# ROTATION OF CROPS FOR CENTRAL KANSAS.

by

RALPH B. FELTON.

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So fertile is the virgin soil of Kansas that the farmers of the past have been able with but scanty tillage to reap bountiful harvests. Nature has stored up vast supplies of plant food and humus, and this together with even scant tillage making an ideal seed bed, capable of retaining such moisture as fell. With these ideal conditions the farmers have raised year after year those crops that would bring in surest and quickest returns. The farmers of Central Kansas have continuously cropped their ground to wheat,with total disregard to the effects of such a system upon the soil. As a result the yield in many places has gradually dropped from twenty-five to fifteen bushels per acre, and if this system is long continued it will become possible to raise paying crops, only by the addition of costly fertilizers. If proper methods were adopted at once, the maintainance of soil fertility, and a continuation of good crop yields, would be a comparatively easy proposition, but if we wait till we have nothing but a worn out soil to work with the task is a far more difficult one, and the business of farming will become much less profitable than at present.

Let us notice briefly the method practiced on many of the large wheat farms of Kansas. As soon as one crop of wheat is remov-

ed, the farmers immediately commence preparing the same soil for next years crop. From this time till late in the fall he plows day in and day out, whether the ground be wet or dry. One such crop injures the physical condition of the soil more than would two or three crops properly raised. The farmer may be unconscious of the fact, but the fact never-the-less remains, that he is robbing the soil in a wholesale manner of plant food that should have been conserved to raise crops for years to come. The farmers of the past have made rich gains by such a method but the farmer of the future must pay natures debt with heavy interest.

If we doubt the ultimate disastrous effects of our present system, we have only to turn to the Eastern United States. In many of these states it is extremely difficult to raise crops and fertilizers must be constantly resorted to. If this soil had been properly handled, it would be in a far better condition. We are told that in some of the countries of the old world, it is necessary to add as much plant food to the soil as is removed from it, and the care these people take in utilizing the soil fertility would certainly be an object lesson to us. It is true that the importance of crop rotation is coming to be recognized, to some extent throughout the wheat belt, but the rotation that is practiced, while beneficial, is far from complete. It usually consists of a shifting of the corn and wheat once in three or four years, and in some cases oats may enter into the rotation. Such a system as previously stated, is more or less beneficial, but lacks two important crops, the legumes and grasses, without which it is impossible to keep the soil in a proper cropping condition. Both of these crops improve the physical condition of the soil, and the former adds nitrogen, the only element which is likely to be lacking in Central Kansas soils. I shall refer to this subject again.

In this connection it may be interesting to give a short history of crop rotation, together with some of the theories that were early advanced to explain the beneficial effects of such a system upon the soil. The earliest records of attempted systematic cropping are amongst the old Roman and Greek writings. Even at this early period it was a known fact that better crops might be raised and the soil kept in better condition, if the crops were grown in rotation. The principles of plant nutrition were not understood at this time, so it was impossible for the early writers to explain the causes of the beneficial effects and we have no records of any attempts to do so, until several hundred years later.

Less than two hundred years ago English scientists began to study the question and theories have been advanced from time to time to explain the peculiar effects of rotation upon both the soil and the crops under cultivation; each theory in turn proving inadequate as more light has been thrown upon the subject.

One of the first theories offered to explain why a given plant,- for example wheat,- when grown year after year on the same soil did not do well, was that it threw off an excreta, injurious to itself but beneficial to other plants. Later investigators repudiated this theory and advanced another quite the opposite to take its place. The latter theory upheld the thought that each species of plant extracted some substance from the soil peculiar to itself, and that a continuous raising of one crop on a given soil removed and reduced to a minimum, the amount of this component in the soil. This theory is of course largely false as plants all contain practically the same elements, but there is under-lying the theory a certain truth. No two varieties of plants contain the essential constituents in the same proportions as is shown in the following table.

Amounts of the Different Elements that Different Crops Remove From the Soil. ( Chamber Encyclopedia).

| Crop | Amount | Nitrogen | Potash | Lime | Phos. Acid | Silica |
|---|---|---|---|---|---|---|
| Wheat | 30 bu. | 48 lb. | 28.8 | 9.2 | 21.1 | 96.9 |
| Barley | 40 bu. | 48 lb. | 35.7 | 9.2 | 20.7 | 68.6 |
| Oats | 45 bu. | 55 lb. | 46.1 | 11.6 | 19.4 | 85.3 |
| Turnips | 17 tons | 112 lb. | 148.8 | 74.0 | 33.1 | 7.7 |
| Mangolds | 22 tons | 147 lb. | 300.7 | 42.9 | 62.9 | 17.9 |
| Potatoes | 6 tons | 47 lb. | 76.5 | 3.4 | 21.5 | 2.6 |
| Beans | 30 bu. | 99 lb. | 67.1 | 29.2 | 29.1 | 7.3 |
| Clover Hay | 2 tons | 102 lb. | 83.4 | 90.1 | 24.9 | 7.0 |
| Meadow Hay | 1.5 tons | 49 lb. | 50.9 | 30.1 | 12.3 | 56.9 |

Notice the difference in the amount of Potash removed from the soil by wheat and clover hay. The latter uses almost three times as much as the former. It will also be observed that clover hay uses twice as much nitrogen as does wheat, but this is taken largely from the air, so that when a crop of clover is plowed under the soil is richer in nitrogen than before the crop was grown. The wheat removes about fourteen times as much silica as does the crop of clover. Thus the rotation of these crops would mean an equalization in the amounts of the different elements removed from the soil. Similar comparisons may be made between other crops given in the table and this emphasizes strongly the importance of changing or rotating the crops grown in a field from year to year. In England, as was mentioned before this was recognized, and to-day on all farms operated by progressive farmers, a regular rotation of crops is practiced. These consist of either four or five year "shifts" as they are called vary-

ing, of course in details for different localities, but being essentially as follows:

Four Shift System.

Fallow, manured; turnips, fed off; oats or barley; grass; wheat.

Five Shift System.

Fallow turnips; oats or barley; clover; peas; wheat.

It is said that by the introduction of the turnip alone thousands of acres have been reclaimed for cultivation that would have otherwise been useless to the farmers of the country.

Russia is equally progressive in this line. The peasants of the great plains region who would appear so ignorant to us have a considerable knowledge of the fundamental principles into practice. Even in the semi-arid districts, a regular system of rotation has been practised for a number of years. In some of the best systems, the same crop is never put on a field two years in succession.

Going back to the fundamental principles of crop rotation, it is now generally recognized that crop rotation proves beneficial in three ways:

1. Conserves plant food.
2. Improves the physical condition of the soil.
3. Facilitates weed destruction.

Let us notice briefly the importance of these three points as shown in the table stated above. No two crops make the same requirements upon the soil and the observation was made that a proper shifting of crops would equalize the amounts of the different elements used, thus greatly lengthening the period of soil productivity. Let us notice in this connection the importance of legumes as soil builders. Nitrogen seems to be an element least supplied by nature, and

one which the majority of our cultivated crops exact of the soil in considerable quantities. This element when purchased in chemical compounds in the form of fertilizers, is quite expensive. Thus, it would seem wise to include in the list of crops grown, some that will add this element to the soil. This is where the leguminous crops prove so beneficial. Through the aid of bacteria living within their roots they are able to use the nitrogen of the air. When the ground is plowed up and put to other crops, after having raised a crop of legumes, an increased yield is always noticed and is due largely to the larger supply of available nitrogen left in the soil by the legume crops. As the country grows older, this class of plants must surely assume an important position in economic crop production.

The second point mentioned in stating the three chief benefits of crop rotation, was the fact that such a system improves the physical condition of the soil. A contrast of two fields, one which has been constantly seeded to wheat and another on which a rational rotation has been practiced, fully illustrates this point. The soil of the first field is hard and lifeless. A rain caused it to run together and bake, and in a way that often chokes the growing crops. When the weather turns dry this is the first soil to show a lack of moisture, for it is in a condition to evaporate the moisture at the maximum rate. It lacks humus, a condition quickly brought about by improper cropping, and good crops can never be raised until the condition is remedied, and the condition must be remedied, chiefly through addition of manures and proper crop rotation. The second field mentioned, will be found nice and mellow; an ideal seed bed, capable of retaining moisture and producing good crops. The notable fact is that the second field makes larger returns per acre, than does the first, while it is at the same time being kept in good condition.

The third point we note is, that a proper rotation aids in keeping down noxious weeds. This point may not seem very important at first, but as the country grows older the fighting of weeds constantly becomes of greater importance and more difficult. On the farms in McPherson County where the land has been cropped for some twenty-five or thirty years, this is very noticeable.

There are two classes of crops, which materially aid in destroying weeds; those that crowd out the weeds, such as alfalfa; and cultivated crops, such as corn which simplifies their destruction. Again there are certain kinds of weeds which proper wheat culture materially retards. By alternating these three crops then, we have the very best opportunity to fight all classes of weeds. Thus far this discussion has related to the possibility of keeping the soil in good condition by a proper system of cropping, but the question must also be treated from another point of view. The farmer is a hard working individual who is doing his work as a means of gaining a livelihood, and of course could not be expected to adopt and grow crops that would mean less money in his pocket, in the long run. It would be absurd, to suggest that the farmer adopt a system of cropping that does not pay, just for the pleasure of keeping his soil in good condition. But the fact is that crop rotation highly recommends itself because the farmer can raise good paying crops and yet keep the soil in good condition, which means large yields for years to come.

In producing commodities for the market, the farmer should as far as possible, produce those which make least requirements upon the soil. To illustrate, it is said that of every $100 worth of wheat sold from the farm, $60 represents actual plant food removed from the soil, and this amount must be returned before the soil is in as good condition as it was before the crop was produced. If every

$100 worth of cattle sold $7 represents actual plant food removed; while of $100 worth of butter sold 50¢ covers the cost of plant food removed from the soil ~~removed~~. Thus if a man can make as good money raising cattle as he can in producing wheat, see how much less he is exacting of the soil. Of course in the last two cases it is implied that all manure made on the farm will be returned to the soil.

In Central and Western Kansas, a proper rotation is a more or less difficult proposition. A complete rotation must contain both legumes and pasture grasses. The only legume that has met with any great success in this region, is alfalfa, and it seems not ~~at~~ all together practical in a rotation. The difficulty in seeding down makes the farmer hesitate to plow it up as long as there is a good stand. It is, however, of unquestionable value in a rotation with other crops and if future experimentation teaches us some surer method of seeding it will undoubtedly come into extensive use in scientific rotations. Alfalfa is a most valuable feed, and this makes its extensive use desirable. Soy beans and cow peas have also been tried to some extent in this region, but neither have proved very successful as yet. They are both good drouth resisters and of excellent quality of feed, and there seems no good reason why they should not come more into use in years to come.

The raising of pasture grasses is still more difficult. None of the pasture grasses which do so well in the east, such as blue grass, can be successfully produced in the Central Kansas regions. A grass, however, which promiese well at present, and which may come into extensive use in the future, is bromus inermis. It makes excellent pasture, comes early in the spring, and lasts well into the fall, and is apparently beneficial to the soil, although evidence on this point is not yet conclusive.

Unfortunately no experiments have been carried on at any of the Western Experiment Stations for sufficient length of time to determine what particular rotation is best fitted for conditions similar to those of Central Kansas, and in fact it is not possible to lay down a system that will be practical on all farms of any given locality. Any suggestions which are given must be more or less general and must be varied to meet individual cases.

At the South Dakota Station there has probably been more work of this kind done than in any other Western State. At the time their last bulletin (No. 29) was published, the experiment had only been in progress some five years, so the results obtained so far are not all together conclusive, but are, however, of considerable interest. Eighteen different rotations were planned, two, three, four and five years in length. Each rotation had as many plots as there were crops in the rotation and in this way every crop in the rotation was being grown each year, thus doing away with any variation due to difference in seasons. It will not be possible to give the experiments and results in full but the following points of especial interest may be noted. The crop immediately preceding wheat had the chief effect upon its yield. Wheat was used as the basis of all the rotations so the effects upon its yield were especially noted.

The best average yield of wheat was wheat following summer fallow. The next best yield resulted from wheat following corn. The lowest yield came from wheat following oats.

Wheat following millet gave a yield below the general average. Continuous cropping of wheat gave a yield of one and one-half bushels below the average.

The following is a table showing the effects of the immediately preceding crop upon wheat.

| | | |
|---|---|---|
| Wheat after corn, | Average yield | 16.28 bu. |
| Wheat after fallow | " " | 16.58 " |
| Wheat after millet | " " | 14.25 " |
| Wheat after peas | " " | 13.97 " |
| Wheat after oats | " " | 11.8 " |
| Wheat after wheat | " " | 13.2 " |

It will be noted that poor results were obtained from wheat following peas. It is thought that this is because the soil is still ~~un~~sufficiently rich in nitrogen. Also in the case of wheat following wheat if it were continued for a longer time it is probable this yield would become markedly less.

Another point of interest in the experiments was the fact that it seemed to make no difference how often wheat came in the rotation just so it did not come every year, the crop immediately preceding ~~wheat~~ wheat seeming to be the only one which had any particular effect upon its yield. This is illustrated in the following table.

| | | |
|---|---|---|
| Wheat once in 5 years | Average yield | 15.27 bu. |
| Wheat once in 4 years | Average yield | 13.04 " |
| Wheat once in 3 years | Average yield | 13.94 " |
| Wheat once in 2 years | Average yield | 15.33 " |

At our own Kansas Station experiments in crop rotation are being conducted at present which should be followed with interest by all Kansas farmers.

The following are a few rotations advised by Professor A. M. Ten Eyck of the Kansas Experiment Station for varying Kansas conditions. No1. Grass; Pasture; Wheat; Wheat; Legumes and Forage; Wheat; Wheat; Grain; etc.

No. 2. Legumes; Wheat; Wheat; Wheat with manure last year; Legumes; Wheat; Wheat; with manure; Grain.

No. 3. Wheat and cow peas; Corn and manure; Grain; Wheat and cowpeas.

No. 4. Legumes; Forage; Wheat; Wheat; Grain; Legumes; Wheat; Wheat; Grain;

Following are a few more suggestive rotations:

No. 1. Alfalfa four years; corn and manure, one year; wheat, three years;

No. 2. Bromus inermis, four years; with manure, one year; corn, one year; wheat, three years;

In either of the last two rotations named it would be advisable to have the farm divided into two divisions, and while pasture was being produced on one part, wheat would be produced on the other, etc.

No. 3. Corn; Wheat; Wheat; Oats; Legumes with manure; Corn; Wheat; Wheat;

No. 4. Wheat; Corn; Wheat; Legumes:

No. 5 Wheat; Wheat; Wheat; Corn; Oats:

As stated above it is impossible to lay down a rotation system that will meet all demands. In the above suggestions possibilities are shown and some one of these may be made to form the foundation for a rotation that will mean in years to come a better soil condition. The farmer who is familiar with the conditions existing on his own farm can plan a rotation that will mean a variety of crops, better yields, more ideal soil conditions, and a more prosperous and contented farmer.