ROTATIONS IN THE CORN BELT.

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"It is not so tiring, sir, to plow well,
For your mind is interested."—*English Plowman.*

INTRODUCTION.

For the purposes of this paper the corn belt will be considered as including the States of Ohio, Indiana, Illinois, Iowa, Missouri, Kansas, and Nebraska, together with the southern portions of Michigan, Wisconsin, and Minnesota, the southeastern portion of South Dakota, and the western half of Kentucky.

Within this area is produced two-thirds of all the corn grown in the United States, or about 2,000,000,000 bushels annually. Statistics of this department for the past 10 years show that on the average corn in this area yields about 31 bushels, wheat 15 bushels, oats 28 bushels, and hay 1.4 tons per acre.

These yields are only about half what they ought to be. There are many farmers within the corn-belt area on land no better naturally than the average who, year after year, are getting 50 to 60 bushels of corn, 25 to 30 bushels of wheat, 40 to 50 bushels of oats, and 2 to 2½ tons of hay per acre, with but little increase in the cost of production and with very satisfactory profits. These larger yields are the results of better methods of farming.

COST AND PROFIT IN CORN GROWING.

Since corn is the chief grain grown in the corn belt, it is presumed that farmers consider it the most profitable crop they can raise, and this is undoubtedly true where the yields are large. Data secured by the section of farm economics of this department show that it costs about $14.63 per acre to grow a 60-bushel corn crop on land worth $100 an acre. With cheaper land and lower yields the cost would be decreased.

The 10-year average yield of the corn-belt States is 30.9 bushels per acre, having an average farm value of 42.4 cents per bushel, or $13.11 per acre. It is probably safe to say that with the farm price of corn at 42.4 cents per bushel, the average for the past 10 years, and with a yield of 30 bushels per acre, there is little, if any, profit in

growing corn anywhere in the corn belt. The individual farmer does not have it within his power to influence the price of corn for the general market, but he can increase his yields by better methods of farming.

How much corn must be grown per acre to make it profitable? At the average farm price of 42.4 cents per bushel the profits per acre for increasing yields (assuming the cost per acre to be fixed at $14.63) may be seen by examining the accompanying table.

Profit in corn growing with increasing yields.

Yield in bushels per acre.	Value per bushel.	Value per acre.	Cost per acre.	Profit (+) or loss (−) per acre.
	Cents.			
31....	42.4	$13.14	$14.63	−$1.49
35....	42.4	14.84	14.63	+ .21
40....	42.4	16.96	14.63	+ 2.33
50....	42.4	21.20	14.63	+ 6.57
60....	42.4	25.44	14.63	+10.81
75....	42.4	31.80	14.63	+17.17

From the foregoing table it may be seen that with a cost of $14.63 per acre and the price of corn at 42.4 cents per bushel, a yield of 35 bushels per acre returns a net profit of but 21 cents, while the net profit from a yield of 40 bushels per acre is $2.33, and for 75 bushels per acre, $17.17.

The significance and far-reaching importance of these figures from the standpoint of a rotation of crops may perhaps be understood more fully if they are presented in a slightly different manner. Thus, based on the profits per acre as shown in the last column of the table, it may be seen that there is as much net profit in one 40-acre field of corn yielding 40 bushels per acre as there is in a 443-acre field of corn yielding but 35 bushels per acre; while a 40-acre field of corn yielding 75 bushels per acre returns as great a net profit as a 293-acre field yielding 40 bushels per acre, a 104½-acre field yielding 50 bushels per acre, or a 3,270-acre field yielding but 35 bushels per acre.

These data bring out in a striking way the importance and necessity of so handling the farm as to get increased yields above the average of 31 bushels per acre.

How can an increased yield be obtained? Data secured by the experiment stations and by this department on many farms throughout the corn belt show that it is as easy to grow 45 to 60 bushels of corn per acre after a clover or alfalfa crop as it is to secure 30 to 35 bushels after a corn or an oat crop. The agricultural experiment

station of Nebraska records[1] that in one investigation 31 farmers reported average yields of 34½ bushels of corn per acre on land before seeding it to clover and alfalfa and 68.2 bushels per acre on the same land after it was plowed up and again planted to corn.

CONTINUOUS CORN CULTURE.

When the rich, black, prairie corn lands of the Central West were first broken up it was believed that these were naturally inexhaustible lands and would never wear out. So crop after crop of corn was planted on the same fields. There came a time, however, after 15 or 20 years, when the crop did not respond to cultivation; the yields fell off, and lands that once produced 60 to 70 bushels per acre annually dropped to 25 or 30 bushels. Insects had greatly injured the crops; the land was "corn sick." In times of drought the corn easily fired.

Bad practices had developed. The stalks, having little or no commercial value, were left standing over winter for pasture and were then broken down, raked into windrows, and burned. At first the loss of this vegetable matter by burning was not noticeable, but with the passing years the soil became more compact and less friable, droughts were more injurious, and the soil baked harder and was more difficult to handle.

This practice of stalk burning is still too prevalent in many sections of the corn belt. It is a vicious practice and should be abandoned. No farmer is so rich that he can afford to burn his cornstalks and thus rob the soil of this supply of vegetable matter, which is the very first essential and foundation of good farming anywhere.

Continuous corn culture has no place in progressive farming. As a temporary practice on rich virgin soils it is legitimate perhaps for a few years while the farm is being paid for and some of the comforts are being accumulated about the home, but it is a shortsighted policy for any other purpose and is suicidal on lands which have been long under cultivation.

CORN IN ROTATION WITH OATS.

With decreasing and unprofitable yields resulting from continuous corn culture came the oat crop as an alternating and improving crop. For a time corn grown after oats gives increased yields, not very large to be sure, but still better than corn in continuous culture, and some of the older farmers in the corn belt have not yet passed beyond this stage of farming. Oats add no plant food to the soil and are quite generally an unprofitable crop. The fact that oats can be seeded in the spring and the comparative ease with which the ground

[1] Bulletin 122, Nebraska Agricultural Experiment Station.

can be put in shape for them are the chief reasons for their use. Like continuous corn culture, a rotation of corn and oats may be justifiable as a temporary makeshift, but it has no place as such in a system of permanently productive agriculture.

THREE-YEAR ROTATION: CORN, OATS, AND CLOVER.

On all the land throughout the corn belt there comes a time when the yields from continuous corn culture, or of corn in rotation with oats, fail to give satisfactory returns. Good farmers then seed clover with the oats and leave the land down in clover the year following the oat crop. The clover sod is then plowed under and the land planted to corn, thus making a three-year rotation—corn one year, oats one year, and clover one year.

The addition of clover to the rotation is a great step forward in progressive and constructive agriculture. Its use not only adds one year to the rotation, thus resting the land from corn that much longer, but it actually enriches the soil by adding nitrogen, a valuable plant food, and, what is probably fully as important, it makes available large amounts of phosphorus and potash in the soil by the decay of its roots and other residue. In the decay of this organic matter both the soil and subsoil are also improved physically. In field tests extending over 29 years on the black corn lands of central Illinois, the experiment station of that State[1] found that at the end of that time corn grown continuously on the same land yielded 27 bushels per acre as an average for the last three years of the test. Corn grown in rotation with oats yielded 46 bushels per acre, while corn grown in rotation with oats and clover yielded 58 bushels per acre without the aid of either fertilizer or manure. These results are typical.

The growing of hay paves the way for a live-stock system of farming and a more equitable distribution of labor throughout the year. The objection to a three-year rotation like this is the fact that only one-third of the farm is in corn each year. As previously shown, however, there is likely to follow as great a net profit from this one-third of the farm in corn, with its larger yields, after clover and with the aid of farm manures made on the place, as there would be on the whole farm put into corn without clover in the rotation.

In some of the newer sections of the corn belt, where the land is still rich in humus and nitrogen, some grain farmers sow clover seed with oats in the spring and then plow down the clover that same fall, thus making a two-year rotation of corn and oats, with clover as a catch crop; or two crops of corn and one crop of oats are grown. As long as a good crop of clover can be secured this system gives good results.

[1] Bulletin 125, Illinois Agricultural Experiment Station.

FOUR-YEAR ROTATION: CORN, CORN, OATS, AND CLOVER.

In a three-year rotation but one-third of the land is in corn. Since corn is the chief money crop, every farmer desires to grow as much corn as possible, consistent with good farm practice. Instead, therefore, of growing but one corn crop after the clover crop, two crops are grown and the rotation becomes corn, corn, oats, and clover. This is a good rotation on good land and about 10 per cent more profitable than the three-year rotation previously described. It is successfully carried out on practically all the ordinary prairie soils of the corn belt, where there still is, for the most part, a large stock of nitrogen and humus in the soil. To be successful over a period of years this rotation requires that the cornstalks be left on the ground, either as manure or cut up, and that the oats, clover, and possibly a part of the corn be fed on the place and the manure returned to the land. It should not be practiced on poor or run-down lands.

CORN IN ROTATION WITH CLOVER ONLY.

The fact that oats frequently fail to return a profit has led a few farmers to omit them and run a rotation of corn and clover only. Usually two corn crops follow one clover crop. This gives two-thirds of the farm in corn each year. The objection to this plan is the frequent failure to get a catch from seeding clover in the standing corn at the last cultivation. When the ground is clean of weeds and firm, but the topsoil loose and sufficient moisture present, a satisfactory stand can generally be secured, but these conditions do not prevail every year.

In case the clover thus seeded fails, the field can be disked and reseeded to clover alone the following spring. Seeding clover in this manner is one of the surest ways to get a stand on land comparatively free from weeds, but on weedy land it is no more likely to succeed than if it were sown with oats.

This rotation of corn and clover is most likely to succeed on rich, black, corn lands, where a catch of clover in standing corn is much more certain than on the average upland clay soil. This method of corn farming is successful only in the hands of the more careful and resourceful farmers and is not to be recommended as a general practice.

CORN IN ROTATION WITH WHEAT; CLOVER AS A CATCH CROP.

Corn in rotation with wheat alone is no more profitable and as certainly leads to decreased yields of both crops as does a rotation of corn and oats, but on some of the richer soils in certain sections of the corn belt where winter wheat thrives a two-year rotation of corn

and wheat, with clover as a catch crop in the wheat, has developed, which gives very satisfactory results. The wheat is seeded in the fall and clover the following spring. After the wheat is cut the clover comes on and makes a considerable late summer and fall growth, which is plowed down for corn.

In this rotation the clover is not cut for hay, the entire growth being turned under for green manure. In this system half the farm is in corn and half in wheat each year, and, as long as a good crop of clover can be secured to turn under, it is one of the most profitable rotations for a grain farm where wheat does well. Should the clover fail to catch in the wheat it is still possible in the more southern portions of the corn belt to sow a crop of cowpeas after the wheat is harvested, to be turned under for corn the following spring.

By letting the clover stand one year, and cutting for hay or seed, this two-year rotation becomes a three-year rotation, corn, wheat, and clover. By seeding timothy in the fall and clover in the spring and letting the grass stand an extra year for hay or pasture it becomes a four-year rotation. A two-year rotation of corn and wheat, with clover as a catch crop, or a three-year rotation of corn, wheat, and clover, or a four-year rotation of corn, wheat, wheat, and clover, is often adopted in sections where oats are unprofitable and the farmer desires to omit them from the rotation.

In the four-year rotation of corn, wheat, wheat, and clover the clover may be seeded with the first crop of wheat, but since the corn land is prepared by disking for the crop the ground is likely to be rough, and farmers prefer to seed with the second crop on the smoother plowed soil. This is a popular rotation on soils specially well adapted to wheat growing.

CORN IN ROTATION WITH OATS, WHEAT, AND CLOVER.

On lands in the corn belt not so well adapted to corn as the black prairie soils the small grains play a more important rôle in the operations of the farm. One of the most popular rotations in such sections and the most satisfactory from the standpoint of labor distribution is (1) corn, (2) oats, (3) wheat, and (4) clover and timothy one or two years. This rotation is adapted to either grain or stock farming, and where pasture is needed the clover and timothy may be left down two years, cutting it for hay the first year and pasturing it the second year, thus making it a five-year rotation.

The principal products sold from the farm in this rotation are wheat, live stock, and live-stock products. As long as good clover crops are secured and the manure of the farm is properly handled and returned to the land, this system will permanently maintain the humus and nitrogen content of the soil, particularly if legumi-

nous catch crops, such as cowpeas or vetch, are sown in the standing corn at the last cultivation.

In general farm practice with this rotation and with most of the rotations noted in the preceding pages in which clover is used, timothy is nearly always sown, being seeded in the fall in the case of wheat or rye and mixed and seeded with the clover in the case of spring-sown grains. Too often, indeed, timothy constitutes the greater part of the mixture and frequently it is made to replace the clover altogether. It must be remembered, however, that the timothy adds no plant food to the soil, nor does it build up the land.

The weakest place in this rotation in many sections of the corn belt is the oat crop. In many cases where farmers started this rotation when oats were a profitable crop, they do not know just how to get out of it now that the oats have become unprofitable. To meet this difficulty the rotation described below has been adopted by many farmers.

CORN IN ROTATION WITH COWPEAS OR SOY BEANS, WHEAT, AND CLOVER.

In the southern half of the corn belt, farmers generally consider oats an unprofitable crop and grow them only because they fit so well into the rotation as a crop to follow corn. Another reason sometimes assigned for growing oats in the corn belt, even where unprofitable, is in order to have the straw to use as bedding. Sometimes oats are also grown under the belief that they are essential as a nurse crop for clover. As a matter of fact none of these reasons for growing oats is valid unless each year the crop can show a profit in itself.

In southern Indiana, southern Illinois, portions of Ohio, and much of Missouri and Kansas either cowpeas or soy beans may profitably be substituted for oats in the rotation. Both these crops may be grown either for grain or hay, producing a quality of product even superior to oats for feeding purposes. Both are legumes, and therefore are superior to oats as crops for improving the land, and both possess the still further advantage of making it unnecessary to plow the ground after them, as in the case of oats, for wheat. Disking is preferable and can be effectually done when dry weather would make plowing impossible. Furthermore, both cowpeas and soy beans can be grown successfully on poorer land and on land in a poorer condition of tilth than can oats, and in themselves, either for feed or hay, they will return a greater cash value than oats.

As to which is the more profitable, cowpeas or soy beans, that matter has not been satisfactorily determined and will vary with the locality.[1] The soy beans will stand a little more frost and therefore can be safely grown a little farther north than cowpeas.

[1] See Farmers' Bulletins 318, Cowpeas, and 372, Soy Beans, U. S. Dept. of Agriculture.

Recent field observations have led to the belief that soy beans will have by far the broader general application and will thrive under a greater variety of soil conditions than cowpeas. On the heavier lands along the central and north-central sections of Ohio, Indiana, and Illinois soy beans are being grown with greater success and with greater profit than cowpeas. Throughout these sections and on the heavier corn lands cowpeas failed to give satisfactory results, but where soy beans are properly grown, which includes a proper inoculation of the soil at planting time, this crop may be very successful. Without inoculation, soy beans are being grown with marked success on some of the stronger soils. However, judging from the past experiences of farmers over large areas, it is safer to use inoculation as a precaution against failure even on the best land.

The value of the soy-bean crop in the sections mentioned is being realized more and more each year and it is rapidly filling a very important place in the rotation on the average farm. At present the crop is principally used to supply feed for live stock, but with the prevailing prices of seed, farmers will doubtless gradually go into seed production, allowing the crop to fill the same place in the rotation as at present.

With a four or five year rotation of (1) corn, (2) cowpeas or soy beans, (3) wheat, and (4) clover and timothy one year or more, the land will be plowed but once in the rotation and that for the corn crop. For the cowpeas or soy beans and for the wheat, disking the ground will usually be sufficient.

In sections where wheat is a more than usually important crop it is often desirable to grow more than one crop in the rotation. For this purpose the above rotation is sometimes modified as follows: (1) Corn; (2) cowpeas or soy beans; (3) wheat, with cowpeas sown as a catch crop immediately after the wheat is harvested and grown either for hay or disked for wheat; (4) wheat; and (5) clover and timothy. Or wheat may follow corn immediately, with a catch crop of cowpeas seeded on the wheat ground as soon as harvested. In this case the rotation will be (1) corn, (2) wheat plus cowpeas, (3) wheat, and (4) clover and timothy. Where clover does not grow satisfactorily the rotation might be (1) corn, (2) wheat with cowpeas as a catch crop, and (3) wheat with cowpeas as a catch crop, then back to corn again.

CORN IN ROTATION WITH ALFALFA.

Where alfalfa can be successfully grown, a combination of corn and alfalfa makes about as satisfactory and profitable a rotation in the corn belt from the standpoint of maintaining productiveness and financial profit as it is possible to devise. After alfalfa, corn gives

from 30 to 50 per cent larger yields than after clover. With clover about one-third of the nitrogen in the plant is in the roots and two-thirds in the portion above ground, which is removed when the crop is cut for hay; while with alfalfa about two-thirds of the nitrogen in the plant is in the roots and only one-third in the portion above ground. Owing to the fact that it usually takes a full year to get alfalfa started and that it is not desirable to plow up the fields so long as good yields are being obtained, the land is left much longer in alfalfa than in the case of clover, and more corn crops are grown before returning to alfalfa. A typical rotation is the following: (1) Corn, (2) corn, (3) corn manured, (4) small grain seeded with alfalfa, and (5) alfalfa three to six years. On land where it is difficult to secure a stand of alfalfa with a nurse crop of small grain, the small grain is omitted.[1]

In these two crops, corn and alfalfa, is realized more nearly than in any other combination of crops yet grown in the corn belt the maximum of grain and hay yields and of profits that can be secured from an acre of land by ordinary methods of farming. Wherever a farmer can substitute alfalfa for clover and timothy in the rotation without too great a cost, he will be able practically to double his profit.

CORN IN ROTATION WITH RYE.

Rye is a very minor crop in the corn belt, constituting less than 1 per cent of the total grain grown. Nevertheless it has an important place in some sections, particularly on the sandy and poorer soils, where it will often give a fair yield when wheat, oats, or barley will return little. It is also regarded as a better crop to seed clover with than any other of the grains, as it is less leafy and is sooner harvested, thus giving better opportunity for the clover to grow. One of the most popular rotations is (1) corn, (2) rye, and (3) clover, each one year. Rye, like wheat, is seeded either in the standing corn or after the corn is removed in the fall, and the clover is sown the following spring. Rye, of course, like all grains, responds to better soils and on the richer lands of the corn belt is often used as a substitute for oats in a rotation of corn, corn, rye, and clover.

CORN IN ROTATION WITH BARLEY.

Only in one State in the corn belt does barley amount to as much as 1 per cent of the grain grown. In Iowa, however, nearly 4 per cent of the total grain crop is barley. Barley requires as good land for its successful culture as oats. It occupies exactly the same place in the rotation as oats, except in the case of winter barley, but is

[1] For methods of growing alfalfa see Farmers' Bulletin 339, U. S. Dept. of Agriculture; also Bulletin 155, Kansas Agricultural Experiment Station.

regarded as superior to oats as a nurse crop for clover. In Iowa the last 10-year average shows a little larger cash return per acre for barley than for oats. Rotations of (1) corn, (2) barley, and (3) clover, or (1) corn and (2) barley, with clover seeded in the barley and plowed down the same fall for corn, and all the other combinations mentioned in the preceding pages with oats, may be successfully practiced with barley.

MISCELLANEOUS ROTATIONS.

With the preceding crops the number of possible rotations is limitless; only the most practical of these which may affect most farmers have been touched upon. Local rotations where corn does not form a part have been entirely omitted. A 6-year rotation of (1) corn, (2) corn, (3) oats, (4) corn, (5) oats, and (6) clover has been found on a grain farm where but little hay was required. Farther south a rotation of (1) corn, (2) corn, (3) cowpeas, (4) corn, (5) clover, and (6) clover has been used on a hog farm, and while meeting the needs of the hogs, bunched the labor too much in the spring. On some large cattle farms a rotation of corn four or five years with hay and pasture four or five years is successfully practiced.

PRINCIPLES GOVERNING THE ESTABLISHMENT OF ROTATIONS.

Farmers adopt rotations because they desire (1) to get larger yields and profits per acre; (2) to distribute their work more equitably throughout the season; (3) to be more certain of an annual income than is possible where a single crop is grown; (4) to maintain the productiveness of the farm; and (5) to minimize the injury from weeds, insect pests, and diseases that generally accompany a system of one-crop farming. A systematic rotation whereby different crops follow one another from year to year on each field of the farm in orderly succession makes possible a more careful planning of the year's work.

In planning a rotation it is necessary to keep in mind the income it will bring, the needs of the land, the requirements of the stock kept on the place, the effects of each crop on the yields of the succeeding crops, and the profitable distribution of labor. There are three main classes of crops to deal with in planning a rotation: (1) Small grain crops, (2) hay crops, and (3) cultivated crops. Long experience has taught that as a general proposition permanently productive and profitable farming requires that these three classes of crops be systematically rotated with each other. This proposition holds true for the corn belt.

In the rotations discussed, corn is the cultivated and cleaning crop of the rotation, but the area of corn land that can be cultivated effi-

ciently with the usual farm force is limited. This makes desirable the planting of some other crop, such as wheat or oats, which can be put in before corn is planted and requires no cultivation. When the corn is laid by, the harvesting of the grain can begin.

Both the corn and the small grain reduce the productiveness of the land; therefore to offset this a soil-enriching crop, such as clover, cowpeas, vetch, soy beans, or alfalfa, should be grown.

LEGUMES IN THE ROTATION.

Every successful rotation revolves around some legume as a chief soil enricher and conditioner. So far as known, history does not record a single instance of any long-continued successful system of general farming that has not included one or more legume crops. The legume is the key to every rotation. The principal legume in the greater part of the corn belt is red clover. In Kansas and Nebraska it is alfalfa. When clover winterkills, in order to meet the immediate situation in the southern half of the corn belt, the field should be disked or plowed and planted to cowpeas or soy beans. If too far north for these, a mixture of Canada field peas and oats for hay or grain in the proportion of 1 bushel of peas to 1 of oats may be planted. If red clover seeded in the spring fails to show a stand at harvest time, the stubble should be thoroughly disked, reseeding to clover and harrowing it in. This should be done by the middle of August or before the first of September if possible. The chances are that the clover will make a fair growth that fall and live through the winter. The importance and methods of securing stands of clover in the corn-belt rotations are forcibly brought out by J. A. Drake [1] in his circular on this subject. On all of the poorer corn lands cowpeas and soy beans should be used at the last cultivation of the corn crop as a green manure and for pasture where stock are kept. In the more northern sections, especially on sandy lands, hairy vetch should be sown.

The use of alfalfa on the richer and better drained lands of the corn belt is highly desirable, and to that end it is suggested that from 2 to 3 pounds of seed per acre be mixed each year with the clover and timothy sown until all of the fields of the farm become inoculated and this legume forms a large part, if not all, of the hay grown. It not only increases the hay yield, but corn also yields more after alfalfa than after clover.

FERTILIZERS IN CORN-BELT ROTATIONS.

A rotation of crops, even where clover is grown, is not sufficient in itself to maintain the productiveness of the soil. After a while the

[1] The Management of Clover in Corn-Belt Rotations. Circular 111, Ohio Agricultural Experiment Station.

clover fails; then the whole system of farming fails. Clover is beginning to fail on many of the corn-belt farms. So long as crop yields are satisfactory the matter of commercial fertilizers may be neglected. A good rotation with the judicious utilization of all the farm manure is the first essential. When the yields in such a system begin to fail, then commercial fertilizers may be considered. Rightly used as a supplement to a good rotation and to farm manures, commercial fertilizers are profitable and their intelligent use advisable. Used without a thorough understanding of their nature and the part they play in the growth of a crop, loss is as likely to result as profit. Practically all the agricultural experiment stations in the corn-belt States have issued bulletins dealing with the use of fertilizers for different crops, for which the reader should send.

SUMMARY.

(1) Average corn yields return little or no profit.

(2) Continuous corn culture, or corn in rotation with oats, barley, timothy, wheat, or other exhausting crops, is justifiable only as a temporary expedient, like getting out of debt. Such a cropping system leads rapidly to decreased yields and a run-down farm.

(3) The addition of clover, alfalfa, or other legume, to the rotation is a long step forward in progressive, profitable, and permanent agriculture. It is the first step necessary in building up the farm and in maintaining increased yields.

(4) A rotation of crops alone, even when clover is included, will not maintain yields permanently. After a while the clover fails. With it the whole system fails.

(5) Barnyard manure is one of the best fertilizers to use in keeping up yields permanently. In addition, some soils require that lime and phosphorus, or potash, or all three, be added to secure the highest thrift of the clover crop and the greatest yields of corn.

(6) Legumes, live stock, and fertilizers, stated in the present order of importance in the corn belt, are the essential features which enter into a system of farming that will keep the soil permanently productive and return maximum yields.