Efficiency of application of fertilizers and meliorants in vegetable growing

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Abstract. The use of fertilizers in vegetable growing in Russia has always been highly effective, increasing the yield of vegetable crops by 20-40%, and during irrigation - by 1.5-2 times. Chemical ameliorants (lime, gypsum) are also very effective. On acidic soils, NPZ lime optimizes the response of the soil environment and reduces the harmfulness of fungal diseases, and on alkaline soils of the southern regions, the use of gypsum can dramatically reduce the incidence of vegetable plants by bacterial diseases. The combined use of organic, mineral fertilizers in combination with growth regulators and ameliorants in irrigation conditions allows to increase the yield of main crops by 37-71% on alluvial meadow soils of the Moscow region and by 81-136% on ordinary chernozem of the Rostov region, which ensures high profitability of the industry vegetable growing.

1. Introduction
According to Rosstat [1], the use of organic fertilizers in vegetable crops in the Russian Federation decreased from 13 million tons in 1990 to 2.1 million tons in 2018, i.e. 6.2 times, which is explained by a sharp decrease in the number of livestock and a significant increase in the cost of storage, transportation and introduction of manure, peat and compost.

The dynamics of the use of mineral fertilizers over 28 years (1990-2018) for vegetables and melons was wave-like. In 1990, 163 kg of a.a. were applied per 1 ha of vegetables, then there was a sharp drop by 2001 (82 kg a.a. / ha), and by 2018, the level of application of mineral fertilizers in vegetable growing and melon cultivation exceeded the perestroika level (197 kg a.a. / ha), which in our opinion allowed to significantly increase the yield of vegetable and melon crops to 22 t / ha, and the gross harvest of vegetables and melons to 16.5-17.3 million tons, which significantly improved the supply the population of this diet and vitamin products. In certain vegetable crops, there is also a significant increase in fertilizer efficiency and vegetable yield. Another section of your paper

2. Materials and methods
Scientific research on the system of fertilizers in vegetable crops was carried out in different years on the experimental field of the Department of Agriculture and Agrochemistry of the All-Russian Research Institute of Vegetable Crops on alluvial meadow soil in the central part of the Moskvoretskaya floodplain, OPK "Bykovo" in the Ramensky district of the Moscow region. Agrotechnics, generally accepted for the Central regions of the Non-chernozem zone. The soil of the
The experimental plot is alluvial-meadow medium loamy, saturated, the depth of the arable layer is 27 cm, the depth of the groundwater is more than 2 m, moisture-intensive.

The soil is well cultivated, has a high level of natural fertility, pH is neutral (6.8-7.0), the humus content in the arable horizon ranges from 2.7 to 3.4%, total nitrogen from 0.17 to 0.24%, the phosphorus content in the soil is increased, the availability of exchange potassium is average. Hydrolytic acidity is 0.7-0.8 mEq / 100 g, the amount of absorbed bases is average, soil saturation with bases is high at about 97%, and bulk density is close to optimal (1.1-1.2 g / cm³).

The experience with mineral fertilizers is laid down in 4-fold repetition, the repetition placement is systematic.

3. Results
Since its foundation in 1930, the FSBI All-Russian Research Institute of Vegetable Production has been actively conducting detailed studies to improve the efficiency of fertilizer use in vegetable production. Prominent scientists of Russia were engaged in this: academicians Avdonin N.S., Litvinov S.S., professors Zhurbitsky Z.I., Wendilo G.G., Borisov V.A., Stolyarov A.I., Bykovsky Yu.A., Doctors of sciences Petrichenko V.N., Magomedov A.K., candidates of sciences Gusev M.I., Kovylin V.M., Vasyuchkov I.Yu., Uspenskaya O.N. and others [2].

It is known that the use of lime ameliorants in the form of dolomite or limestone flour in vegetable production under conditions of low-frequency plant conditions increases the yield of vegetable crops on medium-acid soils (pH 4.6-5.0) by 2-9 t / ha, and on slightly acidic (pH 5.6-6.0) by 1-6 t / ha. Such crops as white cabbage and beetroot responded especially strongly to liming, and tomato and cucumber were less responsive [3].

In the conditions of the southern regions of Russia, on alkaline and saline soils (malt, salt marshes, solonetzes), profitable vegetable growing and melon growing is impossible without chemical reclamation, i.e. without making gypsum and phosphogypsum, the doses of which are determined on the basis of a chemical analysis of the water extract of soil samples. The most dangerous for vegetable crops are soda salinization soils. For profitable vegetable growing and melon growing, only slightly saline soils with sulfate and chloride-sulfate salinization (chernozem, meadow chernozem, chestnut. Light chestnut) can be used. The usual doses of gypsum and phosphogypsum for growing vegetables are 6-10 t / ha, higher doses are undesirable. On slightly saline soils, small-scale gypsum plating (0.3-0.4 t / ha) is possible when sowing vegetable seeds with combined seeders [4, 5].

Long-term experimental data of the All-Russian Research Institute of Vegetable Production (Table 1) revealed the effectiveness of the use of mineral and organic fertilizers, as well as their combined use on various soils. In particular, in the conditions of alluvial meadow soils of the floodplain of the river. Moscow, which had a neutral reaction of the medium (pH 6.9), a powerful humus layer (60-80 cm) with a humus content of 3-3.6%, an average supply of exchange potassium and high reserves of mobile phosphorus revealed a certain advantage of mineral fertilizers over organic. On average, over 18 years of research (2000-2017) on 11 vegetable crops, mineral fertilizers provided an average increase in the yield of vegetables at 27%, and organic (in the form of biocompost) increased productivity by only 21%. The combined application of organic and mineral fertilizers made it possible to obtain an average vegetable yield of 35.8 t / ha, which is 37% higher than the non-fertilized version [6,7].

Table 1. The effectiveness of the use of mineral and organic fertilizers for vegetable crops on alluvial soils of the Moscow region (Borisov V.A., 2016).

| Crop   | Vegetable crop yield | without fertilizer | mineral fertilizers | organic fertilizers | mineral + organic fertilizers |
|--------|----------------------|--------------------|---------------------|---------------------|------------------------------|
|        | t/ha %                | t/ha %             | t/ha %              | t/ha %              | t/ha %                       |
| Cabbage| 35.8 100              | 50.6 141           | 52.1 146            | 61.6 171            |
| Carrot | 43.9 100              | 56.9 130           | 54.3 124            | 54.4 124            |
The best responsiveness to mineral fertilizers was found in broccoli, zucchini, white cabbage, radish and beetroot (27-78%). Organic fertilizers responded well to white cabbage (46%), broccoli (71%), carrots (24%), zucchini and turnips (22%), as well as beets, cucumbers and radishes (19-22%). Obviously, these crops can be used both cost-effectively and in organic farming.

In the conditions of the central regions of the NCHZ of the Russian Federation, the integrated use of organic and mineral fertilizers for vegetable crops ensured the largest increase in yield compared to the non-fertilized version (37%). Crops such as broccoli (94% increase), white cabbage (71%), beetroot (64%), and also radish and zucchini (35-42% increase in crop) increased productivity especially [8,9].

In other regions of Russia, vegetable growing is especially well developed in the conditions of the Central Black Earth region, where leached and typical chernozems prevail, as well as in the South and North Caucasus regions, where vegetables are located mainly on ordinary and southern chernozems.

Our research in a long-term (since 1986) stationary experiment on soils rich in organic matter in the Central Black Earth region in the Voronezh region (humus content of 6.2-6.8%), the efficiency of organic fertilizers was low (19%), and mineral fertilizers were much higher (33% on average). The complex use of organo-mineral fertilizers was less effective. Mineral fertilizer had the greatest impact on the yield of white cabbage (41%) and beetroot (69% yield increase), and organic - on the productivity of table beet (46% yield increase). The low efficiency of fertilizers is explained not only by the wealth of typical chernozems, but also by the insufficient level of moisture in these soils, especially crops such as cucumber, onion, and tomato [10, 11].

**Table 2.** The effectiveness of the use of fertilizers on typical chernozems of the Voronezh region in vegetable crop rotation (Borisov V.A., 2016).

| Crop     | Vegetable crop yield | without fertilizer | mineral fertilizers | organic fertilizers | mineral + organic fertilizers |
|----------|----------------------|---------------------|---------------------|---------------------|-------------------------------|
|          | t/ga | %    | t/ga | %    | t/ga | %    | t/ga | %    |
| Cucumber | 18.2 | 100  | 21.0 | 115  | 19.6 | 108  | 22.1 | 121  |
| Tomato   | 25.3 | 100  | 27.9 | 110  | 28.1 | 111  | 28.3 | 112  |
| Onion    | 12.7 | 100  | 14.6 | 115  | 13.1 | 103  | 15.9 | 125  |
| Peas     | 2.67 | 100  | 3.17 | 119  | 2.86 | 107  | 3.23 | 121  |
| Cabbage  | 59.3 | 100  | 83.6 | 141  | 68.4 | 115  | 67.1 | 113  |
| Carrot   | 40.5 | 100  | 46.5 | 115  | 46.6 | 115  | 48.7 | 120  |
| Beetroot | 36.1 | 100  | 61.1 | 169  | 52.6 | 146  | 52.0 | 144  |
| Average  | 27.8 | 100  | 36.8 | 133  | 33.0 | 119  | 33.9 | 122  |

In the southern regions of Russia, fertilizers in vegetable growing are especially effective under irrigation conditions, which makes it possible to increase the productivity of leading vegetable crops by 1.8–2.1 times (Table 3). Long-term studies in the Rostov Region at the Biryuchekutsky vegetable...
selection experimental station on ordinary chernozems in vegetable crop rotation have revealed a very strong increase in the effectiveness of the integrated use of mineral fertilizers, manure and green manure under irrigated conditions. Irrigation against an unfertilized background allowed to increase the total yield of vegetable crops by 46%, and fertilizers without irrigation by 37%. The combined use of calculated doses of mineral fertilizers in combination with a single application of manure (humus) and stocking of siderates (vetch + oats) against the background of optimal irrigation (80: 80: 80% least moisture capacity) made it possible to increase the average crop yield of vegetables over a six-year rotation of the crop rotation by 2.1 times, from 23.6 to 49.6 t/ha, and the largest increase in yield was observed in crops such as tomato (120%), cabbage (137%), carrots (81%) and zucchini (136%) [12].

Table 3. The effectiveness of the use of fertilizers and irrigation for vegetables on ordinary chernozems of the Rostov region (Borisov V.A., 2016).

| Crop     | No irrigation | Irrigation (80: 80: 80% least moisture capacity) |
|----------|---------------|-------------------------------------------------|
|          | without fertilizer | NPK | NPK + manure | NPK + manure + siderat | without fertilizer | NPK | NPK + manure | NPK + manure + siderat |
| Tomato   | 22.9          | 29.7 | 32.8         | 32.8                  | 32.2           | 45.2 | 50.3         | 50.3                  |
| Cabbage  | 26.7          | 29.8 | 31.5         | 36.5                  | 33.2           | 57.4 | 59.4         | 63.4                  |
| Cucumber | 9.5           | 12.1 | 12.5         | 12.2                  | 11.4           | 16.9 | 19.4         | 20.0                  |
| Carrot   | 33.1          | 40.6 | 44.1         | 43.9                  | 50.4           | 55.9 | 57.0         | 59.9                  |
| Squash   | 31.2          | 34.8 | 41.0         | 46.5                  | 49.3           | 58.7 | 61.5         | 73.6                  |
| Onion    | 18.2          | 19.9 | 18.9         | 22.3                  | 30.1           | 30.2 | 29.6         | 30.2                  |
| Average  | 23.6          | 27.8 | 30.1         | 32.4                  | 34.4           | 44.1 | 46.2         | 49.6                  |
| %        | 100           | 118  | 128          | 137                   | 146            | 186  | 196          | 210                   |

4. Summary
1. The use of fertilizers and ameliorants in vegetable growing is the most important factor in increasing the yield of vegetables and the profitability of the vegetable growing industry.
2. Liming increases the yield of vegetable crops to 6-9 t/ha, and the gypsum plating of slightly saline soils allows introducing vegetables and melons into the crop rotation.
3. The highest level of vegetable crop yields on alluvial meadow soils of the Moscow region is ensured by the integrated use of calculated doses of mineral fertilizers in combination with the use of biocast (4-5 t/ha), which increases the yield of the main types of vegetables by 24-71%.
4. In the forest-steppe zone of Russia on typical chernozems of the Voronezh region with high stocks of organic matter, mineral fertilizers had the highest efficiency of application for vegetable crops with 33% increase, and organic fertilizers had a lesser effect on crop rotation (on average 19%).
5. In the southern region, on ordinary chernozems of the Rostov region, the effectiveness of mineral fertilizers is highly dependent on irrigation conditions. In general, irrigation increased the yield of vegetables by 46%, and fertilizers in irrigated conditions by 40-64%. The most responsive vegetables to irrigation and fertilizer were tomato (120% yield increase), cabbage (137%), zucchini (136%) and carrots (81%).

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