Forming of cropping capacity against the background of effect and aftereffect of diatomaceous earth and poultry manure

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Abstract. The effect of poultry manure, different rates of diatomaceous earth in the combination with poultry manure on the elements of the yield structure and productivity of a hybrid of Ladoga 175 MV corn and Granny spring wheat was studied. It was stated that the most significant effect on the positive change in the elements of the structure of the yield of corn and spring wheat had a direct effect and aftereffect of diatomaceous earth in combination with poultry manure. The maximum productivity was ensured by the integrated use of diatomaceous earth with poultry manure. The productivity of corn against their background statistically exceeded the control by 2.02-2.52 t/ha of grain units or by 47.7-59.6 %, the productivity of spring wheat – by 0.66-0.87 t/ha of grain units, or 26.8-35.4%. The effect and aftereffect of diatomaceous earth with rates 8 and 10 t/ha both pure and in a complex with poultry manure had an equivalent effect on the productivity of corn and spring wheat.

1. Introduction
Currently, the level of crop production development should ensure a further increase in production indicators due to a more complete use of agricultural crops capabilities and improvement of cultivation technology, taking into account soil and climatic conditions.
Under these conditions, in order to increase the productivity of crops and obtain ecologically clean products, the solution to this problem is possible based on a more complete use of biological factors of agriculture intensification, the introduction of various methods of increasing effective soil fertility in order to create optimal conditions for the growth and development of plants [1-4].

In connection with the constantly increasing prices for mineral fertilizers, considerable attention should be paid to the search for the new options, including non-traditional sources of mineral nutrition. Silicon plays an important role in the formation of plant yield among biophilic macronutrients. Silicon plays an important role in plant metabolism, has a positive effect on the strength of the stem component, and increases plant resistance to environmental stress factors. The balance of silicon in agriculture is negative and its deficit ranges from 6 to 20 kg / ha. To eliminate the deficit, it is necessary to introduce silicon fertilizers. In this regard, it is promising to use highly concentrated silicon-containing agronomical ores as a source of silicon.

The effectiveness of the silicon-containing agronomical ores effect on the formation of the yield of agricultural crops increases significantly when they are used in combination with organic and mineral fertilizers [5-10].

2. Materials and methods
The purpose of the research was to study the effect and aftereffect of various rates of diatomaceous earth from Korzhevsky deposit of the Penza region and its combinations with poultry manure on the on the elements of the yield structure and productivity of corn and spring wheat.
In order to reach this goal, a field experiment was laid on a gray forest soil according to the following scheme: 1. Without diatomaceous earth and poultry manure (control); 2. Poultry manure 10t/ha; 3. Diatomaceous earth 4 t/ha; 4. Diatomaceous earth 6 t/ha; 5. Diatomaceous earth 8 t/ha; 6. Diatomaceous earth 10 t/ha; 7. Diatomaceous earth 4 t/ha + poultry manure 10 t/ha; 8. Diatomaceous earth 6 t/ha + poultry manure 10 t/ha; 9. Diatomaceous earth 8 t/ha + poultry manure 10 t/ha; 10. Diatomaceous earth 10 t/ha + poultry manure 10 t/ha.

The experiment was repeated three times, the plots during the experiment were placed by the method of randomized repetitions. The diatomaceous earth of the Korzhevsky deposit, located in the Nikolsky district of the Penza region was used as a silicon-containing fertilizer in the experiment and had the following element content (in oxide form, % on absolutely dry basis): H₂O – 3.14; SiO₂ – 80.42; Al₂O₃ – 8.01; Fe₂O₃ – 2.46; CaO – 0.26; MgO – 0.78; K₂O – 1.00; P₂O₅ – 0.04. Poultry manure was used as organic fertilizer. Diatomaceous earth and poultry manure were introduced for the main tillage. In the experiment, Ladoga 175 MV corn hybrid and Granny spring wheat were cultivated.

3. Results and discussion

As a result of the research, the positive effect of diatomaceous earth and its combinations with poultry manure on the elements of the corn crop structure was revealed.

On the variant without diatomaceous earth and poultry manure the length of the corn cob was 11.95 cm, the number of grains per one corn cob was 182.7 pieces, and their weight was 53.00 g, the weight of 1000 grains was 290.1 g (table 1).

Against the background of the direct action of poultry manure with a rate of 10 t/ha, the length of the cob increased in relation to the control by 27.9%, the number of grains per cob – by 28.5%, their weight – by 40.9% and the weight of 1000 grains – by 9.7%.

One-sided effect of the diatomaceous earth statistically increased the length of the cob in relation to control by 10.0 (diatomaceous earth 4 t/ha) – 19.7% (diatomaceous earth 10 t/ha). The number of grains in this variant varied from 216.90 to 230.53 pcs., the weight of grain per cob from 65.93 to 71.74 g. The increase in relation to the control was statistical and in the first case it made up 18.7-26.2%, in the second – 24.4-35.4%. The weight of 1000 grains varied in the range from 304.0 to 311.2 g. The increase in relation to the control was 4.3-7.3%. Moreover, the statistical increase in this case was provided by the rates of diatomaceous earth of 8 and 10 t/ha.

The combined use of diatomaceous earth and poultry manure increased the length of the cob by 30.0-32.4%, the length of cobs on these variants varied in the range from 15.53 to 15.82 cm. The yield of grain from one cob significantly exceeded the control by 28.1-36.9%, and the weight of grain per cob – by 41.7-51.7%. The mass of 1000 grains against the background of the direct action of diatomaceous earth in combination with poultry manure varied in the range from 319.9 to 322.8 g, statistically exceeding the control by 10.3-11.3%.

Table 1. Elements of corn yield structure.

| Variant | Cob length, cm | Number of grains in one cob, pcs. | Weight of grains in one cob, g | Weight of 1000 grains, g |
|---------|----------------|-----------------------------------|-------------------------------|------------------------|
| 1. Without diatomaceous earth and poultry manure (control) | 11.95 | 182.70 | 53.00 | 290.1 |
| 2. Poultry manure 10 t/ha | 15.28 | 234.73 | 74.68 | 318.2 |
| 3. Diatomaceous earth 4 t/ha | 13.15 | 216.90 | 65.93 | 304.0 |
| 4. Diatomaceous earth 6 t/ha | 13.75 | 220.70 | 66.80 | 302.6 |
| 5. Diatomaceous earth 8 t/ha | 14.20 | 230.23 | 71.57 | 310.9 |
| 6. Diatomaceous earth 10 t/ha | 14.30 | 230.53 | 71.74 | 311.2 |
| 7. Diatomaceous earth 4 t/ha + poultry manure 10 t/ha | 15.53 | 234.10 | 75.11 | 320.8 |
8. Diatomaceous earth 6 t/ha + poultry manure 10 t/ha
   15.68  239.80  76.71  319.9
9. Diatomaceous earth 8 t/ha + poultry manure 10 t/ha
   15.78  247.70  79.89  322.8
10. Diatomaceous earth 10 t/ha + poultry manure 10 t/ha
    15.82  250.10  80.24  320.0

least significant difference (LSD) p = 0.05
   1.18  16.9   4.7   19.4

In 2019, the productivity of corn on the variant without diatomaceous earth and poultry manure made up 4.23 t/ha of grain units. Poultry manure with rate 10 t/ha statistically increased the productivity of corn by 1.73 t/ha of grain units, or by 41.0% (table 2).

**Table 2. Corn productivity (2019).**

| Variant                              | Productivity, t/ha of grain units | Deviation from the control t/ha of g. units | %   |
|--------------------------------------|-----------------------------------|---------------------------------------------|-----|
| 1. Without diatomaceous earth and poultry manure (control) | 4.23 | - | - |
| 2. Poultry manure 10 t/ha            | 5.96 | 1.73 | 41.0 |
| 3. Diatomaceous earth 4 t/ha         | 5.27 | 1.04 | 24.5 |
| 4. Diatomaceous earth 6 t/ha         | 5.34 | 1.11 | 26.1 |
| 5. Diatomaceous earth 8 t/ha         | 5.71 | 1.48 | 35.0 |
| 6. Diatomaceous earth 10 t/ha        | 5.72 | 1.49 | 35.3 |
| 7. Diatomaceous earth 4 t/ha + poultry manure 10 t/ha | 6.25 | 2.02 | 47.7 |
| 8. Diatomaceous earth 6 t/ha + poultry manure 10 t/ha | 6.38 | 2.15 | 50.9 |
| 9. Diatomaceous earth 8 t/ha + poultry manure 10 t/ha | 6.71 | 2.49 | 58.8 |
| 10. Diatomaceous earth 10 t/ha + poultry manure 10 t/ha | 6.75 | 2.52 | 59.6 |
| least significant difference (LSD) p = 0.05 | - | 0.72 | - |

Against the background of the one-sided effect of diatomaceous earth, depending on its rate, the productivity of corn varied in the range from 5.27 (diatomaceous earth 4 t/ha) to 5.72 t/ha of grain units (diatomaceous earth 10 t/ha). The increase in relation to the control variant was statistical and varied in the range from 1.04 to 1.49 t/ha of grain units, or from 24.5 to 35.3%.

The maximum productivity was provided by the combined action diatomaceous earth with poultry manure. The productivity of corn against their background varied in the range from 6.25 to 6.75 t/ha of grain units, significantly exceeding the control by 2.02-2.52 t/ha of grain units, or by 47.7-59.6%.

The number of productive stems by the time of harvesting spring wheat grown without diatomaceous earth and poultry manure in 2020 was 404 pcs. In the variant with one-sided aftereffect of poultry manure, the number of productive stems statistically exceeded the control by 22 pieces. Against the background of the aftereffect of various rates of diatomaceous earth, a tendency towards an increase in the number of productive stems was noted. The number of productive stems in these variants of the experiment varied from 406 to 411 pcs, depending on the diatomaceous earth rate. Against the background of the aftereffect of different diatomaceous earth rates in combination with poultry manure, the number of productive stems statistically exceeded the control by 23-29 pcs. (table 3).
Table 3. Elements of spring wheat yield structure (2020).

| Variant                                                                 | Number of productive stems, pcs./m² | The length of wheat head, cm | Number of grains in a wheat head, pcs. | Weight of grains in one wheat head, g | Weight of 1000 grains, g |
|------------------------------------------------------------------------|--------------------------------------|-----------------------------|----------------------------------------|---------------------------------------|-------------------------|
| 1. Without diatomaceous earth and poultry manure (control)             | 404                                  | 4.8                         | 16.8                                   | 0.61                                  | 36.3                    |
| 2. Poultry manure 10 t/ha                                             | 426                                  | 6.3                         | 19.0                                   | 0.71                                  | 37.4                    |
| 3. Diatomaceous earth 4 t/ha                                          | 406                                  | 4.9                         | 17.0                                   | 0.63                                  | 37.1                    |
| 4. Diatomaceous earth 6 t/ha                                          | 410                                  | 5.0                         | 17.4                                   | 0.65                                  | 37.4                    |
| 5. Diatomaceous earth 8 t/ha                                          | 411                                  | 5.2                         | 17.5                                   | 0.66                                  | 37.7                    |
| 6. Diatomaceous earth 10 t/ha                                         | 411                                  | 2.2                         | 17.4                                   | 0.65                                  | 37.4                    |
| 7. Diatomaceous earth 4 t/ha + poultry manure 10 t/ha                 | 427                                  | 6.3                         | 19.2                                   | 0.73                                  | 38.0                    |
| 8. Diatomaceous earth 6 t/ha + poultry manure 10 t/ha                 | 430                                  | 3.4                         | 19.5                                   | 0.76                                  | 38.9                    |
| 9. Diatomaceous earth 8 t/ha + poultry manure 10 t/ha                 | 433                                  | 6.5                         | 19.6                                   | 0.77                                  | 39.3                    |
| 10. Diatomaceous earth 10 t/ha + poultry manure 10 t/ha               | 432                                  | 6.4                         | 19.5                                   | 0.77                                  | 39.3                    |
| HCP05                                                                  | 21                                   | 0.9                         | 1.6                                    | 0.06                                  | 2.0                     |

In spring wheat crops in the control variant, the length of wheat head was 4.8 cm. The aftereffect of poultry manure statistically increased the length of wheat head by 1.5 cm. Diatomaceous earth with its one-sided aftereffect, did not have a significant effect on the length of spring wheat head. The statistical wheat head length increase was noted against the background of the aftereffect of diatomaceous earth with poultry manure. The wheat head length on these variants varied from 6.3 to 6.5 cm, exceeding the control by 1.5-1.7 cm.

In the control variant, the number of grains in a wheat head at the time of harvesting of spring wheat was 16.8 pieces, and their weight was 0.61 g. The aftereffect of poultry manure statistically increased the number of grains in a wheat head by 2.2 pcs., the weight of grains in a head – by 0.10 g. Against the background of the aftereffect of various diatomaceous earth rates, no significant change in these elements of the spring wheat yield structure was observed. The aftereffect of diatomaceous earth in combination with poultry manure had the most significant effect on the grain content per head and the weight of grain per head. The number of grains per wheat head in these variants varied from 19.2 to 19.6 pieces, and their weight – from 0.73 to 0.77 g. The increase in relation to the control was statistical and in the first case it was 2.4-2.8 pcs., in the second – 0.12-0.16 g.

In the variant without diatomaceous earth and poultry manure, the weight of 1000 grains was 36.3 g. A statistical increase in the weight of 1000 grains was observed in the variants with diatomaceous earth rates from 6 to 10 t/ha in combination with poultry manure. The weight of 1000 grains against the background of their aftereffect varied in the range from 38.9 to 39.3 g.

In 2020, the productivity of spring wheat in the variant without diatomaceous earth and poultry manure was 2.46 t/ha of grain units (table 4).

Table 4. Productivity of spring wheat (2020).

| Variant                                             | Productivity, t/ha of grain units | Deviation from the control t/ha of g. units | % |
|-----------------------------------------------------|-----------------------------------|--------------------------------------------|---|
| 1. Without diatomaceous earth and poultry manure (control) | 2.46                              | –                                          | – |
|                                      |                        |       |       |          |
|--------------------------------------|------------------------|-------|-------|----------|
| 2. Poultry manure 10 t/ha            | 3.03                   | 0.57  | 23.2  |
| 3. Diatomaceous earth 4 t/ha         | 2.56                   | 0.10  | 4.1   |
| 4. Diatomaceous earth 6 t/ha         | 2.67                   | 0.21  | 8.5   |
| 5. Diatomaceous earth 8 t/ha         | 2.71                   | 0.25  | 10.2  |
| 6. Diatomaceous earth 10 t/ha        | 2.72                   | 0.26  | 10.6  |
| 7. Diatomaceous earth 4 t/ha + poultry manure 10 t/ha | 3.12 | 0.66  | 26.8  |
| 8. Diatomaceous earth 6 t/ha + poultry manure 10 t/ha | 3.27 | 0.81  | 32.9  |
| 9. Diatomaceous earth 8 t/ha + poultry manure 10 t/ha | 3.33 | 0.87  | 35.4  |
| 10. Diatomaceous earth 10 t/ha + poultry manure 10 t/ha | 3.33 | 0.87  | 35.4  |

least significant difference (LSD) p = 0.05

Against the background of a one-sided aftereffect of poultry manure with a rate of 10 t/ha, the productivity of spring wheat was 3.03 t/ha of grain units, statistically exceeding the control by 0.57 t/ha of grain units, or 23.2%.

The one-sided aftereffect of diatomaceous earth with a rate of 4 t/ha in 2020 did not have a statistical effect on the change in the productivity of spring wheat. The statistical increase in the productivity of spring wheat was provided by diatomaceous earth with rates from 6 to 10 t/ha. The productivity of spring wheat against their background varied from 2.67 to 2.72 t/ha of grain units, exceeding the control by 0.21-0.26 t/ha of grain units, or 8.5-10.6%.

The complex aftereffect of diatomaceous earth with poultry manure had the highest effect on the productivity of spring wheat. The productivity of spring wheat against their background varied in the range from 3.12 to 3.33 t/ha of grain units, statistically exceeding the control by 0.66-0.87 t/ha of grain units or by 26.8-35.4%.

It should be noted that the one-sided effect and aftereffect of diatomaceous earth at rates of 8 and 10 t/ha and their combined effect and aftereffect with poultry manure had almost the same effect on the productivity of corn and spring wheat.

4. Summary

Thus, the most significant effect on the formation of corn and spring wheat yield structure elements was exerted by the complex effect and the aftereffect of diatomaceous earth with poultry manure. The maximum productivity was ensured by the integrated use of diatomaceous earth with poultry manure. The productivity of corn against their background statistically exceeded the control by 2.02-2.52 t/ha of grain units, or by 47.7-59.6%, the productivity of spring wheat - by 0.66-0.87 t/ha of grain units, or 26.8-35.4%. The effect and aftereffect of diatomaceous earth at rates of 8 and 10 t/ha, both pure and in combination with poultry manure, had an equal effect on the productivity of corn and spring wheat.

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