water level in the fields.

In limited acreages where no water supply is available, it may be advisable to install deep wells. However, consideration must be given to the fact that state control of the removal of large volumes of ground water is likely at some time in the future. Such control would restrict the value of the wells as a dependable water source.

EFFECT OF MANURES AND FERTILIZERS[2]

Any means of increasing the number and activity of the soil organisms is likely to hasten decomposition, and thus shorten the life of a muck. The use of farm manure—unbalanced as it is as a fertilizer for muck soil—adds millions of bacteria and fungi, which attack the soil and break it down. Only on the extremely acid types of muck (pH 4.5 or less), after liming, is the use of manure to increase the bacterial population and promote decomposition generally advisable under Michigan's climatic conditions.

The plowing under of green manure on the less acid mucks is another questionable practice. The addition of this green organic matter can result only in a large increase in the microbial population of the soil. After rapidly completing the decomposition of the green manure, these organisms then attack the soil itself. The repeated practice of sowing winter rye on muck in early fall, and plowing it down in the spring, has caused several muck farmers to say that they have "ryed their muck to death." This is borne out by the fact that such soils have decomposed to powder, have decreased in depth faster, and finally have become less productive than neighboring fields.

As long as the muck has visible fibre in it—and has not reached the finely powdered condition that characterizes the end product in its decomposition—there seems little to be gained, and much to be lost, by the addition of green organic matter to the soil. However, once that finely powdered condition has been reached, the use of green manure is likely to be beneficial, with legumes generally giving greater benefit than non-legumes to the later crop growth.

The older muck soils, finely divided in the plowed layer and well decomposed to a depth of 2 to 3 feet, generally show a marked response to a green manure crop. Where it is possible to raise a grain crop such as wheat or barley[3]—seeded to a legume such as alfalfa or sweet clover—the grain can be harvested and the legume left as a cover crop to be plowed under in the spring. In the same way rye and vetch, or oats and vetch, can be sown following harvest of a spring or early summer crop, to serve as winter cover and then spring-plowed.

Although muck soil is naturally infertile insofar as content of phosphate and potash are concerned, it is highly productive when

[2]Private communication from Dr. N. K. Ellis, Purdue muck soil specialist from 1935 to 1950, indicates he is in agreement with the writer regarding the effect of manure, green manures, and heavy fertilizer applications in increasing decomposition of muck soil.

[3]Yorkwin winter wheat, Henry spring wheat or Mars barley are grain crops which stand up well and yield well on muck. Copper sulfate should be included in the fertilizer for the wheat unless considerable has been applied on the land in preceding years. Scarified sweet clover seed is recommended to avoid having delayed germination in later years.

properly fertilized. However, there is some evidence that the heavier the fertilization, the greater will be the rate of decomposition. From the standpoint of soil conservation, therefore, the smaller the amount of fertilizer necessary to insure good crop production, the less will be the chance of excessive decomposition.

For that reason, in the case of most row crops (potatoes possibly excepted), application of the fertilizer under the row, 2 inches or more directly below the seed, is likely to result in longer life for the muck soil. This method gives optimum yields with a minimum of fertilizer. The distance the fertilizer should be placed below the seed to give the best results will depend on the drainage conditions of the muck and on past fertilization.

FIRE

The destruction of large areas of muck by burning occurs each year, especially during drouthy summers. It has been noticeably prevalent on muck areas which have been drained excessively. Although most of such burning is accidental, in a few cases it has been intentional. Unfortunately it sometimes is done deliberately as a cheap means of clearing the land, or to remove the muck so that the underlying mineral soil can be cropped.

The fact that burning of muck takes place much more readily on sod land which has not been brought under cultivation, than on land which is producing crops, is an added argument against draining muck areas until they are actually needed for crop production.

EFFECTS OF BURNING

The burning of muck is undesirable from an agricultural standpoint, in the first place, because the entire depth of the muck may be destroyed. (Fig. 5.) This may expose a bed of gravel, a sandy soil, a boulder field, an unproductive marl, or a stiff clay. Further, the burning can become excessive in one particular part of the field, so that the level is lowered to a point where adequate drainage becomes impossible. Then there is always the danger of producing an alkaline soil—a result of the burning of the less acid muck—with consequent accumulation of the lime from the burned layer. This alkaline condition presents problems in making the soil suitable for a number of crops.

There is always the chance, moreover, of damaging surrounding fields and destroying neighboring farmsteads. Burning is prohibited by law in practically all of the European countries which contain muck.

The only type of muck which may be benefited by burning is an extremely acid muck overlying less acid muck. In such cases, loosen the surface soil in the early spring—so it will dry—and burn off the surface while the underlying soil is still well-filled with water. In most instances, however, it is desirable from the standpoint of drainage to lime such acid soils—rather than to burn them off.

CONTROL OF FIRE

There are two sound means of reducing and preventing the large number of accidental muck fires in the state. The first lies in the

Fig. 5. A portion of 500 acres of deep muck, accidentally burned over. It has been burned to an average depth of 3 feet, with many spots even deeper. Such badly burned muck soils are harder to drain, and frequently difficult to put into condition for satisfactory crop production.

maintenance of a high water level in the soil, so it will not burn readily. The second lies in the proper education of hunters, picnickers and farmers to the serious consequences which can result from the careless setting of a muck fire.

Once any fire is discovered, haste is extremely important in putting it out. Known means of extinguishing a muck fire are usually insufficient if it has gained much headway.

The first step lies in ditching around the burning area, well down into the wet muck, permitting the fire to burn itself out. When a source of water is available, large capacity pumps, fire hose, and tractors (for power) can be used to flood the burning area. In periods of high winds, sparks may be blown across the ditch confining the burning area; then it becomes necessary to patrol the unburned area to prevent new fires from starting. In times of high winds or drouthy periods, no fires should be started on or near muck soil. The extinguishing of a muck fire without an abundance of water is almost impossible, especially after the fire has burned fairly deep into the muck. If tractors and scoops can be brought to the burning area shortly after the fire is started, it is sometimes advisable to haul the burning muck to the upland, there to allow it to burn itself out. Occasionally the intensive use of a disk harrow in smoldering pockets will aid in extinguishing the fire.

WIND

The three factors which determine the amount of muck which will be removed by wind erosion are: (a) the degree of decomposition of the muck; (b) the moisture supply in the soil, and (c) the exposure of the land to the sweep of the wind. Wind does not have any depleting effect on muck land so long as the muck has not been reclaimed and broken up, but frequently wind does become a serious problem within three or four years after the land has been put under cultivation, due to its rapid decomposition and loss of fibre. Generally, the damage is done in the spring, during the months of May and June.

The immediate injury from wind generally is seen in the damage to the crop which is being grown. That damage is produced by the fine particles of muck which strike the tender young plants to inflict injuries which may result in the complete loss of the crop, or a marked retardation in its growth.

A more permanent injury can occur in the removal of the surface muck. On exposed areas several inches of soil may be carried away in one wind storm, such transplanted muck being lodged in the ditches with consequent impairment of drainage, or behind any wind obstruction, or carried high into the air possibly for several miles before being dropped. Since this surface soil which is carried away is really the most valuable part of the muck, its continued loss year after year is likely to be seen in a marked decrease in the productivity of the soil.

PREVENTION

Means of preventing loss of the surface muck soil by wind erosion include: (a) the raising of the water level in the soil; (b) the addition of fibrous and woody organic matter to bind together the small

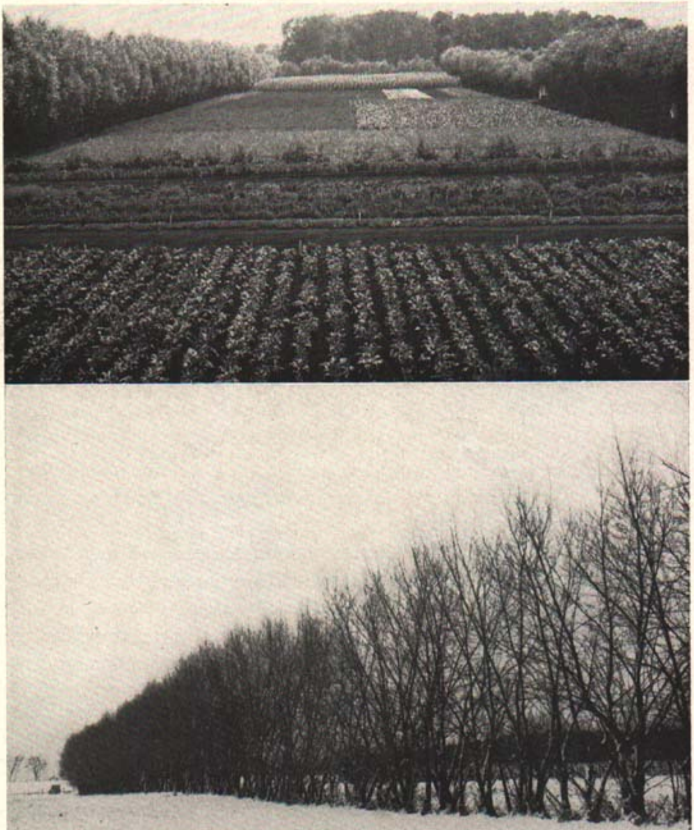

Fig. 6. The green willow, widely used as a windbreak on Michigan muck soils, is shown here after 10 years of growth on the muck plots at Michigan State College. The further end of the righthand row in the upper picture was planted 2 years later than the rest. The willows were cut back to 12 feet of height after 6 years of growth, but were better than 20 feet high at the time of photographing.

The lower picture shows the left row of the upper picture, taken in winter from the opposite end of the field. The willow does not offer much protection against the blowing of muck in an open winter. Seeding to oats in the early fall is advisable, whenever possible, if the muck is exposed to the sweep of the wind.

particles of muck into aggregates, which are sufficiently large so they will not blow readily; and (c) the erection of barriers of trees, fences, or strips of grain to cut down the wind velocity and protect the soil.

Means of raising the water level have already been discussed. The addition of organic matter can best be made in the form of woody vegetative growth, rather than green manure. Oats or corn, sown as a cover crop, give protection during the winter while the ground would otherwise be fallow, and—when plowed down in the spring—tend to give the soil a more granular condition for one to three years.

Flambeau soybeans, combined in the field, will give a good yield and at the same time considerable woody straw which remains longer as fibre in the soil than does green material. On the older types of muck, these crops are likely to be beneficial to practically any succeeding crop, in addition to their function in cutting down wind erosion.

TREES

Of the tree windbreaks which are adapted to muck land, the green willow—already grown to considerable extent for this purpose on the better managed muck areas of the state—will give the greatest amount of protection in the shortest period of time. (Fig. 6.) Frequently, a height of from 15 to 18 feet will be produced within three or four years after the cuttings have been pushed into the ground. Chinese elm also have shown rather rapid growth when transplanted to muck soil. Neither, however, can give much protection against blowing of muck in an open winter. Windbreak plantings from 15 to 30 rods apart generally prove satisfactory, with the rows preferably extending in a north and south direction.

All of the evergreens are much slower growing than are the deciduous trees, but give year round protection. If young trees 18 to 24 inches in height are set out, Scotch pine (Fig. 7, lower) will give considerable protection within four or five years after planting and should reach a height of 12 to 15 feet in 8 years. White pine (Fig. 7, upper), slower to start, will live longest of all evergreen varieties after becoming established. Alternating the two varieties at approximately a 5-foot spacing will give earlier protection by the Scotch pine, which can be trimmed or removed and sold for Christmas trees, when the trees become too close, to leave a row of white pine at 10-foot spacings.

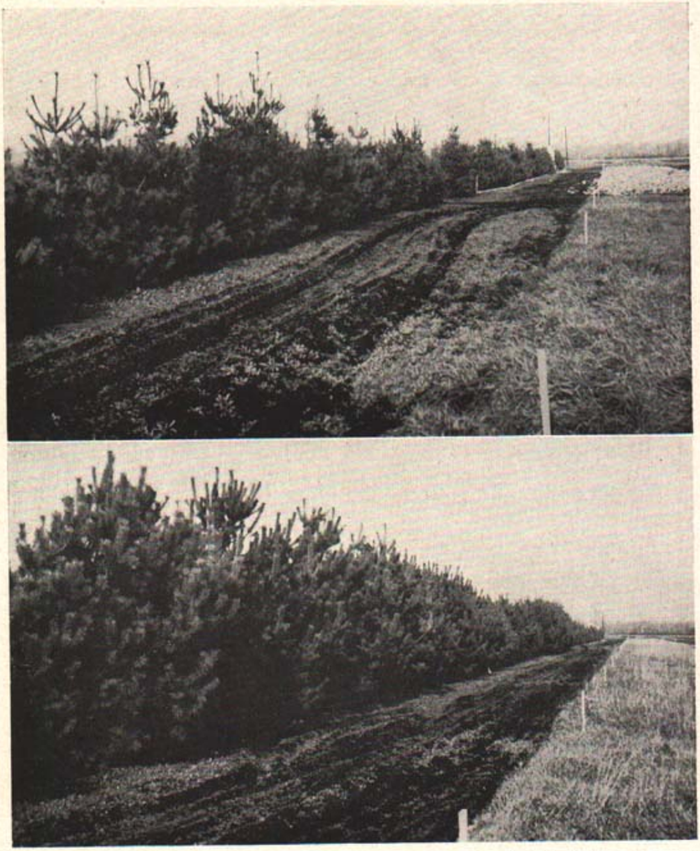

Fig. 7. In the upper picture, White Pine set out at the Muck Experimental Farm in 1942—from twice-transplanted plants 12 to 15 inches high—has reached 9 to 12 feet by the fall of 1950. The White Pine was browsed by deer to some extent in 1943 and 1944, but the Scotch Pine—shown in the lower picture—was not touched. The shorter lived Scotch Pine—a year older and 15 to 20 inches high at the time of transplanting in 1942—reached 12 to 15 feet in 1950. All pine were furnished by the Forestry Department at Michigan State College.

INTERPLANTED CROPS

Although barley has been used for several years as wind protection, either drilled in strips or interplanted between the rows of the cultivated crop, spring rye is now being used to some extent (Fig. 8). It is gradually displacing the barley. The rye has this advantage: it is not frozen down as easily as barley during early growth. Spring rye grows more erect than winter rye and is more easily cut off when its usefulness is ended.

Fig. 8. In this exposed field of onions, broad strips of fall-sown rye are combined with interplanted single rows of spring-sown grain. Where land is plentiful, the strips can be made one or two widths of the grain drill, and combined when they mature.

In most cultivated crops, the grain is interplanted with a drill between every three rows of such crops as onions and carrots; or between every two rows if the field seems likely to be badly windswept. In some fields strips of 8 to 30 drills of winter rye are fall-sown, carefully spaced so that from 24 to 40 rows of the vegetable crop can be sown between these strips in the spring. With the wider strips, the grain can be combined and the space used for driving on in the later spraying or dusting of the vegetable crop.

Where there is no tree windbreak protection, a combination of the interplanted grain and the fall-sown grain strips may be needed. For further information regarding the prevention of wind erosion, the reader is referred to Special Bulletin 314, "The Muck Soils of Michigan, Their Management and Uses," Michigan Agricultural Experiment Station.

WATER

Water is not likely to cause much surface erosion when the muck soil is new. However, sometimes considerable damage occurs from exceptionally heavy rainfall after the soil has become well decomposed, especially when the surrounding upland has considerable slope. Generally the damage results from an excess of water rushing into the muck area from surrounding hills. Sometimes a sheet of mineral soil may be carried in and deposited on the muck surface, occasionally to the point of decreasing the productivity of the muck.

Prevention of this situation can be obtained by constructing a diversion ditch of sufficient size to carry excess water around the muck area. In the construction of such a ditch, the excavated material usually is piled on the muck side of the ditch to form a dyke as an additional barrier against flooding.

If the muck happens to be one that is fairly shallow, sloping, and underlain with sand or gravel, there is also the possibility of gullying at times of excessive rainfall. Sometimes these gullies cut down into the underlying material. Construction of lateral ditches or tile lines at right angles to the slope—with dams spaced at intervals in the outlet ditch to give a uniform water-level in the muck—generally is the best solution. Sometimes additional permanent sodded waterways are necessary.

DISCUSSION

On new muck being put into crop production, any program of soil conservation should be consistent with the program of farm management which will give optimum yields without excessive expense.

On soils which have been badly depleted, special treatments will often be needed to put the muck into condition to produce satisfactory crop yields. This is especially true on deep mucks from which the surface soil has been removed by blowing. The original surface layer generally contains the greater part of the natural fertility—not only of phosphate and potash, but also of the newly recognized, but nevertheless important plant food nutrients, such as copper and manganese.

Where the injury has been due to burning off of the surface muck layer with the resultant production of an alkaline surface layer, frequently an application of sulphur or of manganese sulphate—and sometimes also of borax—is needed to produce satisfactory yields of many crops. On acid mucks a light application of copper sulphate may mean the difference between a complete failure and a good yield. For certain crops, such as beets and celery, an application of ordinary salt in addition to the regular fertilization is highly beneficial.

All mucks must, of course, be given an application of fertilizer high in potash content but containing some phosphate, if satisfactory yields are to be obtained. For further information regarding the fertilization of muck soil for the various crops, and the inclusion of the proper amounts of the needed minor elements, the reader is referred to see Table 3 in Michigan Extension Bulletin 159, "Fertilizer Recommendations."

In the foregoing presentation of the methods of conserving muck soil, the desirability of maintaining as high a water level, as the root systems of the crops being grown will permit, has been emphasized. In any system of water control, it is exceedingly important that the person in charge of the dams has a thorough knowledge of the water requirements of the crop whose moisture supply is being regulated. Growers who have been raising crops under somewhat

Fig. 9. These sugar beets were produced on a muck which had water control, but the control was improperly used. The control resulted in large increases in mint oil yields, but the levels were continued too high in the latter part of the season for the beets on adjoining fields. Note that the beets have good size, but the sprangling root development–resulting from the high water level–undoubtedly decreased the yield somewhat below what could have been obtained with a lower water level.

drouthy conditions previous to installation of water control are likely to be highly pleased with the improved yields with the higher and controlled water level. Under such conditions there is a tendency to swing from the one extreme to the other, with a water level too high for proper root development of some crops, and a nitrogen deficiency appearing in others.

This higher water level may build up in late summer and early fall, as cooler weather results in less evaporation from the soil surface, and less transpiration through the leaves of the growing crop. Unless close attention is given, this higher level may result in a considerable reduction in crop yields—below what might have been obtained. In the case of sugar beets and parsnips, a distorted sprangling root growth is also likely to develop. (Fig. 9.) A yellowing of the tops of most crops, with a reddening of mint foliage, is likely to indicate nitrogen deficiency (provided the crop has been properly fertilized earlier, including any needed minor elements).

Although the use of overhead irrigation has been found to give increased yields for certain crops on the drier muck fields, need for it is much less where a good system of water control has been established. Overhead irrigation is likely to give beneficial results when used on fields from which a heavy growth has been recently harvested—and a new crop is to be sown immediately—in order to get the dry surface sufficiently moist to insure good germination. It is likely to give transplanted crops, such as cabbage, celery and mint, a quicker start, with greater growth of all and an earlier distillation for the mint. Overhead irrigation also may be beneficial in preventing injury to susceptible crops from summer frosts.

With a system of water control, a possible injury from overhead irrigation should be considered in its added effect of reducing the available nitrogen supply. Heavy applications of water should be avoided, especially where the crop has been given a recent side-dressing of a nitrogen fertilizer. Heavy applications of water by overhead irrigation, coupled with heavy rainfall following within a day or so, may so leach the soil of the needed nitrogen and potash that crop yields will be considerably reduced.

It is not advisable for the grower to depend on the level of the water in the outlet ditch as a measure in determining whether the gates in the controlling dam should be raised or lowered. With the same level in the ditch, the water level in the fields may vary considerably, that variation depending on the recency of the last good rain and the distance from the outlet ditch. Because of this, a system of water control should include a set of measuring wells (Fig. 10).

A suitable measuring well can be made of two 4-inch and two 5-inch pine boards 4½ feet long, nailed together to form a tube. A collar 1 foot from the end should be put on the outside to keep that end from sinking too deep in the soil. The tube is then set in the muck to a depth of 3½ feet below the surface level, with 1 foot extending above the soil. A cap should be placed on the top to prevent wild life from entering.

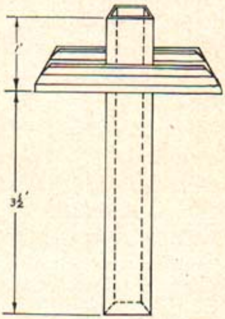

Fig. 10. Diagrammatic sketch of a "measuring well" for determination of the water level in a muck soil.

A convenient measuring stick can be made of a 2-inch strip of board, with depth in inches indicated from a zero starting at one foot from the end, to compensate for the foot of well extending above the ground. To take the water level readings, the stick is extended into the well until the zero end touches the water surface, as indicated by the ripples. The stick is then grasped at the top of the well and is withdrawn and a direct reading of the depth in inches made.

The well preferably should be painted inside and out with asphalt paint to prevent rotting while the outside top and measuring stick should be painted white. If located in cultivated fields, additional white posts placed around the well will tend to prevent its destruction. One of the large sections of a discarded mint condenser can also be readily converted into a measuring well, by cutting it the proper length and attaching a sheet iron collar. It is important that the well be installed exactly vertical so the ripples can be readily seen at the time of taking levels.

Measuring wells should be located at strategic points in the fields, so that readings of the water levels may be obtained in the lowest, highest and average spots in a field. Readings made every week or two, the frequency depending on the variation in level which may be expected, will serve as a guide in regulating the gates; while a record for the growing season may help in determining the water control program for the following year.

A practice of water control will prevent excessive decomposition of the soil, but it may also limit the amount of nitrogen made available to the crop by decomposition in a cool, wet season. In other words, whereas in the past, there may have been little or no need for the inclusion of nitrogen in the fertilizer mixture for a majority of crops—including grain, potatoes, corn and root crops—with water control a greater need for added nitrogen may develop.

Generally, this nitrogen deficiency is not so likely to be present at the time of planting the crop, but to appear later in growth when the nitrogen demands of the crop are much greater. Sidedressing or topdressing at that time is preferable to including the nitrogen in earlier fertilization. Thus in a summer of high rainfall, a crop of onions on muck soil with water control may develop a nitrogen deficiency in June; or a field of corn in July; or of sugar beets in August. In a drier season these nitrogen deficiencies might not develop, to become evident in a chlorotic color and scant top growth of the crop.

This system of water control would therefore likely increase cost of production per acre, but it generally would also increase total production—thus lowering cost of production per unit. The important matter to be considered is the greater depth of muck which would be left, following years of farming with water control, to be handed down to the muck farmers of future generations.

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