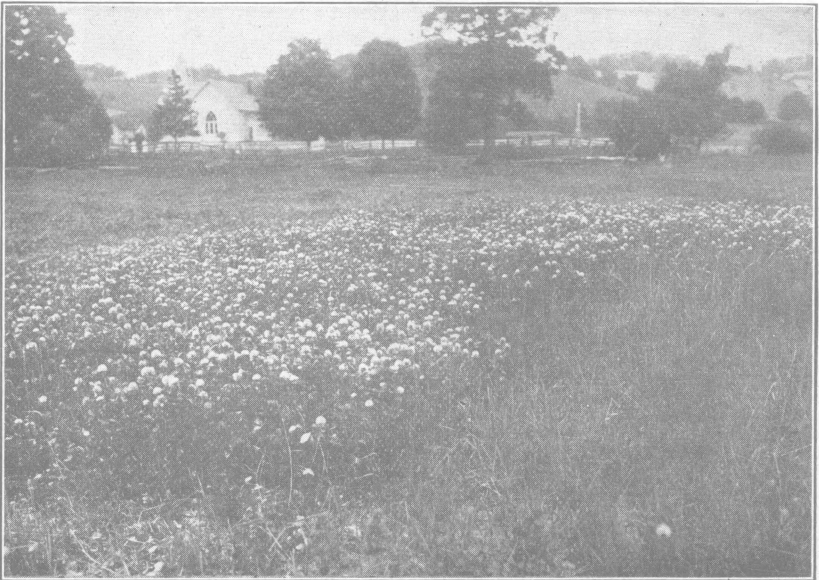


# Ohio Agricultural Experiment Station

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## THE MANAGEMENT OF CLOVER IN CORN BELT ROTATIONS



SIR:—I have the honor to transmit herewith and to recommend for publication as a Circular by the Experiment Station the accompanying manuscript entitled "The Management of Clover in Corn Belt Rotations."

This paper, which was prepared by Mr. J. A. Drake of the Office of Farm Management, Bureau of Plant Industry, U. S. Department of Agriculture, in cooperation with the Ohio Agricultural Experiment Station, is based so largely on observations made within the Corn Belt area of this State that its conclusions are doubtless applicable without qualification to that area. It would seem also that it would be more or less applicable to all parts of the State.

Respectfully submitted,

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*Chief of Department of Cooperation.*

Approved:

CHAS. E. THORNE,  
*Director.*

# THE MANAGEMENT OF CLOVER IN CORN BELT ROTATIONS

By J. A. DRAKE

## INTRODUCTION

Perhaps there is no section of the country where a permanent and well arranged rotation is of so great importance to the maintenance of the most profitable system of agriculture as in the corn belt section, of which Ohio forms an important part. In connection with the kind of farming carried out on the better class of farms, the crops that are grown, and the livestock kept, such a rotation is well-nigh indispensable. The yields, by ordinary methods of farming, cannot well be kept up, much less increased, without it; and especially is it essential in the continuance of high yields of corn, perhaps the most important and most valuable crop that can be grown on the average farm in that area. The disastrous effects of growing corn continuously on the same field for a period of years without some special arrangements for heavy manuring, growing rye, etc., is beginning to be quite well understood. Experiments have shown that a mere alternating of two crops through a period of years will increase the yield of corn about one-half over that of one crop grown continuously through the same period, while the addition of clover, making a three-year rotation, has been known to increase the yield to almost three times that of continuous one crop culture.

Not only is a rotation important in crop production on corn belt farms, but it is highly desirable in connection with the keeping of most classes of livestock. Along with corn a certain amount of clover pasture and hay, or a substitute for them, must be furnished each year, and in no way can it be done with greater ease and with more certainty than to follow a regular rotation of which clover forms a part.

A regular rotation, likewise, adds system to the management of the farm. It is known definitely what is to be done each year. Each field gets its certain crop or certain special treatment in fertilizers or manures at regular intervals. This makes it possible to estimate the number of livestock that can be kept each year, and the general returns that may reasonably be expected from the farm.

Important as continued pursuance of a regular rotation is, no factor in it is so vital and gives so much trouble as the successful

management of clover in the rotation. If there is a failure of this crop, then a profitable and suitable substitute must be found, or the whole field is left idle and the entire rotation disarranged.

It was because of this important relation which the management of clover bears to the rotations generally practiced and the ever-increasing difficulty that farmers in general are experiencing in growing clover successfully, that a careful and systematic study of the farm practices relating thereto was undertaken. The problem has been an interesting one indeed, and has revealed a great many factors not at first suspected.

**Rotations including wheat.** Among the very common rotations found on the average farm of the section under consideration is one of which wheat forms a part. There has been for some time a tendency on the part of farmers to discontinue this crop wherever possible, but for the most part, even though it is considered uncertain and unprofitable, it is kept in the rotation because it is thought necessary or at least very desirable in getting a stand of clover.

Perhaps the most common of these rotations is that of corn, oats, wheat and clover. Another is that of corn, corn, wheat and clover. Again, another is corn, wheat and clover, this being only a three-year rotation. All of these find favor with individual farmers. It generally depends somewhat on local conditions as well as local customs as to which predominates. The first is the old rotation found on many general farms, while the second is found where it is desirable to produce more corn to feed a larger number of hogs. The third is a very useful rotation for building up a farm, especially when used in connection with a thorough system of fertilizing and applying manures.

In all of these rotations the clover is sown in the wheat. This is done at various times and in various ways. Every man has his own "best" time and method, by which he must proceed in order to be successful. Some sow their clover seed as early as February, while others wait until April with apparently equal success. There are still others who sow one-half of their seed early and the other half late and get very good results. Probably more farmers prefer to sow the seed rather early, either in February or March, being especially anxious to catch the ground in a "honey-combed" condition, or, if not in this shape, to sow on a light snow. There are many good features about this. The farmer usually gets the work done when otherwise not very busy. There is very little labor connected with the seeding and thus there is very little invested in

the crop except the seed. And, if conditions are right and everything favorable, a fairly good "catch" of clover is usually secured, but at best there is much uncertainty and a great deal of the element of chance in the average method of seeding clover which ought to be eliminated if possible.

When it is considered that for every other crop the farmer prepares a good seedbed, or at least he should, but that with clover sown in wheat it is nearly all haphazard and largely trusted to luck, we are at once impressed that a mere sowing of the seed on the wheat ground is not giving the clover a fair chance to grow and do its best. Especially does this practice become hazardous on lands that have been farmed for a number of years and have become exhausted in fertility and low in humus and vegetable matter. Under these conditions the soil becomes dead and lifeless, packs and bakes with dashing rains and sunshine, until it resembles a traveled road. There is little chance for the clover seed to become covered or even if a foothold is secured there is little hope of the young plants living.

During the progress of these studies it has been quite evident that as soil conditions change our methods of seeding clover with wheat must be changed and made more thorough. However, it is not an easy matter to introduce radical changes in present methods, with an equal assurance that farmers in general will be more successful. Nor is it the purpose of this work to urge too great changes in these methods, but to call attention to other practices which will make them more reliable and success much more certain.

**Harrowing the wheat.** In nearly every community where these studies have been carried on, one or more farmers have usually been found who make a practice of harrowing their wheat ground in the spring to insure a covering of the clover seed and hence a good stand. Some sow their clover seed and then harrow, while others harrow first and then sow the seed. Still others harrow, sow the seed and then harrow again to cover it. The question at once arises, will this harrowing injure the growing wheat? But the universal testimony of those who have tried it is that, especially during dry years, it is a great benefit to it. Wheat has been thoroughly harrowed as many as three times with good results. Again, will it injure the timothy sown the fall before? Some of the timothy thus sown will be torn out, but enough will live through at least two harrowings to give a sufficient stand of this crop. The clover is of so much more importance that it should have first consideration. The seeding of timothy can likewise be done in the spring with the clover.

In seeding clover after this method there is but one rule as to the time of seeding,—wait until the field is in good condition to harrow. Men who follow this method begin seeding at the earliest possible moment but are in no hurry, even sowing as late as the first of May. It is well not to put it off until the wheat gets so high as to interfere with the harrow, but sowing any time before this, if the harrowing is well done, practically insures a good stand of clover, unless the spring is abnormally dry. A good sharp harrow should be used and it should be sufficiently weighted, if necessary, to do effective work.

The greatest objection to this method is that the work must be done when the farmer is busy preparing ground for other crops, but in view of the great value of clover as a soil renewer and soil builder, together with its great importance in the rotation, this elimination of uncertainty in securing a good stand cannot be urged too strongly on farmers for their careful consideration. At least this method should hold an important place as a supplement to those already in use. For instance, where it is the practice to sow seed early, and if for some reason, as it often happens, it is discovered later that there is a very inferior stand, then more seed should be sown and harrowing resorted to. No farmer who is keeping apace with his business can afford to let a single year pass with a failure to get a good stand of clover.

Using a disk or shoe drill. In some places men were found who were using their disk drills to great advantage in sowing clover in their wheat. A few shoe drills were also used with equally good results. In using the drill for this purpose they sow the seed with the seeder, placing it in front of the grain box, or with the new type of drill they allow the seed to go down through the grain tubes and be covered slightly. This is a very effective method of getting a fine stand of clover and it does the wheat little or no harm. There is a difference of opinion among farmers as to which way the drill should be driven when putting in the clover. Some say it should go the same way the wheat is drilled, while others contend it should go across the wheat rows. Since both ways are quite generally practiced, it is very probable that either one will do very little damage to the wheat crop. Care should be taken not to force the drill into the ground too deep. All in all, the method seems to be a very commendable one which should find a prominent place in general farm practice.

Top-dressing the wheat with manure. Under normal conditions on farms where an abundance of manure is produced, rightly cared for and applied to the land at regular intervals, very little difficulty is experienced in managing the clover

crop successfully. No matter how the manure is applied, when, or to what crop, good stands are nearly always secured, which grow on to maturity without much attention or consideration on the part of the farmer; provided, of course, his soil conditions, such as drainage, lime content, etc., are otherwise favorable. Such is the case especially after several years of this kind of farming. It has been quite noticeable during these studies that on good livestock farms where the manure was properly handled, and especially in dairy sections, very little was heard of so-called "clover sickness," poor stands, etc., while on grain farms where everything has been sold off for a number of years and wasteful methods of burning stalks and trash have been practiced, the failures have been numerous and the clover troubles are increasing at an alarming rate. This last condition exists in sections where they have formerly grown clover very successfully by their present methods of management.

When the soil has become badly run down, manure will doubtless do most good when applied as a top-dressing on the wheat in which the clover is to be sown. The effects of this have been noticed in a small way on nearly every farm. Most farmers have had the experience of "doctoring up" a few of the poor knolls with a light top-dressing of manure and upon going back the next year to observe, they have usually found that there was the best stand in the field and the best clover growing. This, too, occurs where there would otherwise have been scarcely a plant of clover, or very little at most without the top-dressing. Just such a condition as this is shown in the illustration on the next page (Figure 1).

This illustration is a reproduction of a rather remarkable condition. It will be noted that the line between a very fine stand of clover and no clover at all is very marked. This line is the boundary between manure and no manure. The seed, of course, was sown over the entire field alike. A much better growth of clover could not be secured under any circumstances than was found where the manure was spread; whereas, where there was no manure, nothing existed but a very poor growth of timothy, a few stunted weeds, sorrel,\* and bare ground, the bare white ground predominating.

\*It might be well to state that in some sections sorrel (*Rumex acetosella*) is not common. It is found in great abundance, however, in the eastern and southern part of Ohio, and seems to be most abundant on soils of shale and sandstone origin. It is usually considered as indicating the lack of lime. This, however, should not be understood to mean that an application of lime will kill it, except as it might cause clover or other dense-growing crops to grow more vigorously and smother it out. It has been found growing vigorously in the edge of a pile of pulverized limestone. Sorrel should not be taken as an absolutely certain indication that an application of lime is entirely necessary for the growing of clover without some further investigation along this line by experimenting with lime itself. The other factors, such as methods of seeding, applying manure, etc., which are being set forth in this circular, ought to be studied also in this connection.

Where the manure was spread it was very noticeable that all of the sorrel had disappeared and nothing but clover grew. The clover had so thoroughly taken possession of the soil that the sorrel had been completely smothered out, proving that the smothering out process is one and possibly the only successful way of getting rid of sorrel. Anything that makes clover or other crops grow so thickly and so vigorously that the sorrel cannot exist will kill it out. In this case the top-dressing of manure has accomplished this result completely by producing a perfect stand and maintaining it.



Fig. 1. The effects of a top-dressing of manure.

To the right of the picture will be noted a narrow strip of clover which dwindles out to almost nothing. If the picture had been extended a little further to the right it would have shown a narrow patch of clover which gradually disappears and which marks the path of the farmer as he was driving away from the scene of action, and some of the manure sifted down through the "dump boards" or rough wagon bed in which the manure had been hauled. As far as this sifting process continues the clover follows the path of the wagon, but as the manure gives out the clover entirely disappears.

This very pronounced condition found on a poor knob of a run-down farm is an eloquent appeal for the continuance of livestock and more manure, better cared for and applied. One farmer was not far wrong in his answer to the question often used in making these studies, "Do you have any trouble in getting a stand of clover?"



when he replied, "Not since the manure spreader came on the farm." It is needless to say that he top-dressed all of his wheat ground carefully wherever he expected to sow clover. It might be added that in general practice this is done immediately after the wheat is sown in the fall, or during the early part of the winter.

**Spreading straw on wheat ground.** A very interesting and unusual practice in connection with the management of clover in rotations including wheat, is to spread straw evenly over the surface of the soil after the wheat is sown and before it comes up. In the absence of suitable straw spreaders the farmers haul the straw out in small piles and spread it by hand. On the poorest spots whatever manure is available is used, but on the remainder of the field straw is spread with as much care as though the work were being done on strawberry beds. The following illustration gives an idea of such a coating of straw through which wheat has come up, as well as the appearance of a field in which this practice is carried on.



Fig. 2. A close view showing covering of straw on wheat field.

This unique practice is found in a section where clover growing in a wheat rotation is a very uncertain undertaking indeed. In these localities the best farmers are resorting to this method as apparently the last extreme. This is necessary to grow clover and be at all successful. Those who consider this practice not worth while or too laborious have about quit trying to grow the crop at all,

so numerous and constant have been their failures. The soils on which these conditions are found have been farmed for a great number of years with no thought or provision for keeping up the humus and decaying vegetable matter, and as a result the surface has become so hard and lifeless that without some special provision like the covering of straw or manure the young clover plants cannot take root and maintain themselves sufficiently to give anything like a satisfactory stand. The photograph was taken about May 1st, and wherever there was a slight covering of straw, something to give some protection and hold the moisture slightly and prevent the ground from baking, there the young clover plants were to be found in great numbers and growing with great vigor. But where there was no straw and the soil was bare, in no case was clover found growing. On this farm the clover seed was sown at any time in March when it was thought that the conditions were right. No special attention was given. The seed was sown broadcast as it is usually done by farmers. During the past summer the writer has had occasion to visit this farm again after a lapse of about three years, and better success with clover every successive year is reported. A failure to get a stand has not been experienced for some twelve years. This is extremely interesting as other farmers in that section have failed to get good stands unless it is by this method or by the scattering of manure, which is, of course, as good or better. That this man is successful in growing clover by this method is shown by the accompanying photograph, Fig. 3, which was taken on adjoining fields similarly treated the year before.

The practice of spreading straw in order to get a stand of clover is not so valuable as something to be recommended to farmers to practice, as it is in what it teaches. It may be objected at once that it is a mulch, and true, it is. It may also be objected that it is an expensive practice from a labor standpoint. Whether this is true or not may be judged from the fact that the man and his hand were able to haul and spread the straw over three acres per day. If suitable straw spreaders were at hand this labor might be materially reduced, but as it is, and under the conditions found, it is time well spent. The practice, however, is worthy of very careful consideration and study. It is found on land where clover had once been grown without any difficulty whatever, but years of farming has brought the soil to that state where a mere thin scattering of straw on the surface will insure a perfect stand of clover, while without it, or some substitute like manure or the equivalent of trash, leaves, etc., clover cannot be grown. The natural drainage is good. Commercial fertilizers have been used abundantly for years and there

should evidently be no lack of the elements essential for plant growth. There is no lack of lime, the soil in fact being for the most part of limestone origin. But under these conditions it lacked what proved to be a most essential factor to success in clover production; namely, something that will have an effect probably similar to that of an abundant supply of humus and vegetable material incorporated in the soil. It is not the intention to advise this method of applying straw to wheat ground as a general practice, but merely to call attention to the wonderful effect it has had and to bring out the fact that to grow clover on such soil it is necessary to do something for it that will enliven it, cover more seed, prevent baking and cracking, and conserve the moisture. It might be well to add, also, that it suggests a much better means of disposing of straw and stalks than burning or selling them on the market, and it ought to give the average farmer a glimpse of the extreme value of the accumulation of any vegetable matter such as straw, stalks, trash or leaves, especially on the surface of the soil, in connection with getting a stand of clover.



Fig. 3. Stand of clover secured by applying straw to wheat field.

It would seem very probable from this that a condition might arise wherein the extreme lack of humus and organic matter is the principal and perhaps the only element of failure with the clover crop. How prevalent this condition is, investigations have not been carried far enough to say. But farmers, in limestone regions

especially, may well consider the humus problem as one of their important factors in clover growing. The extremely unfavorable condition for young clover on a hard, compact, run-down soil is something that can not easily be over-estimated. The tendency has been in the past to ignore the great value of humus and organic matter in the production of profitable crops of any kind, and it is very probable that the increasing amount of clover failure on soils that have been farmed for a great many years is due to the gradual but certain exhaustion of humus and vegetable material, which constitutes one of the greatest factors of the soil's physical make-up.

The adoption of better methods of farming, and of rotations containing special features for supplying to the soil an abundance of humus-forming material, would doubtless soon put an end to much of the failure with clover in a corn and wheat rotation over a large part of the section where such failures now occur. This, together with better and more careful methods of sœding, and a better preparation of the surface of the soil, which has already been discussed, seems especially advisable. The seed must be covered by one means or another, and the surface of the soil should be either thoroughly pulverized or have an abundance of humus or a temporary substitute for humus in the form of a mulch or covering on the surface. Unless these conditions are supplied the young clover plants can not get a foothold and maintain themselves in their earlier stages of growth. If the surface of the soil is too hard and dries out too readily the young clover nearly all dies out before it gets even a fair start. This fact seems to have been generally overlooked by the great mass of farmers. The physical condition of the soils on many farms is continually growing worse. They are becoming more lifeless and less friendly to young clover from year to year.

Farmers are urged to consider its importance and to do all in their power to correct the evil. The hard, compact condition of the surface soil in the spring, with its tendency to bake and dry out must be overcome. Supplying humus and vegetable material as rapidly as possible will accomplish this result. As this is done perhaps one of the most common causes of clover failure will be removed. Until this is done there will be great need of pulverizing the surface and breaking up the surface crust by the use of some such implement as the harrow or drill.

Rotations containing cowpeas and soybeans preceding wheat. In the southern part of Ohio a very interesting practice was found. Some of the farmers have adopted rotations in which cowpeas or soybeans come in just before the wheat crop. It is the usual practice to make the crop into hay in time to have the ground ready for fall seeding, but occasionally the entire crop of cowpeas

or soybeans is rolled down and crossed with a disk in the preparation of the ground for wheat. By using a disk drill the wheat can be sown without any inconvenience because of the litter on the surface of the soil. The accumulation of cowpea and soybean vines on the surface of the ground serves as a mulch very much on the order of the straw just discussed, and is very helpful in getting a stand of clover. In fact, it only emphasizes again the great value of some accumulation of vegetable matter on the surface of the soil to keep it in better condition for the growing of the young clover plants. The nitrogen furnished by these crops is also a great stimulus to the wheat as well as to the clover throughout its growth. The practice of turning the entire crop back to soil, however, is somewhat wasteful. If it could be so arranged as to have the peas and beans ripen early enough it would be better economy to gather them with hogs, thus allowing only the vines to fall back to the soil. This would accomplish the same results in reference to the stand of clover, besides getting the value of the crop in pork.

**Rotations including rye.** Rye is becoming more and more popular as a crop in the rotation in which clover is sown. It has some points of advantage over wheat in that it grows taller and less dense and does not shade the clover so much as wheat. The methods of seeding clover in rye are much the same as in wheat. The seed is sown in the spring by the usual methods. Harrowing the rye can be resorted to the same as on the wheat crop. Farmers have also been found who use a disk drill and even a disk harrow in breaking up the surface of the soil so as to secure a covering for the seed when sown in the rye crop. The use of a disk harrow can be resorted to on rye, but it is rarely ever done in connection with wheat. Even with rye it should be set straight so as not to do much damage to the rye crop. If this is not thought desirable or possible the seed may be sown and hogs turned in for early spring pasture. The tramping of these animals over the field will plant much of the seed in the ground and make a good stand more certain. A top-dressing of manure or a covering of straw can be used with the rye the same as with wheat. The use of a good commercial fertilizer on rye, the same as on the wheat crop, will often prove very beneficial in securing a good stand of clover, and in the absence of manure, the value of which has already been discussed, the use of a good commercial fertilizer is very commendable. This will often insure a good crop of clover where otherwise there would be a failure.

The rotations followed, which include rye, are usually on the same general plan as those including wheat. These are usually corn, corn, rye and clover, or corn, rye and clover. Some of the

potato growers have a rotation of potatoes, rye and clover, running it as a three-year rotation, while others run it as a two-year rotation, clipping the rye and clover about three times but taking no crop off. The next year, then, potatoes are planted after the clover has had time to make some growth in the spring, for what is called the late crop of potatoes. In a similar manner a two-year rotation of rye and potatoes can be practiced, and the rye hogged down when ripe, the clover being sown in the rye in the spring and allowed to grow up before the ground is plowed for potatoes the next year.

**Rotations with oats.** Some farmers run a rotation in which oats is the only crop in which the clover is sown. Such rotations are usually corn, corn, oats and clover, or corn, oats and clover. With these rotations failures in securing stands of clover are rather numerous, but some men are quite successful in the management of the clover crop even under these circumstances.

If a good stand of clover is particularly desired, one of the first things to be avoided is a very heavy seeding of oats. Lighter seeding will probably cut down the yield of oats somewhat, but the chances of a catch of clover will be very much greater. Not over a bushel and a half of oats per acre should be sown, whereas it is generally the custom to sow from two to two and a half bushels per acre. Oats at best is a bushy crop and produces a very dense shade under which the clover is not likely to thrive. Then too, when the oats crop is taken off the clover is exposed to the sun very suddenly and sometimes damage is done in that way; especially is this likely to happen where the shading has been very heavy. However, with proper methods of seeding and watching this one point, very satisfactory stands can quite frequently be secured in oats.

Rolling the oat field after the clover seed has been sown is considered by many farmers to be of great importance. This covers the seed just about deep enough and firms the surface of the soil in such a way as to insure a good moisture supply to the young plants. Some prepare the ground and sow the oats with a drill, and the clover with the grass seeding attachment, allowing the seed to fall back of the hoes or disks. The roller is then run over the field. Others sow the oats either with the drill or broadcast, using the roller to cover the seed. The beneficial effects of the roller on the clover is very marked where the soil is in fit condition for rolling. It usually insures a good stand which is quite uniform on the ground.

Another very good method of seeding with oats is to sow in stalk ground and allow the stalks to remain on the surface of the soil. This again is only a repetition of, and brings again to our

notice, the value of the accumulation on the surface of the soil of some protection in the form of vegetable matter, which will prevent the baking and drying out of the soil. In doing this the stalks are usually broken down and the ground disked, after which the oats are sown and disked in. If the stalks are not too large and are well cut up a disk drill can be used, but the former method is most generally practised. The clover seed is sown after the seeding of the oats and the roller in this case also should be used. This, together with the great protection which the stalks furnish, practically insures a good stand. A great many farmers have been visited during these investigations who follow this method exclusively and very rarely fail. The following illustration shows a field which has been sown after this method, although the rolling was omitted.

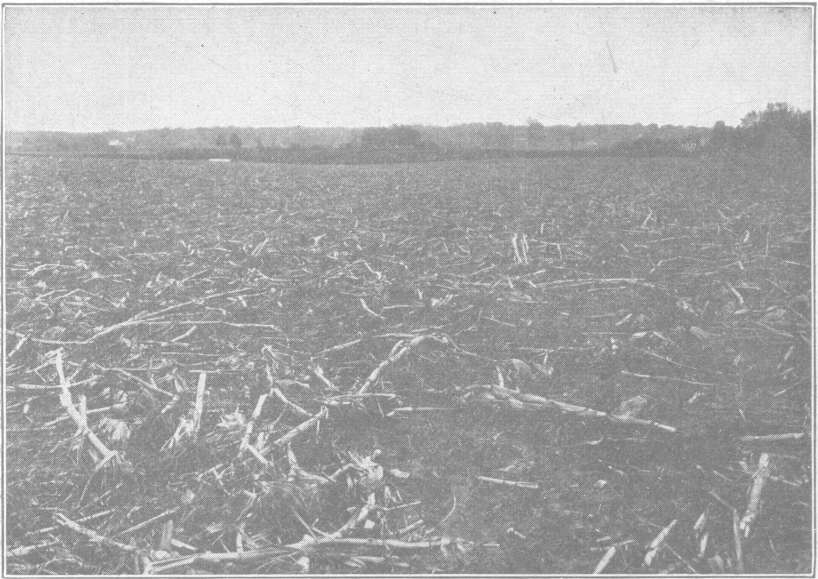


Fig. 4. Corn stalks on the surface of the soil where oats and clover have been sown.

In the field shown in the above illustration it was very noticeable that wherever there was a slight accumulation of stalks or corn husks on the surface to hold the moisture and serve as a slight shade and protection, the young clover was getting a much more vigorous start than it was in the open ground where exposed to the full force of the wind and sunshine. The folly of raking and burning such litter, as is sometimes done, should be at once apparent. Not only is it greatly needed in the soil but as a surface protection

for the clover crop its value cannot be too highly appreciated. The accumulation of litter in the way of stalks, straw, manure, etc., on the surface of the soil in getting a stand of clover should be considered as something of vital importance by all farmers.

**Rotations of corn and clover only.** Only a few instances of corn and clover rotations have been encountered. These were usually corn, corn and clover, or two years of corn and two of clover. The clover in such rotations is either sown in the corn at the last cultivation or by itself in the spring without a nurse crop. Both of these methods have several objections for the use of the average farmer. The first one, seeding in the corn at the last cultivation is, under ordinary conditions, very uncertain. However, on rich black soils, some farmers were found who, being especially careful to have their corn ground in "onion bed" condition at that time, were very successful, rarely ever missing a stand of clover. But on average clay upland soils and with the cultivation the average corn field receives, especially in a dry year, seeding in the corn is a very uncertain undertaking indeed. Such a method cannot be advised for the average farmer except as he experiments with it in a very small way and finds out what results he may expect.

As for the second method of seeding in the spring without a nurse crop, in some sections they have found that it is a very certain method of getting a good stand of clover. However, it is not to be advised on fields which are badly infested with weeds, unless provisions are made for one clipping. If the conditions are favorable in this respect, and the seed is sown rather early in spring, even after one clipping, a good crop of hay or seed can usually be cut sometime during August or early September. If hay is cut and the crop not allowed to go to seed the field can be left in clover another year.

**Lime applied in the rotation.** Without the presence of a certain amount of lime in the soil, no matter what the rotation may be or how thorough the method of seeding, the clover crop will not do well. Most soils, however, in limestone and limestone-glaciated regions, usually have an abundance of this element to grow clover successfully. But again, there are other soils, such as are found in sandstone and shale regions, which were not abundantly supplied with lime in the beginning or in their virgin state. When such soils have been farmed for many years the numerous crops, and more particularly those of clover, have drawn heavily on this supply and in many instances have reduced it to the point where a full crop of clover cannot be grown. In extreme cases even though manure be applied it will produce perhaps only a half crop or less as compared with the same land on which lime is supplied with the manure, or



preferably in advance of it. Nothing can take the place of lime in some form where lime is really needed, and there seems to be no way out of it but to apply the lime to the soil.

This condition, however, may vary on different farms in the same community on the same soil formation, depending on the treatment given and the kind of farming carried on in the past. It is always well, therefore, to make sure that this need is apparent, and the only test which a farmer should consult in this is to make an application of lime on small sections of a field at different rates (perhaps a half ton, a ton, and one and a half tons per acre) and see for himself whether it produces an increased growth. If ground limestone is used in place of lime the amounts should be doubled. If it gives results then it is safe to plan for further and more extensive applications to the rest of the area that is in a similar condition, at the rate indicated as necessary by the test. If, however, no difference can be detected between the clover where the lime was applied and where it was not, even at the heaviest rate, it is fairly good evidence that it will not pay to use it. If it is found unprofitable it is poor business to use it, but if it is found that lime is really needed it is likewise very poor business not to use it and its application should not be delayed.

After the first preliminary experimenting with lime to ascertain its value, in general practice it is best to apply lime on the corn ground, whether the rotation is that with wheat, rye or oats for a nurse crop. The same is true if the clover is sown in the corn at the last cultivation or following corn the next spring without a nurse crop. When the lime is sown on the corn ground the cultivation of this crop stirs it into the soil in a very thorough manner, more so than would be the case if it were applied when the ground is being prepared for the wheat, rye or oats crop. Lime, however, can be applied at this time with good results, provided it is not convenient to do so on the corn ground.

**Value of clover in the rotations.** No rotation is complete without clover. It is the crop that supplies nitrogen to the soil, the most expensive element when it is bought in the fertilizer sack. Clover brings up the mineral elements, phosphorus and potassium, from the sub-soil, and stores them in the large surface roots and crowns to be used later by other crops. It has been estimated that a good crop of clover on one acre has in its roots and tops elements of fertility equal to that contained in ten tons of manure, the roots alone containing about one-third to one-half of that amount. It is extremely important to keep the soil well supplied with humus and decaying vegetable material, and this the clover crop does by filling it with an immense root system. The value of this feature it is not an easy matter to estimate.

Farmers in general are apt to continually underestimate the full significance and the extreme importance of this crop. However, its real and immediate value is so great, and its continued success means so much in keeping up the rotation, and the rotation so much toward keeping up a continuous and profitable system of farming, that every effort should be made and every means applied to make sure that each year there will be success in growing clover and maintaining the rotation as planned.

#### SUMMARY

On the average farm success in maintaining a profitable system of agriculture hinges very largely on keeping up a systematic rotation.

No rotation is complete without clover or some legume as a substitute for it. Hence the importance of continuous success with clover.

Continued success with this crop is a very broad problem. Failure may be due to one or more of a number of factors. Assuming that the land is well drained, and that a liberal amount of seed is to be sown, the following points are of extreme importance:

**The method of seeding.** The seed must be covered; the soil at seedtime must be in condition to insure this, and if not, the conditions are not favorable for germination and for the young clover plants taking root. If the common method of sowing on "honey-combed" ground or on the snow, in winter grains, does not afford this covering, a seed bed should be prepared by the use of a harrow, disc drill or even a disc harrow. The seed will thus be covered and moisture conserved to insure further growth. It may be necessary under some conditions to sow clover in the spring without a nurse crop, and after a careful preparation of the seed bed.

**The top-dressing of manure.** With only the ordinary method of sowing clover on the frozen ground or on snow, even on some of the poorest lands, a top dressing of manure will most generally insure a good stand. (See Figure 1). On run-down lands, and where only a limited amount of manure is available, this is doubtless one of the best ways in which manure can be utilized.

**A mulch of straw.** (See Figure 2). When sufficient manure is not available, a mulch of straw will prove very effective. If there is a slight covering of straw, leaves, stalks or other vegetable matter on the surface of the soil, it will usually insure a good stand of clover and maintain it throughout the season. Such a covering holds moisture, prevents undue baking and cracking of the soil and is a great protection to the young clover crop. (See Figure 3).

**Humus and vegetable material in the soil.** The depletion of organic matter in the soil, and its immediate effects, are doubtless responsible for many of the increasing clover failures. In its absence the soil becomes compact and lifeless, crusts and cracks and moisture escapes very rapidly, thus furnishing a very unfavorable condition for the growth of clover in its early stages. Most soils when new, and as long as properly handled thereafter, have an abundance of vegetable matter in them, and little difficulty is experienced in getting a stand of clover, but with years of continuous cropping this becomes used up and a change takes place in the soil, very largely due to this fact, which makes clover growing more and more uncertain. A decided effort should be made to correct this deficiency.

**Lime.** Most soils have sufficient amounts of lime to insure a good growth of clover if other conditions are favorable, but some soils are naturally low in their lime content. On such soils many years of cropping sometimes reduces this lime to a point where a profitable crop of clover cannot be produced. The surest and safest way for the average farmer to find out whether his fields need lime is to apply lime to a small area and watch the results on the clover as compared with no lime. Sorrel should not be taken as a certain indication that lime is needed. It will grow in the presence of an abundance of lime. Applying lime will not kill it out, but a rank growth of clover or some other similar crop will usually accomplish this.

When a farmer begins to experience failure with clover, he should avoid jumping at conclusions and saying that any one factor is the cause. It is a broad field for him to think upon and to work out, and one indeed in which there are many factors to be considered. These investigations may very probably have only touched a few of the most important of them. This report is submitted, however, to the farmers of Ohio, in the hope that it may rouse a greater interest and more careful thought on their part, and thus develop further solutions of the problems in connection with this extremely important crop.

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