# THESIS

## FERTILIZER REQUIREMENTS OF UNPRODUCTIVE SOILS

by

Ernest Adams

&

R. E. Williams

upon graduation from the

K A N S A S  S T A T E  A G R I C U L T U R A L  C O L L E G E

1907.

# FERTILIZER REQUIREMENTS OF UNPRODUCTIVE SOILS

Soils are unproductive for many reasons, among which are lack of moisture, absence of bacteria, excess of soluable salts, and some of the essential elements to plant growth. It is of this last requisite that we treat in this paper.

Among the necessary chemical elements for plant growth, those that are most liable to be deficient in available form are: N. P. and K. Some soils are lacking in lime as is shown by their acidity.

Since we are unable to tell the elements that are deficient in an unproductive soil by chemical analysis, we have to determine them by experimental work. A new method for determining the unproductiveness of soils is by the wire basket method. This is the method that we have used in conducting this experiment. This method is quicker than field tests and promises to be practical.

The soil used in this experiment was taken from one of the poorer fields on the College Farm. It was put in good condition, different fertilizers added, placed in wire baskets, and five grains of wheat planted in each basket. After running the experiment for about four weeks the fertilizer requirement was determined by the growth of the wheat and the amount of moisture used.

The baskets used were about three inches deep and three

inches in diameter. They were filled with soil and then covered with paroffin. After the wheat was up the tops were sealed with paroffin and paper so as to prevent evaporizion.

Wire having 1-8 inch mesh and a size heavier than window screen wire was used to make the baskets. Strips 3.5 inches wide were cut off and then cut into three strips ten inches long. These were then bent around a three-inch gas pipe and riveted with split copper rivets, one rivet being place as near the top as possible and the other 3-4 inch from the bottom.

From six to eight cuts 1-2 in. long were then made in the lower edge and the pieces bent up to support a bottom. Then round bottoms, previously cut out, were placed in and supported by these bent up strips.

The baskets were then ready to dip into paroffin. They were dipped top first half way down in paroffin that was just too hot to solidify. This process was continued until a solid ring was formed. Then a sheet of heavy tin was ruled into spaces 1-2 x 3-4 in. and numbers from one to sixty stamped on them and holes punched in them. Light wire was passed through these holes and the marks thus attached to the top of each basket, when they were then ready to fill with soil.

The soil was taken from various places in a field on the College Farm. This field did not produce large crops. The same sized samples were taken in each place and to a uniform

uniform depth of six inches and enough samples were taken to get a true average of the entire field. These soil samples were spread out on a clean cement floor and dried. They were then pulverized by running through a fine sieve and then completely mixed by shoveling back and forth. Next 9.4 lbs. or 4272 g of soil was put into each of twelve covered half-bushel measures. The moisture content was found to be five per cent, so figuring on a dry basis, 4068 grams of soil was used in each bucket.

The method of determining the amount of fertilizer to get the correct rate per acre was as follows, figuring the weight of the soil per acre as 2100000 lbs:

In the case of manure:

3000 : 2100000 : : x : 9.4
X = .134 lbs. to be added to get 15 per acre.
.134 lbs.= 60 grams.

The commercial fertilizers were applied in such small amounts that it was impracticable to weigh them out, so stock solutions were made as follows:

10 gms. each of $C_aH\ Po_4$ , $N_a\ No_3$ , $K_2\ So_4$ and $Fe\ So_4$

These were weighed on a chemical balbance and then added to a liter of distilled water and dissolved and then the required amount of solution was added to the soil. Since a liter contains 1000 cc the weight of salt in each cc of solution must be 1-100 gram.

If 60 grams are necessary to get fifteen tons per acre, then four grams will give one ton per acre.

To find the amount to apply to get 150 pounds per acre,

1952 76

divide 2000 by 150 getting 13.3.

4 ÷ 13.3 = .3 or amount of salt necessary to all.

Since each cc of the solution contains 1-100 gram, 30 cc must be added to have fertilisers at the rate of 150 lbs. and 60 cc to get rate of 300 lbs. The following table shows the amounts added to each measure of soil:

| No. of basket. | Kind of fertilizer. | Amt. added | Amount per acre. |
|---|---|---|---|
| 1. | Lime | 4 gms. | 2000 lbs. |
| 2. | Green manure | 20 " | 5 ton. |
| 3. | Manure | 60 " | 15 " |
| 4. | $Ca\ H\ Po_4$ | 60 cc | 300 lbs. |
| | $Na\ No_3$ | 30 cc | 150 " |
| | $K_2\ So_4$ | 30 cc | 150 " |
| 5. | $Na\ No_3$ | 30 cc | 150 " |
| | $K_2\ So_4$ | 30 cc | 150 " |
| 6. | $Ca\ H\ Po_4$ | 60 cc | 300 " |
| | $K_2\ So_4$ | 30 cc | 150 " |
| 7. | Check | | |
| 8. | $Ca\ H\ Po_4$ | 30 cc | 150 " |
| 9. | $Na\ No_3$ | 30 cc | 150 " |
| 9. | $Fe\ So_4$ | 20 cc | 100 " |
| 10. | $Na\ No_3$ | 30 cc | 150 " |
| 11. | $Ca\ H\ Po_4$ | 30 cc | 150 " |
| 12. | $K_2\ So_4$ | 30 cc | 150 " |

This mixing was done April 24, 1907.

The lime used was slacked and completely pulverized. The green manure was green alfalfa, cut from the field and chopped very fine. The manure was from a barnyard and had leached some.

The fertilizers were thoroughly mixed with the soil by hand and left until the 30th of April, when enough distilled water was added to bring each up to 18 % moisture, which amount was determined to be best for growth by careful handling. The total amount of water necessary to bring each measure up to 18% was 530 grams. Some of this water was applied in the stock solutions added, and the total amount that was added was subtracted from the 530, leaving an amount to be added in case of bucket No. 4 410 grams, and No. 5 470, etc.

Three days before the moisture was added some wheat had been put in a germinator to be ready when needed. Only plump, even sized kernels were used. Then five of the wire baskets were filled to within 1-2 inch of the top of the basket with soil from each of the twelve measures. The first basked was filled, the soil being pressed firmly in. It was them emptied and the soil carefully weighed and found to be 273 grams. This amount was put into each of the other baskets.

Five kernels of wheat were then carefully placed a quarter of an inch below the surface near together in a row. Only kernels that had made the same progress in germination

were used, the average length of the sprout being 5-8 in. Next a 1-4 in. layer of fine sand was spread over the top of the soil. The amount put into each basket was the same and was measured in cc by a graduate glass tube. The reason the sand was used is that it will not permit as rapid evaporation and will not bake as readily as soil.

The baskets were then dipped and redipped into melted paroffin until a continuous inferior layer had been made over the entire surface, the wire acting as a frame. Each basket was then immediately weighed on a scale weighing to .1 grams and this weight was taken as the optimus moisture condition for the soil.

The baskets were then weighed every third day until the plants were about two inches high, which was about ten days. At each weighing enough distilled water was added to bring each back to the optimus moisture condition.

On the tenth day of May the baskets were sealed up by means of paper disks dipped in melted paroffine, a slit being cut in each disk to fit over the plants and to allow water to pass through. The edges were well seasled and the only loss was through the leaves. So, knowing the relative amount of water lost or transpired the relative amount of growth could be determined.

Just before sealing each basket was brought to the optimus weight and after sealing each was again weighed and this last weight taken as the optimus. The baskets were then weighed every three or four days until June1. A record

1955

was kept of the amount of water lost with the following results, records being kept of each fertilizer instead of each basket:

Water in Grams used by each Five Baskets.

| | May | | | | | | | | June | Total | Rank. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13 | 16 | 18 | 20 | 22 | 24 | 27 | 29 | 1 | | |
| Lime Manure | 29 | 29 | 48 | 41 | 51 | 60 | 54 | 30 | 34 | 376 | 6 |
| Green Manure | 20 | 29 | 41 | 42 | 46 | 61 | 63 | 33 | 48 | 382 | 5 |
| Manure | 29 | 34 | 46 | 41 | 41 | 60 | 60 | 32 | 46 | 388 | 4 |
| Complete | 25 | 31 | 45 | 48 | 51 | 62 | 55 | 40 | 51 | 418 | 2 |
| N & K | 26 | 30 | 46 | 54 | 51 | 66 | 68 | 26 | 46 | 413 | 3 |
| P & K | 29 | 34 | 50 | 48 | 47 | 65 | 57 | 32 | 48 | 425 | 1 |
| Check | 27 | 30 | 45 | 41 | 41 | 50 | 69 | 22 | 26 | 357 | 11 |
| P & N | 21 | 31 | 39 | 39 | 42 | 53 | 60 | 28 | 41 | 354 | 9 |
| Fe | 26 | 28 | 44 | 39 | 44 | 51 | 51 | 32 | 43 | 356 | 8 |
| N | 21 | 28 | 43 | 37 | 42 | 52 | 63 | 29 | 47 | 352 | 10 |
| P | 21 | 27 | 37 | 35 | 40 | 51 | 52 | 30 | 34 | 324 | 12 |
| K | 27 | 28 | 41 | 43 | 43 | 56 | 58 | 30 | 32 | 358 | 7 |

On the 4th of June the wheat was clipped at the surface and weighed on an analytical balance. The tops from each five baskets containing the same kind of fertilizer were weighed together. Had the soil all been the same the growth should have been equal but since different pertilizers were used, there was a noticeable difference in the amount of growth.

1956

Showing growth made by each five baskets.

| | Wt. in gr. | Rank as to Wt. | Wt. $H_2O$ used. | Rank asto water used. |
|---|---|---|---|---|
| Lime | 3.90 | 5 | 376 | 6 |
| Green Manure | 3.78 | 6 | 382 | 5 |
| Manure | 3.95 | 4 | 388 | 4 |
| Complete | 3.89 | 3 | 418 | 3 |
| N & K | 4.00 | 2 | 413 | 2 |
| P & K | 4.18 | 1 | 425 | 1 |
| Check | 3.48 | 11 | 351 | 11 |
| P & N | 3.68 | 8 | 354 | 9 |
| Fe $So_4$ | 3.50 | 10 | 356 | 8 |
| N | 3.73 | 7 | 352 | 10 |
| P | 3.20 | 12 | 324 | 12 |
| K | 3.63 | 9 | 358 | 7 |

Theoretically the results obtained from weighing the tops and from the amount of water used should be the same, and each should furnish a reliable method of determining which fertilizer was best to apply. The variation may be due to the imperfect sealing of the baskets, allowing more water to evaporate, and inaccuracy in weighing and measuring the soil. Also there may have been a difference in the kernels of wheat used. Some may have been slightly stronger growers than others.

The baskets containing Ca H $Po_4$ and $K_2$ $So_4$ gave the

best results in each case, showing .18 gr more growth and using several grams more water. So it is fair to conclude that it is the best combination to apply.

There was very little difference between the complete fertilizers and the nitrate and potassium salt used together, the former using five grams more water and the latter showing .02 gr. more growth. The $CaHPO_4$ seems to be of little value in this case so it would be more economical to use the cheaper fertilizer.

The fertilizer showing the next best results was manure in each case, but there is only a very little difference, ( 8 gms. ) in the water used by the manure, green manure and lime. The green manure baskets showed a growth .17 gr. lighter than the manure, but this is not sufficient to give one an advantage over the other.

This was probably not a fair trial for the manure and green manure, as they were added in solid form and had no opportunity to decay and becaome a part of the soil. If they could have been mixed several weeks sooner, their results would probably have been better. Their greatest action must have been to improve the texture of the soil.

In the next five sets there can be very little choice. As this includes the check plot we see that very little was gained by the use of these fertilizers. There is only a variation of 7 grams in the amount of water used, and .25 grams in the amount of growth made. As it is improbable that results worked out absolutely, we must conclude that