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D. D. Johnson

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Agricultural Experiment Station

MORGANTOWN, W. VA.

PLAT EXPERIMENTS

WITH

COMMERCIAL FERTILIZERS

ON

WHEAT.

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PLAT EXPERIMENTS WITH COMMERCIAL FERTILIZERS ON WHEAT.

By D. D. JOHNSON.

For the purpose of these experiments, two and one-half acres were selected at each of the Out-Stations and divided into plats of one quarter of an acre each. The plats are placed side by side in the order in which they are named in the tables except at the Out-Station in Doddridge county, at which Out-Station plat No. 11, lies on the outside of plat No. 1, and is in fact the beginning of the series. All of the plats except No. 11 above referred to, are parallelograms; each plat being $247\frac{1}{2}$ feet long and $43\frac{1}{2}$ feet wide, the plats being separated from each other by strips of land three feet wide which were neither fertilized nor seeded. Plats, Nos. 1 and 6, at three of the Out-Stations were not fertilized. Through a mistake of the farmer, Plats Nos. 1 and 6 were omitted and plat No. 11 was left unfertilized at the Out-Station in Roane County.

The fertilizers used to supply the necessary plant food were Kainit, containing 14 per cent. of Potash; Muriate of Potash containing 50% of Potash; Sulphate of Potash containing 25% of Potash; Nitrate of Soda containing 15% of Nitrogen; Dried Blood containing 12% of Nitrogen; Ground Fish containing 7.5% of Nitrogen and 4.5% of Available Phosphoric Acid; Tankage containing 5.5% of Nitrogen and 12% of Available Phosphoric Acid; South Carolina Dissolved Bone containing 14% of Available Phosphoric Acid and 11% of Sulphate of Lime; Dissolved Bone Black containing 17% of Available Phosphoric Acid and 13.5% Sulphate of Lime, and Stable Manure.

The Sulphate of Potash was applied at the rate of 200 lbs. per acre; the Nitrate of Soda, Dried Blood and Muriate of Potash each at the rate of 160 lbs. per acre; the Ground Fish at the rate of 240 lbs. per acre; the S. C. Dissolved Bone and the Dissolved Bone Black each at the rate of 320 pounds per acre; the Tankage at the rate of 400 pounds per acre; the Kainit at the rate of 450 pounds per acre, and the Stable Manure at the rate of 16 tons per acre. The cost of the fertilizers is calculated at the retail price in Baltimore in April 1891, and does not include freight, handling, etc.

TABLE A.

Showing the results of the use of Fertilizers in growing wheat at the Experimental Out-Station in Marshall County, in charge of Jeremiah Fish, Esq.

Number of Plat.	Fertilizers Applied.	Weight of Wheat.	Weight of Straw.	Yield Per Acre.		Increased Yield per Acre.		Value of Increased Yield.	Cost of Fertilizers.	Profit per Acre.	Loss per Acre.
		Lbs		Bu.	Lbs	Bu.	Lbs	Dols.	Dols.	Dols.	Dols.
1	Nothing	270½	301	18	2	.....	.....	.....	.....	.....	.....
2	50 lbs. Sulph. Potash, 40 lbs. Nitr. Soda and 40 lbs. Dried Blood.....	238	283½	15	52	-2	8	-1.60	8.84	.....	10.44
3	40 lbs. Mur. Potash & 60 lbs. Ground Fish.....	368	423	24	32	6	32	4.90	6.20	.....	1.30
4	40 lbs. Mur. Potash and 80 lbs. S. C. Diss. Bone.....	348½	422½	23	13	5	13	3.91½	5.36	.....	1.44½
5	100 lbs. Tankage, 80 lbs. S. C. Diss. Bone and 40 lbs. Mur. Potash.....	423	548	28	12	10	12	7.65	9.76	.....	2.11
6	Nothing	269½	401½	17	58	.....	.....	.....	.....	.....	.....
7	40 lbs. Dried Blood and 40 lbs. Mur. Potash	385¾	485½	25	43	7	43	5.78½	6.00	.....	0.21½
8	80 lbs. Diss. Bone Black	382½	592½	25	30	7	30	5.62½	2.88	2.74½	.....
9	112½ lbs. Kainit	313½	461	20	54	2	54	2.17½	2.58¾	.....	0.41½
10	40 lbs. Nitrate Soda	280½	909	18	42	0	42	0.50½	3.04	.....	2.53½

TABLE B.

Showing the results of the use of Fertilizers in growing wheat at the Experimental Out-Station in Doddridge county, in charge of N. E. Duckworth, Esq.

Number of Plat.	Fertilizers Applied.	Weight of Wheat.		Weight of Straw.		Yield per Acre.		Increased Yield per Acre.		Value of Increased Yield.		Cost of Fertilizers per Acre.	Profits per Acre.	Loss per Acre.
		Lbs	Lbs	Bu.	Lbs	Bu.	Lbs	Bu.	Lbs	Dolls.	Dolls.			
1	Nothing.....	280	481	18	40	.....	.....	.....	.....	.....	.....	.....	.....	.....
2	50 lbs. Sulph. Potash, 40 lbs. Nitr. Soda and 40 lbs. Dried Blood.....	253	423½	16	52	-1	48	-2	10	8	84	.....	10	94
3	40 lbs. Mur. Potash and 60 lbs. Gro'nd Fish.....	308	480½	20	32	1	52	2	15	6	20	.....	4	05
4	40 lbs. Mur. Potash and 80 lbs. S. C. Diss. Bone.....	278½	386½	18	34	.....	-6	-07½	5	36	.....	5	43½	
5	100 lbs. Tankage, 80 lbs. S. C. Diss. Bone, 40 lbs. Mur. Potash.....	282½	433½	18	50	.....	10	12½	9	76	.....	9	63½	
6	Nothing.....	243	379	16	12	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	40 lbs. Dried Blood and 40 lbs. Mur. Potash.....	228	333	15	12	-1	.....	-75	6	00	.....	6	75	
8	80 lbs. Diss. Bone Black.....	227½	392½	18	10	1	58	2	72½	2	88	.....	15½	
9	112½ lbs. Kainit.....	220	366	14	40	-1	32	-1	90	2	58¾	.....	4	48¾
10	40 lbs. Nitr. Soda...	138	482	9	12	-7	.....	-5	25	3	04	.....	8	29
11	8,000 lbs. Stable Manure.....	363	507	24	12	5	32	4	15	4	00	15	.....	

TABLE C.

Showing the results of the use of Fertilizers in growing wheat at the Experiment Out-Station in Wood County, in charge of S. S. Stone, Esq.

Number of Plat.	Fertilizers Applied.	Weight of Wheat.		Weight of Straw.		Yield per Acre.		Increased Yield per Acre.		Value of Increased Yield.		Cost of Fertilizers per Acre.		Profits per Acre.		Loss per Acre.	
		Lbs	Lbs	Bu.	Lbs	Bu.	Lbs	Bu.	Lbs	Dols.	Dols.	Dols.	Dols.	Dols.	Dols.	Dols.	Dols.
1	Nothing.....	224½	340½	14	58	.....	.....	.....	.....	\$.....	\$.....	\$.....	\$.....	.....	.....	.....	.....
2	50 lbs. Sulph. Potash, 40 lbs. Nitr. Soda and 40 lbs. Dried Blood.....	340	546	22	40	5	49	4	36½	8	84	.....	.....	.....	.....	4	47¾
3	40 lbs. Mur. Potash & 60 lbs. Ground Fish.....	341	425	22	44	5	53	4	41½	6	20	.....	.....	.....	.....	1	78½
4	40 lbs. Mur. Potash and 80 lbs. S. C. Diss. Bone.....	316½	358	20	58	4	7	3	08¾	5	36	.....	.....	.....	.....	2	27½
5	86½ lbs. Tankage, 13½ lbs. Ground Fish, 10½ lbs. S. C. Diss. Bone, 69½ lbs. Diss. Bone Bl'k, 40 lbs. Mur. Potash.....	358½	439½	23	54	7	3	5	28¾	9	66½	.....	.....	.....	.....	4	37.8
6	Nothing.....	281	405	18	44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7	40 lbs. Dried Blood and 40 lbs. Mur. Potash.....	335	393	22	20	5	29	4	11¼	6	00	.....	.....	.....	.....	1	88½
8	80 lbs. Diss. Bone Bl'k.....	298	352½	19	52	3	1	2	26½	2	88	.....	.....	.....	.....	0	61¾
9	112½ lbs. Kamit.....	317	358½	21	8	4	17	3	21¼	2	58¾	0	62½	.....	.....	.....	.....
10	40 lbs. Nitr. Soda...	298	408½	19	52	3	1	2	26½	3	04	.....	.....	.....	.....	0	77¾
11	40 lbs. Nitr. Soda...	272	420	18	8	1	17	0	86¼	3	04	.....	.....	.....	.....	2	17¾

The Out-Station in Marshall county is located on both sides of a ridge running east and west. On the south side of the ridge the ground slopes at an angle of about 15 degrees. On the north side it slopes at an angle of about 25 degrees. Plats Nos. 1, 2, 3 and 4 are located on the south side of the ridge. Plat No. 5 lies on the top of the ridge, the east end being slightly on the south side, and the west end slightly on the north side. Plats Nos. 6, 7, 8, 9 and 10 are located on the north side of the ridge.

The unfertilized Plats Nos. 1 and 6 show the remarkable yield of an average of 18 bushels per acre, there being a difference of only 4 pounds of grain per acre in the yield of each of these plats, yet we find that while Plat 6 produced one pound less of grain, it produced 100½ pounds more of straw than Plat 1. The average production of grain of the ten plats is 329.95 pounds and the average production of straw is 482.72 pounds, making an average of 154.77 pounds more of straw than of grain. But if we eliminate from this calculation Plat 10, where we find a very remarkable abnormal yield of both grain and straw, we have an average yield of grain of 333.27 pounds and an average yield of straw of 435.36 pounds, or an average yield of a little more than 102 pounds of straw more than of grain.

The average yield of grain on the unfertilized plats is 270 pounds and of straw 351¼ pounds, showing that the increased yield of grain or straw produced by the use of commercial fertilizers is, for grain about 23½% and for straw about 24%, or practically the same. What effect the different kinds of fertilizers have upon the production of straw is a very difficult question to determine from this experiment. By comparing the unfertilized plats 1 and 6 we find that while each produces substantially the same amount of grain, plat 6 produces 33% more straw than plat 1.

Let us compare plats 7 and 8. Plat 7 has 4.8 pounds of Nitrogen and 20 pounds of Potash, and plat 8 has 15.6 pounds of Phosphoric Acid, and while each plat produces substantially the same amount of grain, plat 8 with about one-half the amount of fertilizer (but of a different kind) produces a little more than 22% more of straw than plat 7.

Again, take plats 4 and 8. Plat 4 has 11 1-5 pounds of Phosphoric Acid and 20 pounds of Potash, while plat 8 has 13.6 pounds of Phosphoric acid, yet plat 8 produces a little more than 9.5% more grain, and 40% more straw than plat 4.

Now let us compare plats 2 and 7. Plat 2 with 12½ pounds of Potash and 10.8 pounds of Nitrogen produces 19% (omitting decimals) more straw than grain, while plat 7 with 20 pounds of Potash and 4.8 pounds of Nitrogen produces nearly 26% more straw than grain, and also produces about 62% more grain and over 71% more straw than plat 2. By an examination of Table A., it will be found that plat 2 is the only plat which falls below the average yield of the unfertilized plats: Did the diminution of the amount of potash and the more than doubling of the amount of nitrogen applied to plat No. 2 cause this decrease in yield? The

results secured on plat 7 seem to answer this question in the affirmative. Here we increase the potash 60%, and diminish the nitrogen 55½%, and secure an increased yield of both grain and straw, making a difference in the yield of the two plats of 147¾ pounds of grain, and 204¾ pounds of straw. The results secured in the experiment in Roane county (table D) confirm this theory, but the results secured in Wood and Doddridge counties contradict it.

At all of the Out-Stations upon the plats treated with commercial fertilizers, plats 5 produce the largest yield of both grain and straw, with the two exceptions of the production of straw, in Wood and Marshall counties. The abnormal yield of both grain and straw on plat 10 in Marshall county (table A) has already been referred to. This plat lies on the hillside below the other plats, occupying the comparatively flat part of a terrace of the hill. Immediately below it is a fence of long standing dividing the field containing the experiment grounds from other fields on the farm. It also being a favorable location for the rest and rumination of cattle feeding in that field, the land had become exceedingly fertile from the droppings of the cattle, which contributed, no doubt, very largely to the immense growth of straw. Besides, the chickens from an adjacent farm house were very frequent visitors to this plat during the ripening and harvesting period, and consumed a large quantity of the grain. For these reasons, we will exclude Plat 10, Table A, from all calculations in considering the results of these experiments.

Upon these plats (No. 5) we used ordinary "complete fertilizer" both in composition and quantity, except that the phosphoric acid was almost doubled.

On plat 5, tables A. & B., we used 5.5 pounds nitrogen, 23.2 pounds of phosphoric acid and 20 pounds of potash. On plats 5 in tables C. & D., we used 5.76 pounds of nitrogen, 24.28 pounds of phosphoric acid and 20 pounds of potash, the amount of fertilizing elements being practically the same on each plat.

By a comparison of plats 5 in the several tables, we find a large variation in the yield of both grain and straw produced by the application of fertilizers, under this formula, the yield of grain being the least (10 pounds) in Doddridge county, and the greatest (10 bushels and 12 pounds) in Marshall county. Taking the unfertilized plats as a basis, the fertilizers applied to plats 5 produced an increased yield in Marshall county of 56%; in Doddridge county nine tenths of one per cent; in Wood county of 42%, and in Roane county of 216%.

Judging from its appearance, which is partly confirmed by an analysis made of the soils at the several Out-Stations by the Chemist of this Station, the natural fertility of the soils in these several plats decreases in the following order: Marshall, Wood, Doddridge and Roane, and although three of these plats in Marshall county produced a greater yield than any of the plats in Wood county, yet the general average yield of the Wood county plats is greater than that of the Marshall county plats. It will also be ob-

served that the greatest percentage of increased yield was on the poorest plats (in Roane county, table D.) and the least, on the next poorest (in Doddridge county, table B.) This presents the very interesting question upon which there seems to be a great diversity of opinion as to the relative effects of commercial fertilizers upon poor and rich soils. These experiments give us no solution of this problem, and we are compelled to pursue other lines of investigation to discover the truth. I have no doubt that the presence or absence of humus in the soil has very much to do with these variable results. I call attention to plat 11 in table B. Here, by the application of stable manure, at the rate of 16 tons per acre, where all the commercial fertilizers, whether applied singly or combined, had failed to produce any substantial effect we secure an increased yield of five bushels and thirty-two pounds per acre, taking plat 1 as the basis of the calculations, or taking a general average of all the plats as the basis, we have an increased yield of six bushels and twenty-six pounds, or an increased yield of over 36%.

It is interesting to note the variations in the yield of the several plats in these tables. Comparing the yield of these plats with each other in the order named, plats 2, tables A and B, show a decrease from plats 1, while in the tables C. and D, they show an increase. Plats 3 in all the tables, show an increase over plats 2. Plats 4 in tables A, B and C, shows a decrease from plats 3, while in table D, it shows an increase. Plats 5 in all the tables shows an increase over plat 4, and further shows an increase over all other plats, except in table B. Plat 7 in all the tables shows a decrease from plat 5. Plat 8 in table A shows less than one per cent. decrease from plat 7, and in table C shows about 12% decrease, while in table B it shows an increase of over 16%, and in table D, it shows an increase of over 40%. From plats 8 to 9, we have a very large decrease in all the tables except table C, which shows an increase of about 6%, and the decrease continues in all the tables from plats 8 to 9 and from 9 to 10.

To what extent the fertilizers are responsible for these variations, it is difficult to determine. That the natural fertility and conditions of the soil have a very decided influence upon the action of the fertilizers applied, and the growth and fruitage of the plant, there can be no doubt. To enable us to secure satisfactory results in these experiments, it is necessary that we should have a uniform soil for each series of plats. The conditions of moisture and solidity, the elements from which the soil is made, the amount of humus, and all the elements of plant food contained therein, should be the same in each plat of a series. Practically, we find it almost impossible to secure land of this character, especially among the hills of West Virginia. As a consequence, there must be a certain degree of inaccuracy in all our experiments in fertilization, and soil testing by growing plants.

In looking over these tables, we find that while in most cases there is a very gratifying increase in the yield, yet there are very few plats which have paid back the investments made.

Whether the continued effect of these fertilizers for a period of years, without any additional artificial fertilization would produce an increased yield in the crops sufficient to repay the investment and leave a surplus, is a question which we have not yet determined, as this is the first year of our experiment on these plats.

CONCLUSIONS.

From these experiments we draw the following conclusions :

- First:—That it is not profitable to use nitrogenous fertilizers in large quantities, or use them in ordinary quantities alone as fertilizers for growing wheat. (See Plats 2 and 10.)
- Second :—That the combination of Potash, Nitrogen and Phosphoric Acid, produces the largest yield. (See Plats 3 and 5)
- Third :—That Phosphoric Acid alone produces very satisfactory results. (See Plats 8.)
- Fourth:— That probably the most profitable application of Commercial Fertilizers would be Potash, in the form of Kainit and Phosphoric Acid, in the form of South Carolina Dissolved Bone (S. C. Rock.)