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Tillage, Fertilizers and Shade Crops for Orchards.

BY

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RED CLOVER AS A SHADE CROP.

Tillage, Fertilizers and Shade Crops for Orchards.

WENDELL PADDOCK.

Clean cultivation has been practiced by the majority of our orchardists from the time the first trees were planted. It would be difficult to explain just why this plan has been followed but it is probable that it was brought to us from California. While a certain amount of cultivation is necessary we wish to state emphatically that we do not believe in any system by which the soil is exposed to the action of Colorado sunshine during the heat of the summer. In fact, we believe that this practice has been very much over done and the older orchards are in some cases beginning to show the effects. We may well profit by the experience of fruit growers in other states and in this connection the following quotation should be instructive:

"For a quarter of a century great areas of vineyards yielded thousands of tons of grapes. All these years, under the stimulus of success, these same areas of land received clean, annual and (may we not truthfully add) **merciless** cultivation. The natural fertillity of the soil was gradually reduced by enormous crops of fruit and its physical condition lowered year by year, without the restoration of any considerable amount of plant food or vegetable matter. After the lapse of many years, from various troubles and diseases, the vigor and fruitfulness of the vineyards waned and the industry began to languish. Hundreds of acres of vines were pulled out and the land immediately and without improvement set to peach trees which, for another long term of years, and under the usual relentless culture without the addition of humus in any form, thrived and produced numerous, heavy crops of fruit. Again, as the remaining store of fertility became further depleted by the searching root systems of adult peach trees, enemies began to appear and make their presence felt. San Jose scale and leaf curl fell upon the Island as a scourge and came near writing the final chapter in the history of successful peach culture there. With the destruction of great areas of orchards by the scale and the injury of thousands upon thousands of trees, upon which the scale was not quite successfully combated, it is only natural that great discouragement and depression should overtake the orchardists, so long accustomed to bountiful rewards for labor performed under such favorable conditions."

Has not Prof. Green* truthfully portrayed what we have a right to expect will happen to Colorado fruit growers if our system of orchard management is not changed? No sane man should hope to continue to take large crops of first class fruit from an orchard for very many years without doing something to restore the lost fertility. True we do not expect to have the San Jose scale or the peach leaf curl to contend with, but both are possibilities. We have however been faithful in giving clean cultivation and when one comes to think of it,

*Green, W. J. and Ballou, F. H., Ohio Expt. Sta. Bul. 157, p. 118.

do not the expressions, "merciless cultivation" and "relentless culture" aptly describe this system?

Prof. Bailey** has summarized the benefits of tillage as follows:

1. Tillage improves the physical condition of the land.
   (a) By fining the soil, and thereby presenting greater feeding surface to the roots;
   (b) By increasing the depth of the soil, and thereby giving a greater foraging and roothold area to the plant;
   (c) By warming and drying the soil in spring;
   (d) By reducing the extremes of tempreature and moisture.
2. Tillage may save moisture,
   (e) By increasing the water-holding capacity of the soil;
   (f) By checking evaporation.
3. Tillage may augment chemical activities,
   (g) By aiding in setting free plant-food;
   (h) By promoting nitrification;
   (i) By hastening the decomposition of organic matter;
   (j) By extending these agencies (g, h, i) to greater depths of the soil.

A composite of the practices of a number of the most successful fruit growers results as follows: Use the turning plow in the spring, each year or often enough to prevent the ground from becoming hard. Follow the plow with a harrow or disc, if lumpy, and this with the smoothing harrow. Some use a float instead of the harrow. The subsequent cultivation consists in going over the ground often enough to prevent a crust from forming and to keep the weeds down. This necessitates cultivation after each irrigation and after rains. The Planet Jr. cultivator and the smoothing harrow are used for this purpose. Cultivation is continued until the branches are bent down by the fruit which will average about the first of August.

Winter cultivation is practiced when the condition of the ground will permit. Two cultivations during the winter is considered to be about right. The Planet Jr. or a disc harrow is used for this purpose.

Turning now to the classification of the benefits of tillage it would seem at first thought that the system followed by our best orchardists met all requirements. We find first that tillage improves the physical condition of the land. By the physical condition is meant its tilth and general make up, whether it is compact and heavy or whether it is loose and loamy. But any one who has traveled about among the orchards knows that in the majority of cases the soil is far from being loose and loamy. On the contrary, it soon becomes compact, lacks fibre and it becomes puddled after irrigation or rains. We have even seen orchard soils so hard two inches below the surface that an opening could be made into it only with the aid of a pick. And yet thorough cultivation had been given the land for years. Evidently something is wrong, so we follow on down the classification and find under i, that tillage may hasten the decomposition of organic matter. Here we believe is the cause of our difficulties. Cultivation, bare soils and intense sunshine do hasten decomposition

**Bailey, L. H. The Principles of Fruit Growing p. 139.

and in fact the burning up of such material. The classification is correct but we have failed to adapt our system of cultivation to the climatic condition.

We are absolutely dependent upon decaying organic matter to keep the soil in proper physical condition; that is loamy and friable. But upon examination we find that this material is largely absent, having been literally sacrificed as a burnt offering to the gods of clean cultivation.

A certain amount of cultivation is necessary but one need not wear out his soil in an effort to supply it. As will be seen in the following pages, we advocate growing a shade crop in the orchard during hot weather. If this system is adopted, the land should be plowed at least every second season, depending upon the soil. By so doing a sufficient amount of cultivation will be given the land and at the same time organic matter will be supplied.

In the case of young orchards, unless the ground is very poor, some hoed crop will probably be advisable. Such crops shade the soil and their growth need not interfere with the proper development of the trees. Among the crops used are cantaloupes, potatoes, squashes and corn.

We often hear it said that Colorado soils are well nigh *inexhaustable, and indeed it is true that they are fairly rich in many of the elements of fertility. But we now know from experience that land cropped year after year to wheat becomes unprofitable, even the second crop of potatoes is rarely satisfactory and all fruit association men and local dealers know that small apples and pie peaches are becoming more and more common. In several sections of the state the land was planted continuously to wheat in the early day and as any one would now expect the soil became exhausted and in some instances the farmers faced bankruptcy. This same land is now producing immense crops of wheat, oats, sugar beets, potatoes and alfalfa. What has brought about the change? Alfalfa was introduced about the year 1863. It was adapted to our conditions from the first and soon large areas of this land were growing luxuriant crops of this unexcelled forage crop. The feeding of animals was then in its infancy and alfalfa soon became a drug on the market. It was then found that alfalfa sod could be successfully broken and much to the surprise of

*Some of our readers have no doubt seen the papers on various phases of soil fertility published during recent years by the Bureau of Soils of the Department of Agriculture. This bureau is attempting to show that there is no such thing as soil exhaustion as is generally understood, but rather that there is an inexhaustable supply of all of the mineral elements of plant food in all soils at all times. They contend that the decreased yields of the various crops is due to poisonous substances excreted by the roots of plants. Thus, according to this view, any crop will soon poison the land to such an extent that proper development of the plants is hindered and decreased yields result. The remedy according to this theory is, naturally, a proper rotation of crops. The idea that the roots of plants excrete poisonous materials is an old one and one which we believe to be true with some plants at least. But that this is accountable for all of the many cases of unsatisfactory yields is difficult to believe. At any rate the writer prefers for the present to adhere to the well established theories, believing that the available supply of plant food may be depleted and that the texture of the soil counts for much. The presence of decaying vegetable matter in the soil improves its physical condition, helps to set plant food free and in a measure takes the place of crop rotation in the orchard. This may best be supplied and conserved under arid conditions by the use of shade crops.

all, when planted to wheat the yield per acre was far greater than when the land was first subdued.

Now what had the alfalfa done to the soil? It had actually added some nitrogen which by the aid of the nitrogen fixing bacteria it is able to gather from the air. It also brought up from the lower depths of soil, ten or more feet below the surface, potassium and phosphorus. These two important elements of plant food were deposited in the surface soil in the shattered leaves and stems as crop after crop was removed from the soil and when the sod was broken the decaying roots and stubble added their quota. But more important than all these, decaying vegetable matter and its products had been added to the soil. Without decaying vegetable matter the physical condition of the soil is almost ruined for agricultural purposes and the host of bacteria which perform many essential activities are prevented from developing.

Our orchards have, for the most part, been planted on desert land and in most cases the land was cleared of the native growth and planted directly to trees. Thus there was little or no vegetable matter in the soil and, since our growers have been very insistent on clean cultivation and stable manure is scarce, but little has been added. Now does it not stand to reason that continued croping to apples or to peaches will bring the same disastrous results that befell the wheat growers mentioned above? The following table complied by Dr. Roberts* is valuable in this connection. Table I shows the amounts of plant food elements which are removed in the grain and straw in twenty years of continuous cropping to wheat. It is assumed that an average of 15 bushels of grain and 35 pounds of straw are removed from an acre each year.

Table I. Amounts of Plant Food Removed From an Acre in 20 Years Continuous Cropping to Wheat.

	Nitrogen lbs.	Phos. Acid lbs.	Potash lbs.	Value
Grain	424.80	160.20	109.80	$79.86
Straw	234.78	50.40	214.20	48.37

In contrast with this the same author gives similar figures of the amounts of plant food which may be expected to be carried away in 20 years in fruit and leaves from an acre of bearing apple orchard. The figures represent 20 years of the productive life of a New York apple orchard between the ages of 13 and 33 years and does not include the materials stored in the wood of the tree.

Table II. Amounts of Plant Food Removed From an Acre of Apple Orchard in Twenty Years.

	Nitrogen lbs.	Phos. Acid lbs.	Potash lbs.	Value
Apples	498.60	38.25	728.55	$110.26
Leaves	456.75	126.	441.	97.17
Total value in wheat, grain and straw for 20 years				$128.23
Total value in apple, fruit and leaves for 20 years				207.45

These figures show that an apple crop takes more fertility from

*I. P. Roberts, Bull. 103, Cornell Experiment Station.

the land than wheat and most farmers know from experience that continued cropping to most farm crops leads to disaster. The day of reckoning does not come quite so soon, perhaps, with mismanaged orchards but it is none the less certain. The fact that trees grow to great size and live for many years in forests, does not apply to growing apples, unless, perchance, they are grown for cider. The quicker the fruit grower realizes that each crop of fruit makes large inroads upon the available supply of plant food the quicker will he awaken to the fact that scrupulously clean cultivation is not all there is in the handling of orchard soil.

There are 38 elements which enter into the make up of a plant; 10 of this number are essential to its proper growth. These elements are as follows: Carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, potassium, calcium, magnesium, and iron. Normal development of a plant is impossible if a single one of these elements is absent. Only three of this number are considered, ordinarily, in the fertilizing of soil; namely, nitrogen, potassium and phosphorus.

Nitrogen is essential to vigorous growth in plants and an oversupply in the soil often promotes a rank growth of twigs and foliage at the expense of fruit production.

Potassium or potash is especially important in fruit growing since it aids in developing color and is the base in combination with fruit acids. It also forms more than 50 per cent. of the ash of fruits and constitutes a large proportion of the ash of the wood of fruit trees. Phosphorous is not so important in fruit growing as in grain production as it enters largely into the composition of seeds. But it is an essential constituent of tree and fruit and aids particularly in the proper ripening of the latter.

These substances are supplied in various forms in commercial fertilizers and it would seem to be a simple matter to supply any one or all of them as the individual orchard seemed to demand. Such manures are used very extensively by orchardists in the eastern states, but so far as we know commercial fertilizers have not been tried in the orchards of Colorado and we hope that their use will not become necessary for many years to come. In any event, freight rates are so high as to make their use almost prohibitive, and then, the benefit to be derived from their use under Colorado conditions is problematical as the following experience would indicate.

Potato growers feel that they should grow two crops in succession after turning under alfalfa sod. The second crop, however, is rarely as good as the first and is very often produced at a loss. To one who is familiar with farming methods as practiced in the East it would seem to be a simple matter to bring up the yield of the second crop by an application of commercial fertilizers. Accordingly a series of acre plots were laid off in a potato field at Greeley to which commercial fertilizers were applied. High grade nitrate of soda, sulphate of potash and phosphoric acid in the form of dissolved bone meal were secured and applied separately and in various combinations. These experiments were carried through four years and at the end of that

time it could not be shown that the fertilizers had in any case produced an increased yield over the unfertilized plots.

How then, are we to maintain the fertility of our orchard lands? We have already seen what the benefits are of plowing under alfalfa to wheat and potatoes, so why not adopt a system of green manuring for the orchard? The Greeley potato growers do not think of growing more than two crops of potatoes after alfalfa has been turned under. If they can afford to grow alfalfa for the purpose of producing better potatoes and in the meantime get but two crops in five years, surely the orchardist can adopt similar methods. There will be no rotation with the orchard crop but an actual saving in labor may be made in that there is little or no cultivation while the green manure is occupying the ground. The potato grower gets some returns, to be sure, from the alfalfa hay and from the grain with which it is seeded but the potato crop is the money maker.

We have already noticed what some of the effects of plowing under green crops are. But the importance of the subject will warrant a repetition. The following summary has been adapted in part from Professor Bailey's writings on cover crops:

I. Green manures improve the physical condition of the land:
   Shade the surface soil from intense sun in summer thereby protecting the trunk and limbs from the reflection of the sun from the soil; prevent the very rapid burning of organic matter in the soil; conserve some of the surface moisture, and prevent crusts from forming.
   Prevent soils from cementing and puddling.
   Prevent the rapid drainage of water from loose, porous soils.
   Prevent one form of freezing dry.
II. They catch and hold some of the leaching nitrates;
   Render plant food materials available;
   Appropriate nitrogen if legumious crops are grown.

Cover crops have become very popular in the East in orchard management. The name is derived from the fact that the seed is sown in the fall or late summer and sufficient growth results so that the ground is covered and protected during the winter. The crop is intended primarily for a green manure but under eastern conditions it cannot occupy the land during the growing season. The trees usually need all of the available moisture during that period and clean cultivation is practiced to conserve it. As soon as the trees have made their growth for the season the cover crop is planted and its growth uses up the surplus moisture and thus the trees are aided in maturing before cold weather comes on. Colorado conditions are quite different from the fact that the water is largely under man's control. We believe that our conditions demand a cover for the soil far more in the summer than during the winter. And moreover, nearly as much protection is afforded during the winter if the crop is plowed under late in fall, as is the case when the plants are allowed to stand. We therefore propose the name, *shade crops,* for a system which we hope may come into general use in this state.

Many orchardists have seen young trees killed by running water close to them during a hot day; the reflection of the sun from the

water causing sun scald. It is thought that reflection from a hot, baked soil may cause similar injuries.

As has been noted before, Colorado soils are very deficient in decaying vegetable matter and it is very rapidly dissipated when it is supplied. A summer cover will preform one of its most important functions in preventing, at least a portion of this loss.

Examine a moderately heavy soil in an orchard where a manurial crop is growing. The surface soil under the plants will be found to be cool, moist and friable, while adjacent unprotected land will be found to be hot, dry and compact. This difference is due not alone to the shade afforded by the plants but to the transpiration of immense quantities of water as well. It has been found, for instance that a grass plant will give off its own weight of water every 24 hours in hot, dry summer weather. To be sure it requires more water to irrigate an orchard where any crop other than the trees is grown, but where sufficient water can be had for irrigation this feature need not be considered.

It is a well known fact that our heavier soils, particularly if they are strongly alkaline, become so compact that it is almost impossible to cultivate them after the first irrigation in the spring. It is also true that continued clean cultivation, particularly if plowing is omitted, will make almost any of our soils compact. It is this condition that prevents the proper development of absorbing roots and the setting free of the native fertility of the soil. A few of our fruit growers have shown that green manures in combination with the necessary plowing, will work wonders with such soils as well as with the appearance of the trees growing on them.

Earth worms do damage in some orchards for the reason that they puddle the soil and much of the irrigation water seems to disappear through the channels which they make deep in the ground. A supply of decaying organic matter should do much to overcome these effects.

Soils are occasionally found which are so porous that water leaches down through them much like a seive. If fiber can be incorporated in such land by plowing under green crops this tendency will be overcome, to a certain extent at least.

Many young trees are lost each year in the colder districts as a result of "freezing dry." This term is used as a name for a condition which may be induced in different ways. The usual cause is simply a lack of water in the soil during the winter. Trees give off water during cold weather from twigs and limbs, and if the supply is not replenished, death results. A similar effect is produced when a damp soil is frozen to such a depth that root action is suspended. The tops of such trees usually die after a feeble attempt at putting forth leaves has been made, while the roots are usually in perfect condition.

The condition mentioned first, may be avoided by winter or late fall irrigation. The deep freezing of soil presents more of a problem but we believe that it may be prevented to a considerable extent by the use of shade crops. True, the system we propose contemplates plowing in the fall but eastern experience proves that as much pro-

tection from frost is secured when a crop is plowed into the land in the fall as when it is left standing throughout the winter.

The winter of 1903-4 was very severe in the East and in some sections hundreds of orchard trees, particularly peach trees, were destroyed. Prof Green* made a survey of the injured orchards the following summer and found that injury occured only on impoverished and bare soils. A cover crop, sod, good growth of weeds, or stable manure afforded almost complete protection from the cold. And moreover, and what is more important for our purpose he found that where such materials had been plowed under recently, the protection was just as efficient.

Popular writers on horticultural topics have woefully confused humus with decaying organic matter and have implied that all organic material is humus as soon as it is mixed with the soil and decay has set in. The fact is, humus is the final product of organic decay and as such has entirely different effects on soils than have organic materials which are undergoing the processes of decomposition.

When green manure is plowed into the soil various low forms of plant life including fungi, yeasts and bacteria attack it thus inducing decay. [1]Fraenkel "found in the cultivated soil of Liebefeld 5,750,000, in meadow land 9,400,000, in a manure pile 44,500,000 bacteria per cubic centimeter." These figures seem high for so small a quantity of material, but taking the average size of a bacterium, a cubic centimeter might readily contain six hundred millions.

Other forms of bacteria begin to multiply as soon as fermentation sets in. Different organisms have different and important functions to preform in promoting chemical activities in the soil; plant food elements are set free, changed and combined into substances which plants can use. No less than five different acids are generated by the processes of decay, carbonic acid being among the more important. [2]Sackett found that clover taken in full bloom in June when ground and mixed with soil at the rate of 10 tons per acre, gave off, at the end of three days, [3]carbon dioxide corresponding to 3812 pounds per acre foot. This action continued through a period of three weeks, gradually diminishing however until at the end of that period very little of the gas was evolved. One hundred tons per acre of red clover treated in the same manner gave off after 12 days five tons of carbon dioxide per acre foot. This investigator also tested the solvent action of pure carbon dioxide on various materials. Pure ground bone meal was placed in a flask and carbon dioxide was allowed to pass through it. At the end of one hour 2.11% of the insoluble phosphoric acid had been made soluble. At the end of two hours 5.21% was made soluble. Ground phosphate rock treated in the same manner gave the following

*Green Bull. 157 Ohio Agri. Exp. Sta. 1904.

1 Hilgard, Soils, p 143.

2 Sackett, W. G., unpublished notes.

3 Carbon dioxide and carbonic acid gas are synonymous; when combined with water, carbonic acid is formed.

results: after one hour .16% of the insoluble phosphoric acid had been made soluble; in two hours .28%. Magnesium phosphate similarly treated yielded 16.33% in one hour and 22.35% in two hours of soluble phosphoric acid.

Carbonic acid is, then, an important agent in dissolving rock particles and with its aid, latent fertility is brought into a condition which plants may use.

Organic matter is often almost entirely consumed under arid conditions very quickly after it is incorporated with the soil. The heat of the sun in conjunction with insufficient moisture, produces conditions which oxidize the matter, or in other words, burn it much as though it had been consumed by fire, hence the burning out of soil, an expression common among farmers. This change in organic matter is no doubt begun by soil organisms while the later stages are probably of a chemical nature.

The decay which results in humus, takes place at moderate temperatures. Organisms do not develop in a low temperature and if it is too high, oxidation or burning results. An apparent contradiction to this statement is found in the difficulty with which unrotted stable manure decays when plowed into land, if moisture is not abundant. The lack of moisture probably prevents the development of bacteria in sufficient numbers to begin decay, consequently the chemical changes which result in burning do not occur. The presence of such material is a detriment to growing plants as it keeps the soil so open that an undue amount of moisture is permitted to escape. This effect is so noticeable that many of the so-called dry farmers make no use of stable manure. This wanton waste might easily be prevented by composting as there is sufficient moisture in the rain and snow to thoroughly rot manure treated in this manner.

The compound resulting after organic decay is completed is humus. Such decay results in a dark colored material, without organic structure, soluble in alkalies after the lime has been removed. Humus gives a dark rich color to otherwise light colored soils. It is complex in composition and is especially important as being a reservoir of nitrogen. Much of the nitrogen that is brought to the soil by leguminous plants, as well as that which is stored in the plant in the process of growth, is not made available to growing plants until the humus stage is reached.

Humus usually exists in small quantities in arid soils but often is entirely absent where clean cultivation without manuring has been practiced. It may also be present in small quantities along with partially decayed organic matter. Much of this valuable material is lost by constant clean cultivation and the consequent burning of the organic materials, before it reaches the stage where humifaction may take place.

A large part of the loss could be prevented, not only of nitrogen but of the many benefits to be derived from decaying organic matter and humus as well, by shading the soil.

While it is no doubt true that humus does aid in improving the physical condition of the soil, it is probable that most of the beneficial effect, such as giving fibre, and tilth as well as increasing the water holding capacity, is due in a much larger degree to the partially decayed organic matter.

By leguminous plants is meant the family which includes the beans, peas, clovers, alfalfa and vetches. These are the only plants of importance so far as now known which have the power of taking nitrogen from the air and converting it into combinations which other plants can use. Thus they actually add plant food to the soil and nitrogen is the most expensive element to supply in commercial form as well as the most difficult to keep, since it is readilly dissipated in gaseous form. The manner in which such plants take nitrogen from the air was a mystery for a long time. It was finally determined that a certain species of bacterium lives on the roots of vigorous legumes where the swollen regions or tubercles are formed. This low form of plant life is able to take the free nitrogen from the air and change it into forms which plants can use. Consequently legumes can be grown on land from which nitrogen has been exhausted.

It was also found that leguminous plants do not thrive in soil where the accompanying bacteria are absent. This led to the making of pure cultures of the bacteria which are now supplied in commercial form. These cultures after being diluted and sufficient multiplication of bacteria has taken place, are sprinkled over the land, or better still, seeds are soaked in the culture material just before planting.

Such cultures have not been the success that was anticipated but in the meantime a mass of overdrawn articles on the subject has been printed in magazines and papers. The result has been that many farmers have been lead to believe that by simply applying the cultures to their land wonderful benefit would result to any and all crops. The truth is, these cultures have no direct effect on any plants other than the legumes. And moreover, should one wish to secure such material he must designate the particular crop he intends to grow. Cultures from clover bacteria would not be expected to have any effect on beans or alfalfa. It would be idle to apply these cultures to land which is already producing good crops of any of these plants.

What crops shall be grown for shade crops and how shall they be handled? This is a difficult question to answer as the practice is new and but little has been learned as yet about the subject. The system of cover crops as advocated in the East will not apply for various reasons. We can not plant in the fall and expect to get much growth to plow under in the spring because of the short seasons. Then it might not be advisable to irrigate at the particular time the seed should be sown as would probably need to be done to insure the germination of the seed. We have also found that fall plowing is better suited to our conditions than spring, particularly if a crop or manure is to be turned under. If a mass of vegetable matter is plowed under in the spring the ground is apt to remain so porous that difficulty

is experienced in irrigating. The ground at the upper end of the row soon becomes saturated but still a large head of water must be used in order to force it through to the lower end. Naturally the trees at the upper end are injured. Finally, we believe that both land and trees will be benefited by keeping the surface of the soil shaded during the heat of the summer for the reasons already advanced.

In the light of our present knowledge it will probably be the best plan to prepare the land fairly early in the spring and sow the seed. Or if experience shows that we need a certain amount of spring cultivation in order to aerate the soil and to promote soil activities the planting may be delayed until June. Whether in the case of a perennial it will be best to let it occupy the land for two seasons, plowing it under the second fall, or not must be determined by experience and individual conditions. It now seems best to plow the land at least every second season. All of the land may be occupied by the crop in old orchards but with younger trees space must be left for irrigation as well as to prevent the possibility of the crop appropriating food and moisture to the detriment of the trees. There would also be more danger of injury from small vermin and grasshoppers; the latter pest would probably have to be reckoned with in the young orchard at any event.

One must take pains to see that the irrigating furrows are kept open and not allow them to become choked with vegetation. Provision must be made so that water may be as judiciously distributed as though the land were bare. The trees should always receive first consideration; do not allow the prospects of a few jags of hay to warp judgment when it comes to a question of the health of the trees.

Whether or not it will be advisable to remove any of the crop for hay must be determined for each orchard. When the land has been badly impoverished, or is in poor physical condition, all of the growth should be returned to the soil.

If, later on it is found that the continued use of legumes is furnishing too much nitrogen, as will be indicated by a rank growth, then a change should be made; rye or buckwheat may be used instead.

The kind of crop which will be best adapted for use as a shade crop is yet to be determined and it is likely that different soils and different localities will demand different things. Red clover is at present most in favor among the few who have tried any crop at all. A number of orchards at Paonia have recently been planted to clover and the results are very satisfactory. It has made a splendid growth, even close to the trunks of the largest trees. (See Plate I.) Clover also does fairly well in the northern district. Winter vetch has been used to some extent, for several years in the vicinity of Rocky Ford. This plant will make a fairly good growth in any of the orchard districts of the state. A few orchardists are experimenting with Canada field peas. Peas have the advantage that they make a splendid feed if one wishes to combine hog feeding with orcharding. The pods will not fill nearly so well, however as they do in the higher altitudes where the climate is much cooler. Pea seed should, therefore be planted as early in the season as possible. Cow peas have been tried

to a limited extent but the season seems to be rather short for them and the young plants are easily injured by over watering. In one orchard where we were experimenting with this crop the plants made almost no growth, possibly because the proper bacteria were not present. Alfalfa has been tried by some, but at the mere mention of the word most orchardists will hold up their hands in horror. If it were not so difficult to plow it would certainly be an ideal crop for the purpose. We do not wish to give the impression that we advocate the use of alfalfa but is it not possible that a method of handling may be devised that will make its use possible, except in stony land? Why not plant it in rows? then cultivation could be carried on throughout the season if desired. Then if the tops are mown off before the seed has set there ought not to be a great deal of trouble with its spreading. If the turning plow is used when the plants are not over two years old it is not such a difficult matter to cut the roots and the ground will usually need to be plowed that often at least. But if one wishes to continue to grow alfalfa in the orchard it would be an advantage not to kill it out but to have it contiue to come up year after year. Mr. B. A. Smith, of Grand Junction, has been experimenting with alfalfa in one of the best orchards in the Grand Valley and he is very much pleased with the results so far. He does not plan to kill the plants but expects to use the plow and the disc as much as the land seems to require.