Soil Management Practices in the Orchard
Michigan State University Agricultural Experiment Station
Circular Bulletin
T.A. Merrill, Horticulture
Issued June 1946
30 pages

CIRCULAR BULLETIN 199 JUNE 1946

An ideal soil management practice in the young orchard, a cover of red clover and timothy with clean-tilled tree rows.

SOIL MANAGEMENT PRACTICES *in the* ORCHARD

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By T. A. MERRILL

Michigan fruit growers are becoming increasingly conscious of the limitations of clean cultivation and of the seriousness of soil erosion and water loss. They are becoming increasingly interested in soil management methods which will control soil erosion and water run-off and at the same time maintain the productive capacity of the orchard soil. The purpose of this bulletin is to present a number of such soil management methods, but leaving to the grower the adoption of the particular management program best suited to his requirements.

The effectiveness of any soil management practice should not be measured by immediate response alone, especially of yield, but rather by the performance of the trees over the entire time they occupy the land. Orchard soil management practices should be such that, when the trees are eventually removed, the soil will not have been impoverished as to make it unsuited for further orchard purposes. It should be possible by intelligent soil management practices to continue orcharding permanently on a given piece of land. The problem is to use the best management practices possible and thus insure that the present fruit areas will continue indefinitely as such.

SOILS FOR FRUIT GROWING AS THEY AFFECT MANAGEMENT PRACTICES

Over-emphasis cannot be placed upon the importance of the soil in the profitable production of fruit. It is the medium—"home," if you will—in which the tree must grow. Unproductiveness in orchards is due to lack of organic matter, available fertility, unsuitable moisture relations or a combination of these. When examining a soil as to its possible adaptability to fruit growing, the color should be carefully noted because it serves as an index of the drainage conditions. Poor subsurface drainage results in inadequate aeration which causes mottling in the subsoil. These mottled colors may vary from yellow and brown, brown and gray, or gray and yellow, or varying combinations of these colors. As a general rule, the depth of mottling corresponds rather closely to the depth of good subsurface drainage. If mottling occurs

near the surface, such soils are usually poorly drained and unsuitable for fruit growing.

Such soils are characterized by an impervious subsoil at comparatively shallow depths, usually not exceeding 3 or 4 feet. The soil above may be quite pervious, but the water is caught in hollows or pockets of the impervious layer, usually heavy blue or reddish clay, whence it cannot escape. The tree roots remain above the water-soaked layer, in which iron-impregnated hardpans and possibly toxic salts of aluminum, iron and manganese may accumulate. The thinner the layer of well-drained upper soil, the more precarious is the existence of the tree. Such poorly drained soils are more frequently found on broad plains, but are not infrequent on slopes of heavy soils. In the latter case, they may be difficult to locate since the depressions in the clay surface may have been filled with sandy or loamy soil and often seem to be the most productive spots in the field.

Trees set on soils of poor internal drainage frequently grow well for several years, and then show symptoms of distress during periods of drouth when the upper soil—all that is reached by the roots—becomes very dry. Shallow-rooted trees are characteristically short-lived.

Occasionally, it may be practicable to grow profitable orchards on land that has been artificially drained; but, more frequently, drainage proves impracticable owing to the fact that the clay ridges which catch the water are hidden beneath the surface of the soil. Moreover, draining the land adds to the cost of producing fruit and makes it difficult to compete profitably with fruit grown on naturally well-drained soils.

As well as being too wet, soils can likewise be too dry for orchard purposes. Those that are too dry are usually either deep sands or gravels with a relatively small percentage of silt or clay in their upper layers. Although tree roots may penetrate deeply and traverse considerable distances, the trees do not obtain sufficient moisture for their needs during drouths. Consequently, the trees of such orchards are small and produce few fruits; many of them die at an early age. Occasionally, similar results occur when a thick layer of gravel, or rarely of a cemented hardpan, prevents the penetration of the roots into an otherwise favorable subsoil.

Different kinds and varieties of fruit trees do best on different soil types. These adaptations are not completely understood at present, although some of the differences are known. Peaches and cherries are particularly subject to winter injury when grown on moist, productive loam soils, which cause a prolonged period of growth and delay the maturity of the wood. Peaches are particularly susceptible to winter injury on poorly drained soils, and cherries are only slightly more

resistant. Peaches, when fertilized, have done very well on sandy soils overlying the impervious clay at depths of 6 to 8 feet, on loamy sands in which silt layers are found in the upper 6 feet of soil, as well as on penetrable sandy loam soils overlaying sands and gravels. Sour cherries do well on the two latter kinds of soil mentioned. Apples are very sensitive to dry soils and are unsuccessful on the deep, dry sands unless the trees are widely spaced. They do fairly well on the sandy loam overlying sand or gravel, but make their most vigorous growth on sandy loam or loam soils overlying clays which contain enough sand and gravel to be permeable and easily penetrated by the roots. They are not successfully grown on the heaviest clays. Pears are successful on soils that are satisfactory for apples. They also do well on soils that are too heavy for apples. Plums and sweet cherries usually do best on a moist, medium loam soil.

There are differences in the soil adaptations of varieties as well as species of fruit, but these are not well known for the most part. However, it is generally agreed among fruit growers that Northern Spy, Jonathan, Delicious, Steele Red and Grimes succeed better on the heavier soils of Michigan than do some other varieties. Wealthy and McIntosh are better suited to the lighter soils. In general, within the limits of soil adapted to the particular kind of tree, those grown on the heavier types of soil have a longer growing season, wood growth is continued later in the summer, the fruit requires a longer time to mature and put on color, and the trees are more productive. On the lighter types of soil, fruit ripens earlier and attains a higher percentage of color. In all probability, these differences are closely related to the inherent productivity of the different soils, the heavier soils usually being more fertile. When the lighter soils are fertilized sufficiently, the trees behave very much as though they were growing on heavier soils unless the moisture supply is inadequate.

Peach trees should not be replanted on land from which a peach orchard has been removed until 3 years have elapsed, because of danger of black root aphis infestation.

SOIL MANAGEMENT IN THE YOUNG ORCHARD

Orchards can be planted following any crop, but it is easier to start in an established grass-legume sod. Orchards have been planted in Michigan on soils so badly depleted by cropping and erosion that it was no longer profitable to grow grain crops. It may be possible to improve the soil on such sites after the trees have been planted, but it is more practical to give the soil certain basic treatments before the trees are planted.

Fig. 1A. Montmorency cherry growing in chewings fescue sod. These trees were beginning their third year in the orchard when seeded to the permanent sod cover.

Fig. 1B. Same as 1A, but tree is mulched with straw. While the growth is satisfactory in either case, the foliage is a little more dense on this tree. Both trees received the same amount of nitrogen fertilizer.

After the site for the new orchard has been selected, plans for preparing the land for trees should be made. Some orchardists do this from two to several years before they intend to plant. Too often the price of fruit in the fall influences the decision to plant the new orchard the

Fig. 2A. Peach orchard planted on the contour. Second year in orchard showing narrow cultivated strip along tree row. (U.S.D.A. Photo)

Fig. 2B. Young peach orchard planted on the contour with cultivated middles and sodded strip in the tree row. Cultivated middles are seeded each year to some annual cover crop. (U.S.D.A. Photo)

following spring regardless of site preparation. This practice is all right for the grower who has land ready for planting, but it is not recommended that planting should be done for the sake of getting a new orchard started. It is more profitable in the long run to get the land ready before planting.

Marking the Tree Rows and Planting

When it is time to plant the orchard, back-furrow strips six to eight furrows wide in the sod at the proper intervals. Plant the trees on the ridges and cultivate until the trees are of bearing age, at least 5 years. The middles should be mowed to maintain the legume. If red clover, mow when the first blossoms appear and let the second growth produce seed. If sweet clover, mow after most of the seed has matured. The cuttings should not be raked unless they are to be used as mulching material under the trees.

Where it is necessary to start the new orchard in an idle or crop field, back furrow and plant the same as in a sod (Fig. 2). The middle should be fertilized and seeded as recommended for grass or grass-legume sods.

There are many advantages of seeding a sod cover at least one year before planting trees: (1) The whole area can be limed, if necessary, and fertilized without the disadvantage of driving around trees; (2) A heavy residue of quickly decomposable organic matter is produced to plow under before the trees are planted; (3) It is cheaper to prepare seedbed and seed an entire field than to seed only the middle after the trees are set; (4) The trees are provided with a vegetative protection against erosion from the time they are planted; and (5) The grass-legume sod improves soil structure and tilth of the soil.

Cultivation

The first year it is necessary to cultivate only 2 or 3 feet along the tree row (Figs. 2A and 2B). Each year as the roots of the trees extend, it is necessary to widen the cultivated area, at least one plow furrow on each side of the tree row. It may be more practical from the beginning to cultivate a wider area—2 to 8 feet depending on the size of equipment available—with a tractor.

When the trees are of bearing age, the tree roots will have extended several feet into the middles. The tree rows should then be seeded to a shallow-rooted grass. The middle will be managed by one of the methods described for bearing orchards (Figs. 3A and 3B).

If the trees are to be heavily mulched instead of the tree rows cultivated, it will be necessary to get mulching material from an outside source. Where the middles are producing a sod crop, such as red clover and timothy, the cuttings can be used for mulching the trees until the orchard is of bearing age. In dry years the cuttings may be of more value for mulching the middles than for mulching the trees. If the middle cuttings are used for tree mulch, the sod crop should be fertilized each year with from 250 to 400 pounds of 0-20-20 per acre to maintain high production of mulching material.

Fig. 3A. Showing an apple orchard in its fifth year. The alternate middle method of soil management has been practiced in this orchard since the second year. Red clover and timothy seeded in the alternate middles.

Fig. 3B. Same as Fig. 3A, after the clean-tilled middle has been seeded to red clover and timothy. The middle with the heavy clover-timothy cover will be tilled the following season.

Intercropping

When it is essential to have some income from an orchard during the early life of the trees, the middles are planted to some cash crop. Truck crops such as tomatoes, potatoes, cabbage, beans, melons and strawberries are suggested. Corn, small grain, grapes and brambles should never be used in any circumstances, as the competition for moisture is too great. The intercrop should be planted so it will not interfere with the cultivation or spraying of the trees. It should be fertilized heavily and cultivated. A winter-cover and green-manure crop should be used to protect the soil from erosion and to supply some organic matter. With strawberries use oats or spring barley for the cover crop.

Intercropping is not to be encouraged. It defeats the purpose of the sod cover system, which is to build up the organic matter and in-

crease the productivity of the soil. Using the middles to produce a crop to be removed depletes the soil even when heavily fertilized and followed by cover crops. Unless the income derived from intercropping is necessary, the middles in the young orchard should be used for growing a grass or grass-legume sod cover and not cultivated. The cuttings should be left on the ground after mowing or in some cases moved under the trees for mulch.

Contour Planting

Contour planting of fruit trees is recommended as a standard soil and water conservation practice for use on all erodible sites where cultivation is to be practiced to any significant degree as a part of the cultural system. The only exception would be where an uneven topography makes contour planting impractical. In that case other conservation methods, such as sod cover, mulching, alternate sod middles and other practices, should be substituted as much as possible.

Contour planting should be regarded only as a means to an end. It is not in itself a method of erosion control. In other words, if not used as a basis of other contour practices such as terracing, ridging, or simple contour cultivation, it is little more than a system of planting. The convenience of hauling spray material and fruit on the level instead of up and down hills justifies contour planting.

In contour planting it is to be expected that slope variation will occur which will result in a variable distance between the contour rows, and even the necessity for occasional "point" or "spur" rows. For this reason it is necessary to provide for a minimum distance between rows, which when doubled will give the distance at which an extra row will be inserted. Usually the minimum distance between rows will be determined by the kind of fruit and the necessary clearance for orchard machinery. With only one-way orchard operations, the spacing of trees within the rows can be as close as desired—just so the trees do not crowd each other—and still permit the proper number of trees per acre.

The practice of terracing goes hand in hand with the contour planting of orchards. The accumulation of run-off water on sloping land is sure to result in significant erosion losses unless properly retained or disposed of. Terracing is a logical, if not necessary, accompaniment to contour planting. It will vary from ordinary field terracing to the extent that the interterrace intervals, as well as the size and shape of the terraces, will conform to the planting distances (between rows) and the system of orchard layout.

Fig. 4. Showing what can happen in the young orchard when soil is not properly managed. As a result of erosion, this area at the present time, is no longer suitable for agricultural purposes. (U.S.D.A. Photo)

Terraces

The young orchard must be protected from erosion if the productivity of the soil is to be maintained (Fig. 4). Where this is done, old, mature trees can be replaced by replanting with young trees and the same land used for fruit production indefinitely. Terracing is the most effective mechanical erosion control practice for orchards. When combined with suitable soil management measures, soil and water losses are reduced to a minimum and the soils remain productive.

It requires skill and experience to lay out an adequate terrace system. Every field is a different problem. There are no set rules that can be applied to all conditions. Unless the orchardist is exceptionally experienced, it is best to secure the assistance of farm planners in soil conservation districts or surveyors where the services of farm planners cannot be obtained, in laying out terrace systems in orchards.

It is important that the terrace system be planned, laid out and constructed before the trees are planted in the new orchard.

If it is necessary to plant trees before the terraces are built, ample room should be left between tree rows to construct the terraces and provisions made for roads. A ridge should be plowed where the terrace ridge is to be and the trees set high on this ridge so that when the terrace ridge is graded, the trees will not be set too low.

Orchard terraces are essentially the same as for field crops except that the horizontal spacing is adjusted to conform as nearly as possible to recommended spacing of tree rows for the kind of fruit to be planted. Where this terrace spacing is closer than would be used in field terrace, the size of the terrace can be reduced proportionately.

One method of laying out a terrace system is to establish the desired horizontal interval on the steepest slope in the new orchard. This spacing will be influenced by such factors as degree of slope, irregularity of topography, soil type, length of terraces, kind of fruit, and location of outlets. It is usually best to arrange the terrace system so that each "through" tree row can be planted on the terrace ridge. As the degree of slopes lessens, the horizontal distance between terraces gets wider. Where the interval doubles the spacing used at the steepest point, a short or spur row is planted parallel to the terraces. Where the terraces or terraced rows converge in the direction of the flow of the water, the intervening or spur row should follow the upper terrace; and where the rows diverge, they should follow the lower terrace. Such an arrangement allows any water following along the tree rows to empty into a terrace channel instead of concentrating at the low places in the rows. As a safety factor the spur rows can be planted on the ridges made by back-furrowing when the tree rows are laid out. These ridges can be increased in height at each cultivation by working the soil to the tree rows.

Usually terraces are constructed on a grade that allows run-off water to flow in the channel without causing erosion. On soils that absorb water freely, level terraces (with open ends) can be constructed.

Where it is necessary to intercept a large volume of water from a large area above the orchard, diversions can be constructed (Fig. 5). These are simply large terraces built with a channel wide enough and of sufficient grade to carry the expected water from the drainage area. Usually the back slope of the terrace ridge is too steep to cultivate and should be protected by a sod cover. Where slopes are very steep in the orchard it may be necessary to approach this type of terrace construction.

Terrace Outlets

Terrace outlets should be built and seeded at least a year before the terraces are built and before they are to carry any water. The outlet is important because of the cost of construction, efficiency of operation, and convenience of orchard management. Usually it is cheapest to use a natural drainageway for the terrace outlet. It should be graded to sufficient capacity, fertilized and seeded. (See recommendations for seeding grassed waterways, page 13). It may be necessary to con-

Fig. 5. Showing the construction of a diversion terrace in an established orchard. In some cases it is necessary to remove an occasional tree in order to properly construct such a terrace.

struct the outlet at the edge of the orchard. This is more expensive than to use a natural drainageway, and it interferes with orchard operations.

Where it is necessary to cross the terrace outlet with tillage implements, they should be thrown out of the ground. The terraced outlet should never be used as a road for hauling fruit or for spray equipment.

Grassed Waterways

In any orchard regardless of the method of planting but particularly in contour planted orchards grassed waterways are necessary to remove run-off water without causing erosion. Usually these should be put in the natural drainageways. It is more expensive to locate them any other place.

Where the new orchard site is seeded to sod before the trees are set, the natural drainageways should be shaped so as to carry water. Small gullies can be filled with plow or disk. Larger ones may be filled with grader or scraper. All litter (brush, tree stumps, dead grass, stone) should be removed before any filling is done. Be sure that the waterway is wide enough to carry the water and flat enough so that it can be crossed with orchard machinery. Any fills should be thoroughly packed and the seedbed well prepared. Fertilize and seed as recom-

mended for sod cover crop. When the tree rows are plowed, the plow should be thrown out of the ground while crossing the waterway. Trees should not be set in the waterway. When the trees reach bearing age and the sod cover crop in the middle is plowed, the waterways are left unplowed. Gradually grass will take the waterway, especially if nitrogen fertilizer is used.

When the waterway is prepared as a separate operation, lime as needed, fertilize with 250 to 400 pounds per acre of 0-20-20 and 100 to 150 pounds per acre of ammonium sulfate or its equivalent in nitrogen fertilizer and seed with 16 pounds per acre of Kentucky bluegrass or 8 pounds of Kentucky bluegrass and 8 pounds of Canada bluegrass, or 10 to 12 pounds per acre of chewings fescue. This seeding should be made shallow (on top of the ground) on a firm seedbed between August 15 and September 1, and cultipacked. A top dressing of manure or a light application of straw mulch rolled in with a dull disk set straight or a cultipacker will give the seeding some protection until established.

Roads in the Orchard

Roads for spray equipment, for wagons hauling fruit, and for other orchard machinery should be provided for in the young orchard. With some fruits planted rather closely, 6 to 8 feet of extra space may be needed between certain rows which are to be used for permanent roadways. These roads should be located in the driest part of the orchard, along a natural ridge top, or just below a terrace ridge. They should be close enough together so that containers of picked fruit can be taken to them conveniently for removal from the orchard. Waterways, terrace outlets or terrace channels should never be used for roads.

Erosion in roads on the contour is less than where roads are located up and down slopes. Where they cannot be placed on the contour, some mechanical means should be provided to prevent water from running in them. In addition to keeping roads graded high and round, water diverters, and "thank-you-mams," can be used. Culverts should be provided to carry water under roads rather than allowing it to flow over them to the grassed waterways.

Border Strips

Border strips of sod (25 to 30 feet wide) at the ends of the tree rows can be used for turning machinery. Tillage machinery should be disengaged from the tillage operation while turning, so as not to destroy the vegetation in the border strip. Recommendations for grassed waterways can be used for seeding border strips. They should receive nitrogen fertilizer to maintain a dense sod. In orchards receiving much cultivation, the border strips get very heavy traffic. Care should be taken to prevent soil washing and gullies forming.

SOIL MANAGEMENT IN THE BEARING ORCHARD

As the orchard attains bearing age the soil management practices must change from those used in the young orchards. There are five common methods of soil management in bearing orchards: (1) sod cover, (2) mulching, (3) alternate middles, (4) cover crop, and (5) clean cultivation (the least desirable of any).

Sod Cover Method

Where the sod cover method is to be used, it is important to establish a dense sod of shallow-rooted vegetation: bluegrass and chewings fescue are the best adapted for this purpose. The following steps are suggested for establishing grass:

1. Use a disk to prepare a seedbed and to destroy any growing vegetation and a cultipacker to make a firm seedbed. Fill all gullies before preparing seedbed.

2. Seed before fall rains, from August 15 to September 1, or in the early spring soon after the surface soil thaws, but not later than May 1. The late summer seeding is preferable.

3. Use hand seeder or seeder attachment on grain drill set as shallow as possible (less than one inch) with hoses pulled out of the seeding spouts to distribute the seed. Cultipack to cover and to firm the seed into the soil. It is best to sow the seed on top of the ground. Tillage operations should be on the contour or as nearly across the slope as possible.

4. Use 15 pounds of Kentucky bluegrass, or 8 pounds of Kentucky bluegrass and 8 pounds of Canada bluegrass, or 10 to 12 pounds of chewings fescue per acre of area covered.

5. Use 100 to 150 pounds of sulfate of ammonia or its equivalent in other nitrogen fertilizer (not to be confused with fertilizer for trees.) Mulch lightly (two straws thick) on eroded areas. Make annual application of nitrogen fertilizer where denser sod is desired.

A sod cover of perennial grass is the most effective vegetative control for erosion in orchards. Where the erosion hazard is great, sod cover and terraces will give complete erosion control. Bluegrass, with its thick top growth and bulky root system, makes a dense sod on soils of high organic matter. It starts early and makes all of its growth while there is plenty of moisture. When the weather gets dry and hot, the grass becomes dormant, leaving a mat of top growth which reduces evaporation of moisture from the soil and insulates the soil against high temperatures. Chewings fescue also has the same quali-

ties but is better adapted to soils of low organic matter content than bluegrass.

Bluegrass sod should be mowed at least once each year, but it is not necessary to mow fescue after the first year. Unless hay production is very heavy, it should be allowed to lie without raking. Where cutting is heavy and the material is needed, it can be used for mulching under the trees. In this case the middles should be fertilized as recommended for starting grass in the bearing orchard (page 15).

Observations and experimental data show that any of the fruits can be grown successfully in a sod cover by applying enough nitrogenous fertilizer for the grass and trees. Orchardists generally agree that apples and pears can be grown in a sod cover, but all do not agree that peaches, cherries and plums can be. However, many successful growers are doing it. The only extra precaution is that more nitrogen fertilizer is applied to the tree. By watching the trees for symptoms that indicate a shortage of nitrogen, experienced growers can determine when to make additional applications.

As a rule, in orchards with grass-legume middles, it is necessary only to seed grass in the tree rows after the trees are of bearing age and row cultivation stops. The grass will eventually predominate in the middles if enough nitrogen fertilizer has been applied to make them productive. A little grass seeded in the middles—if the stand of grass is thin—when the tree rows are being seeded and the application of nitrogen fertilizer will hasten the establishment of a dense sod.

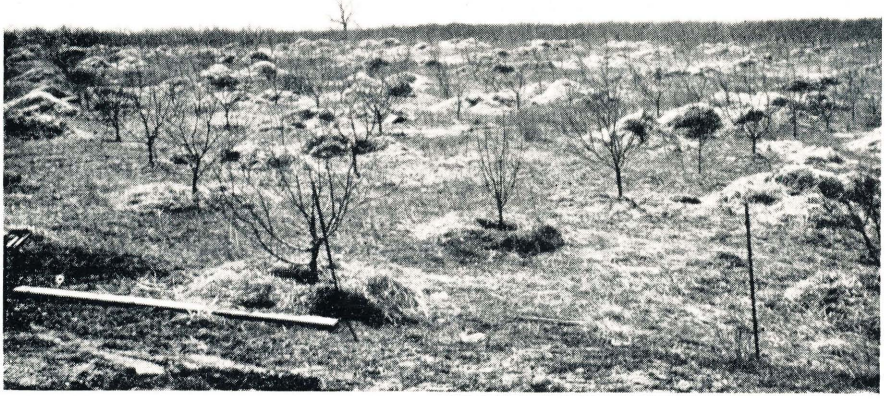

Fig. 6. Mulching in an interplanted peach and apple orchard growing in permanent sod cover. As can be noticed by peach tree in left foreground, the trees are thrifty and vigorous. (U.S.D.A. Photo)

Mulching

Mulching is a desirable orchard practice. Straw or other plant material is applied in quantities that will just cover the soil up to quantities that will smother all weed growth (Fig. 6). It is used for several reasons.

1. Controls erosion. Several tests and demonstrations have definitely proved that practically no erosion takes place where complete mulching is practiced. The degree of erosion control depends on the amount of mulch used and the extent of area covered.

2. Promotes biological activities in the soil as a result of increased aeration. However, when highly carbonaceous materials are used, it is necessary to apply larger quantities of nitrogen.

3. Improves soil structure and tilth.

4. Prevents compacting on the surface of the soil, allowing more rapid penetration of water.

5. Keeps the soil from getting so hot in summer and so cold in winter.

6. Increases available potash. This has been reported by research workers.*

7. Conserves moisture. Not only is evaporation of soil moisture reduced, but because of the improved tilth of the soil under mulch more water enters the soil that would otherwise run off. This, however, is not true if peat is used as a mulch as it actually prevents more moisture from entering the soil when it becomes thoroughly dry.

8. Encourages feeding roots of trees to come to the surface of the soil under mulch. This is because of moisture, soil tilth, temperature of the soil and available plant nutrients. Soils that are not protected or cultivated have very few roots at the surface of the soil.

9. Reduces loss of fruit that drops at picking time. With certain varieties of apples such as McIntosh, Wealthy, and also plums, this is an important factor, especially to growers who have roadside markets.

10. Increases yields. Improvement of soil structure under mulch, increases of soil moisture and available plant food, lower summer temperatures of the soil increase bud formation, leaf production and size of trees, all of which contribute to higher yields.

Six different systems of soil management in orchards involving the practice of mulching are:

1. The trees mulched to the periphery (spread) of the branches with the middles and tree rows left in sod. See figure 6.

*Increasing available potassium to greater depths in an orchard soil by adding potash fertilizer on a mulch. S. W. Wonder and J. H. Gourley, Proceedings of the Am. Soc. for Hort. Sci., *46* (1945): 21-24.

2. The trees mulched with the middles and tree rows clean tilled and winter cover crops grown.

3. The tree row mulched with middle clean tilled and winter cover crops grown.

4. Trees or trees and tree rows mulched with alternate middles in sod cover.

5. Areas subject to severe erosion mulched.

6. Entire orchard (trees, tree rows, and middles) mulched.

Some growers apply mulch heavily shortly after trees are planted instead of cultivating the tree rows. At this time relatively little mulching material is required. As the trees grow and the mulch decomposes more material is applied. Most growers cultivate the tree rows in the young orchard and delay mulching until trees are ready to bear.

The amount of mulch required varies from 2 to 10 tons per acre, depending on the depth and the extent of area covered. When first applied, it should be about 6 inches deep and extend under the spread of the branches. The area immediately surrounding the tree trunk should be left bare as a protection against mice.

In areas where plant material for mulching is difficult to obtain cropland can be seeded to a grass for this purpose. Sudan grass is easy to grow and will produce a large tonnage. Sorghum sown thickly with a grain drill will also produce a large amount of mulch. Where there are areas of wet land, reed canary grass can be used. Ordinary slough grass found on low, poorly-drained land has been used successfully. Any of these crops can be cut late, even after killing frost, and hauled directly to the orchard or bailed and stored until needed.

STRAW REQUIRED FOR MULCHING TREES[1]

Spacing	Number of trees per acre	Tree spread	Area covered	Pounds of straw per acre
40 x 40	27	25	13,230	2,215
40 x 40	27	30	19,098	9,545
40 x 40 [2]	52	25	25,480	12,240
40 x 40 [2]	52	30	36,764	18,382
20 x 20	108	15	12,116	6,058

(1) Using 1 pound of straw for each 2 square feet.
(2) Interplanted in centers of squares (quincunx).

Where mulch is used, a little higher rate of nitrogen fertilizer usually is required, especially the first year. This is not necessary where legume hay is used for mulch.

The danger of fire is always greater in orchards that have been mulched.

Fig. 7A. Sweet cherry orchard growing under alternate middle method of soil management. Cover—red clover and timothy. (U.S.D.A. Photo)

Fig. 7B. Same as Fig. 7A, looking across the rows.

Alternate Middle Method

The alternate middle method of managing soils in orchards has fast grown in favor with orchardists (Figs. 7A and B). It represents a step between clean-tilled orchards and sod cover in orchards. It consists of planting a grass-legume cover in alternate middles while the other set of alternate middles is clean-tilled. Seed 10 pounds of red clover and either 5 pounds of timothy or 10 pounds of domestic rye-grass between August 15 and September 1 in alternate middles. A firm seedbed should be prepared, from 250 to 400 pounds of 0-20-20 applied, the mixture seeded shallow, and the land cultipacked. In peach orchards if a heavy peach crop prevents the use of machinery, sow the seed mixture on top of the ground and do not cultipack. The two important things are to seed at the proper time and not too deep.

The sod cover crop occupies one set of alternate middles from the summer (August 15 to September 1) it is seeded until the spring of the second year. It is necessary to mow the first year in order to control the growth of the sod crop, especially during the fruit swell period. Leave the hay on the ground where it was cut. Mowing will reduce the competition between the sod crop and the trees for moisture. Leaving the hay will reduce evaporation from the soil.

During this time (the first year of the sod cover in alternate middles) the other set of alternate middles is cultivated. Between August 15 and September 1, this set of alternate middles is seeded to the grass-legume mixture as described above for alternate middles. From this time until the next spring all middles are growing a sod cover, the first set of alternate middles has a sod cover a year old and the other set has just been seeded.

In the spring of the second year the sod cover in the middles first seeded is clean-tilled, while the sod cover in the other set of middles (seeded the August before) is mowed to control growth. It is not necessary to kill entirely the sod in the middles by the first cultivation. The middles may be disked lightly early in the spring, allowing some of the old sod cover to make some growth. The disking is repeated at rather regular intervals, leaving some of the residue on the surface as a mulch. The cultivation (disking) is continued in this set of middles as in any clean-tilled orchard (Fig. 8). All the old sod must be destroyed before there is any danger of competition for moisture.

During this time the other set of middles is growing a grass-legume sod cover.

In some cases the alternate sod cover middles are allowed to stand an undetermined number of years (2 to 5). During this time the other alternate middles are cultivated. This modification of the alternate middle method requires the seeding and care of an annual cover crop

Fig. 8. Alternate middles with sod strip at the end of the rows.

on the clean-tilled middles each year. Most growers favor seeding a grass-legume sod cover in one set of alternate middles rather than sowing the sod cover one year and a cover crop the next. There is little difference in labor or cost between the two methods. The sod cover gives more protection against soil and water losses and it produces more organic matter than the annual cover crop.

Cover Crop Method

The cover crop method is used in orchards to supply organic matter and nitrogen, to protect the soil from erosion and leaching, to hold snow, and to check the growth of new wood before winter. Several field crops can be used as cover crops.

Deep-rooted grasses and legumes compete with the trees for moisture and should be avoided on soil where moisture is a limiting factor. Sweet clover, though a deep-rooted legume, can be used to advantage as a "catch crop" in young orchards when kept at a safe distance from the trees. Grasses and legumes should be grown together to make a quickly decomposable green manure and to provide a more effective protection from erosion.

Domestic rye grass seeded at the rate of 10 to 15 pounds per acre makes a good cover crop for orchards in Michigan, but should not be seeded before August 15 (Figs. 9A and B). It is quick-growing, has a dense root system and should be included in seeding mixtures. Sudan grass makes a quick growth and may be planted almost any time during the growing season but kills with the first severe frost, produces very little tonnage unless sown early, and has a comparatively light root system. The small grains, rye and oats particularly, are used but they, too, have sparse root systems and the other limitations of Sudan grass

Fig. 9A. Domestic rye grass as a cover crop in bearing peach orchard. (U.S.D.A. Photo)

Fig. 9B. Close-up of domestic rye grass showing density of cover. This grass makes a very good annual cover but should not be seeded before August 15.

which must be considered. Select crops that can make a desirable growth when protection is needed most and sow at the proper depth and at an appropriate time. For example, if winter cover is desired, sow an annual crop such as rye grass or rye or Sudan grass at a time when it can be established. Don't sow Sudan grass in September or winter rye in June (Tables 1 and 2).

TABLE 1—*Seeding recommendations for cover crops in orchards*

Crop	Rate	Time	Depth	Remarks
Domestic Ryegrass	10-15 pounds	Aug. 15-Aug. 30	½ inch	For all orchards.
Soybeans	1½ bushels	Up to June 1	1-2 inch	Little production when planted late. Substitute some other cover crop if it must be sown after June 1.
Sudan grass	15-25 pounds	Up to June 1	½-1 inch	Little production when planted late. Substitute some other cover crop if it must be sown after June 1.
Rye	1 bushel	Aug. 15-Sept. 15	1-2 inch	Seed sometimes hard to locate.
Buckwheat	¾-1½ bushels	June 15-July 5	1-2 inch	Usable when wet conditions prevail in early spring which prevent regular cover crop practice.
Barley, Spring	½ bushel	Aug. 15-Sept. 15	1-2 inch	Summer annual—will not live over winter.
Wheat	1-1½ bushels	Aug. 15-Sept. 15	1-2 inch	Seed generally available.
Vetch	15-20 pounds	Aug. 15-Sept. 15	1-2 inch	Generally works better if sown with rye or wheat.
Oats	2 bushels	Aug. 15-Sept. 15	1-2 inch	Summer annual—will not live over winter.
Spelt	1½-3 bushels	Aug. 15-Sept. 15	1-2 inch	Can be used where seed is locally available.
Millet	10-15 pounds	June 1-Aug. 1	½-1 inch	Competes seriously with trees for moisture when planted at these dates.
Soybeans Sudan grass	½ bushel 15 pounds	By June 1	1½ inch	Little production can be expected when planted late.
Rye Vetch	1 bushel 15 pounds	Aug. 15-Sept. 15	2 inches	Perhaps the mostly widely used of the annual covers.

TABLE 2—*Seeding recommendations for sod crops in orchards*

Crop	Rate	Time	Depth	Remarks
Kentucky Bluegrass	10-15 pounds	Aug. 15-Sept. 1	On top of ground and cultipacked	For sod crop in orchards.
Kentucky Bluegrass, Canada Bluegrass	8 pounds	Aug. 15-Sept. 1	On top of ground and cultipacked	For sod crop in orchards.
Sweet Clover Orchard grass	10 pounds 5 pounds	Aug. 1	On top of ground and cultipacked	For soil improvement crop in young orchard until bearing age. Mow after sweet clover has seeded. Let cuttings lie or in some cases use cuttings for mulching trees. May be used in alternate-middles or buffer strip method of sod cover in bearing orchards.
Red Clover Timothy	10 pounds 5 pounds	Spring before March 1 Aug. 15-Sept. 1	On top of ground and cultipacked	For soil improvement crop in young orchards until bearing age. Mow when clover shows first bloom and let second crop reseed area. Let cuttings lie or use for mulching trees. Also recommended for alternate-middle or buffer strip method of sod cover in bearing orchards.
Red Clover, Timothy or Chewings Fescue	10 pounds 5 pounds or 10 pounds	Aug. 15-Sept. 1, or Spring	On top of ground and cultipacked	Same as for red clover-timothy.
Chewings Fescue	10-15 pounds	Aug. 15-Sept. 1	On top of ground and cultipacked	For sod crop in orchards, particularly on soils of low organic matter.
Brome, Domestic Rye grass	15 pounds	Aug. 15-Sept. 1	½″ – 1″	For grassed waterways only.

The cover crop system has no place in the management of young orchards. Even in bearing orchards, many growers favor the sod cover or alternate middle method because of the expense of planting a cover crop (cost of seed and seedbed preparation), the amount of protection it gives, and the amount of organic matter produced. One of the reasons for its failure is due to late planting, improper seedbed preparation, and depth of planting. Growers are usually rushed with other work when it is time to plant the cover crop so they rush it in at the first opportune time.

Clean Cultivation

Clean cultivation which does not include systematic maintenance of organic matter is just as much a system of neglect in the orchard as a sod cover that is not properly managed, or lack of spraying or pruning. Many growers, especially of peaches and cherries, continue to clean cultivate without providing some method of replenishing the organic matter supply in the soil.

Organic matter decay is essentially a burning process, carried out by the soil organisms, and like any burning process, the greater the supply of air, the more rapid will be the burning and the more quickly will the organic matter disappear. This explains why cultivation tends to increase the rate of organic matter decomposition in the top soil and emphasizes the importance of a minimum of cultivation, especially on the lighter soils where peaches and cherries are generally grown.

Clean cultivation, in addition to speeding up the processes by which organic matter is lost from the soil, also increases the soil losses from erosion by several times. This system of soil management, when necessary, should in all cases—no exceptions—be followed by a cover crop in order to help maintain the organic matter content of the soil and to lessen the danger from erosion during the fall, winter, and the early part of the spring. During the cultivation period the cover crop should not be thoroughly incorporated into the soil. A more satisfactory method is to cultivate just enough to knock down the growth and have it as a trashy mulch on the surface (Fig. 10). This system is being practiced very successfully by many fruit growers.

Combination of Methods

While the five methods (sod cover, mulching, alternate middles, cover crop, and clean cultivation) have been discussed separately, combinations of them are used by orchardists. For example, mulching under the trees can be used successfully with any of the other four methods. As already described (pages 20 to 25) the alternate middle and cover crop methods can be used together. The cover crop method

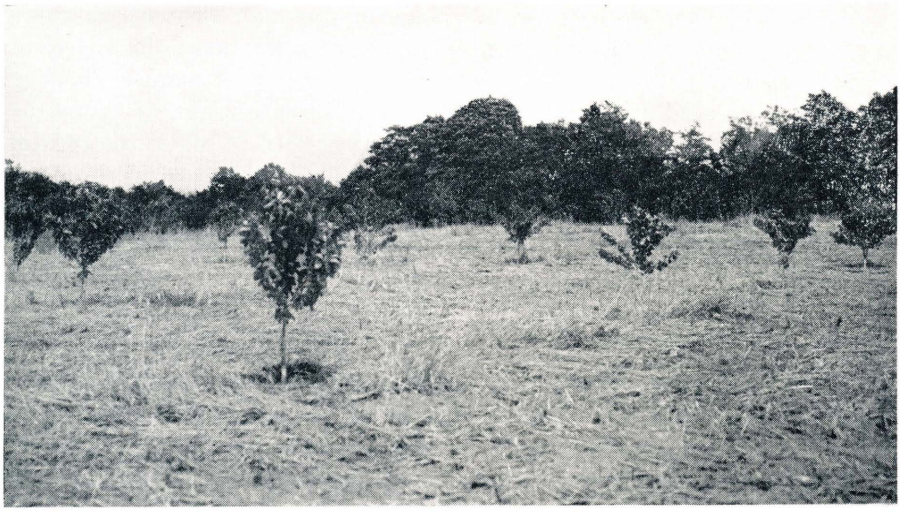

Fig. 10. Young sour cherry orchard in which over-winter cover of rye and vetch has been "mopped-down" using trashy system of cultivation. This is a very satisfactory method controlling erosion in the clean cultivated orchard.

and the clean cultivation method are used together so generally that the two are often considered as one method. Clean cultivation, cover crops, and mulching can all be used together. Thus, some combinations of these five methods may not only be more practical but provide a more efficient soil management in orchards than any one method alone.

Erosion Control

If the bearing orchard has not been planted on the contour little can be done in the way of mechanical practices to control erosion. If the trees have been spaced wide apart, it may be possible to terrace the orchard although usually too many trees are lost to make it practical. In some cases some of the cultivation can be done across the slope which is of some benefit. Roads can be relocated if they are the cause of soil losses and of gullies. The ends of the orchard where tillage machinery is turned gradually work low in places, causing water to concentrate and run, which eventually leads to the development of gullies. Diversions can be built to take water out of these channels and force it back to natural drainage-ways.

The most effective erosion control practices for the bearing orchard not set on the contour are vegetative. In some cases the orchard can be fertilized and seeded to a sod cover of bluegrass or chewings fescue as already described (page 15, Figs. 11A and B). Where this is not prac-

Fig. 11A. Montmorency cherry tree after eight years chewings fescue sod. Growth and production have been very satisfactory. Compare with Fig. 11B.

Fig. 11B. Montmorency cherry tree in clean cultivated orchard. This tree is growing near tree in Fig. 11A. Neither growth or production has been as good as that for tree in Fig. 11A.

Figs. 12A, B, C. Showing various stages of erosion in the orchard. If early steps are not taken to correct this condition, the soil and site will eventually be lost for orchard purposes. (U.S.D.A. Photo)

tical, all waterways should be shaped and seeded (page 13). In areas where there is serious erosion, mulching the entire area is effective. Where water follows the tree rows, mulching may help, but if the soil in the orchard is to be saved, it likely will have to be seeded to a sod cover.

On sites that are especially adapted to fruit production if erosion is severe and difficult to control, it may be advisable to destroy the bearing orchard in order to save the soil or the site (Figs. 12A, B, C). Where some of the original topsoil remains, plans can be made for a new orchard that includes all the measures and practices required to control erosion. Soil management practices to improve the productivity of the soil can be started. In this manner the site can be saved and in a few years a new producing orchard will be obtained that can be kept in profitable production indefinitely.

Fertilizer Practices

Supplying plant nutrients to fruit trees in the form of commercial fertilizers, whether in organic or inorganic form, introduces a subject on which there is some difference of opinion among fruit growers. However, there is much experimental evidence and practical experience available, and in many sections the results of the application of fertilizer can be predicted with considerable certainty. Obviously, the amount of fertilizer that trees require depends basically on the inherent fertility of the soil together with the activity or nonactivity of soil organisms and the associated factors of soil temperature, aeration, and moisture-supplying power.

While fruit trees absorb from the soil a number of elements, several of which are essential for the maintenance of growth and fruitfulness of the trees, nitrogen is the element most widely used in most orchard sections of the northern United States. Mineral elements such as potash, boron, magnesium, calcium, sulfur, phosphorus, and others, are essential to all plant growth and need to be added in sufficient quantities to correct deficiencies. However, fertilizer need not be added to soils that supply sufficient quantities of mineral nutrients for the trees.

It must be recognized in dealing with fruit trees that the problem of fertilizing is essentially different from that presented in dealing with field crop plants. This is particularly true because of the fact that fruit trees occupy the land for long periods of time, a quarter to a half century or longer. The root system, under favorable conditions, is very extensive and is found in the subsoil as well as the surface soil, the depth depending on the kind of tree and the character of the soil.

The question often arises as to the importance of chemical tests of the soil as a guide to fertilizer practices. While such information is

helpful it rarely follows that such tests provide a reliable guide. The major difficulty comes in securing a sample that adequately represents the huge volume of soil exploited by the root system. Fruit growers frequently want information regarding the fertility of their soil and have been hopeful that the "quick tests" that have been devised for the different elements would provide the answers. However, there seems to be no reliable substitute for field trials and the interpretation of the appearance and behavior of the trees.

No generalization can be made regarding the fertilization of orchards. As pointed out previously, the inherent fertility of the soil, and the cultural practices and methods used determine the need for additional nutrients. Also, if insects and diseases are abundant, or the soil is poorly drained, it makes little difference what kind of fertilizers are used, since a positive response from them is unlikely. It then becomes a question of what limiting factors exist under a given condition. Even though soil conditions are favorable, nitrogen and moisture are more likely to be limiting in orchards than other factors. The need for fertilizers or manures may be judged by the orchardist from the color and size of the leaves, the length and diameter of shoots, and yield of fruit.

ACKNOWLEDGMENTS

The author expresses his sincere appreciation to individuals of the U. S. Soil Conservation Service, particularly Dr. H. H. Gardner, W. R. O'Brien, Lee Rosecrans; and to Dr. C. E. Millar, of the Soil Science Department, Dr. C. M. Harrison, of the Farm Crops Department of Michigan State College for their helpful suggestions and assistance in the preparation of the information in this bulletin. Also, to members of the Horticulture Department for their many helpful suggestions and criticisms.