Influence of humic preparations on productivity increase of cucurbits in arid farming conditions

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Abstract. The paper presents the results of studying the influence of liquid humic fertilizer produced from milled lowland peat on biological activity, the dynamics of nutrients in brown semi-desert soils in arid climate conditions with leaf fertilization of cucurbits. In arable farming of the Astrakhan region most of the harvest is formed by mobilizing soil fertility without compensation for the elements of nutrition carried out with the harvest, which leads to a negative balance of humus and nutrients, as a consequence, the soil is depleted, its fertility becomes lower. It is shown, that application of humates promotes increase of the content of humus in soil in arable horizons and reception of higher harvests of an early ripe watermelon that is caused by activization of biochemical processes in soil and increase of nutrients availability that has accelerated development and ripening of fruits of studied crop.

1. Introduction

In the conditions of unsatisfactory use of agricultural land in many regions of the Russian Federation and the task of ensuring food independence, research on satisfaction of agricultural crops in nutritional elements and obtaining high yields of good quality is becoming increasingly important. One of the most important indicators for obtaining a good quality crop is fertility. Fertility is the ability of soils to simultaneously supply water, nutrients, air to plants and to create favorable conditions for growth and development of plants [1, 2]. Analysis of the state and dynamics of soil fertility over the past 5 years showed a sharp decline in organic matter in the Astrakhan region, as well as nutrition. In today's situation in the Astrakhan region agriculture most of the harvest is formed by mobilization of soil fertility without compensation of nutrients carried out with the harvest, which leads to a negative balance of humus and nutrients, as a consequence, the soil is depleted. The problem of reproducing soil fertility without compensation of nutrients carried out with the harvest, which leads to a negative balance of humus and nutrients, as a consequence, the soil is depleted. The problem of reproducing soil fertility, increasing yields and product quality while reducing the anthropogenic load on agroecosystems is currently being solved through the use of biological technologies of agriculture [3].

Organic fertilizers remain one of the main types of biological agriculture [4]. The resources and efficiency of organic fertilizers can be significantly increased by using humic preparations based on various natural organic sources. Currently, many scientific institutions have proved the multifunctionality, high agroecological and economic efficiency of humic preparations for different crops in different soil and climatic conditions [5].

The purpose of the research is to study the influence of liquid humic preparation on the agrochemical properties of brown semi-desert soils under cultivation of cucurbits in arid climate conditions and the influence on the yield of foliar application.
2. Materials and methods
The research was conducted on agricultural land located in Yenotayevsky district, the Astrakhan region. The soil cover is represented by brown arid soils, which have been in the deposits for 3 years. Description of the soil cover was made at the sites laid on the agricultural lands in the most typical places designated by homogeneous plant communities (Figure 1).

![Figure 1. Experimental site location.](image)

Morphological description of soil was carried out according to generally accepted approaches [6]. In accordance with "Classification and diagnostics of soils of Russia" [7] and taking into account "Soil systematics of Volga-Akhtuba floodplain and Volga Delta" [8].

The technological scheme of variants of potassium humate treatment of the experimental site was defined, and presented in Table 1 and in Figure 1.

| Experiment option | Experiment option content                                                                 | Rate of application                                           |
|-------------------|-------------------------------------------------------------------------------------------|--------------------------------------------------------------|
| Reference sample  | Untouched soil                                                                            | Untouched                                                   |
| (R)               |                                                                                           |                                                              |
| Option 1 (O1)     | Potassium Humate (standard application of key mineral fertilizers)                         | Stage I<br>(Potassium Humate 400 ml /250 l water, 250 l/ha)<br>Stage II<br>(Potassium Humate 400 ml /250 l water, 250 l/ha) |
| Option 2 (O2)     | Potassium Humate (20% decrease in basic mineral fertilizer application)                     | Stage I<br>(Potassium Humate 400 ml /250 l water, 250 l/ha)<br>Stage II<br>(Potassium Humate 400 ml /250 l water, 250 l/ha) |

Table 1. Technological scheme of variants of experimental sites potassium humate treatment.
The following indicators were used to assess the agrochemical state of soils: determination of the content of readily hydrolyzable nitrogen, mobile phosphorus, potassium exchange, soil pH, the content of organic matter and the degree of salinity [9]. Soil samples were taken from the arable layer before sowing the cucurbits and applying main fertilizer to the soil, as well as after harvesting.

Agrochemical analysis of soil cover was carried out by using proven methods:
1) the reaction of the soil medium (pH) was determined with the DELTA 320 pH-meter;
2) organic carbon content - dichromate method according to Thurin;
3) easy hydrolysisable nitrogen was measured by the Cornfield method;
4) mobile compounds of phosphorus (P$_2$O$_5$) and potassium (K$_2$O) were determined by Machigin’s method.

The used humic preparation is a liquid based on humic acids, pH neutral (6.5-7.5), the content of the active substance (humic acids) - up to 70 g/l. It is produced from milled lowland peat with a degree of decomposition of at least 30%. It has a stimulating effect and fungicidal activity. It is intended for pre-planting treatment of seeds and planting material, as well as for foliar and root supplements during the vegetation period in the cultivation of cereals, legumes, fodder, technical, vegetable, flower and decorative, cucurbit and fruit crops in order to accelerate growth and development of plants, increase their resistance to adverse conditions, increase yield and improve their quality.

3. Results and discussion
The research area is located in the zone of Southern Sarpinskaya lowland. General description of the soil cover of the study subject was made by us based on analysis of medium and small-scale maps. The soil map of the RSFSR (under the editorship of V.M. Friedland, M 1:2500000, 1988) in the area of our work shows the predominance of brown semi-desert (arid) soils. The vegetation cover is represented by Artemisia lerchiana, Tanacetum achillefolium, Festuca valesiaca, Poa bulbosa, Stipa capillata, Anizantha tectorum, 50% turfness, cereals-camomile-artemisia lerchiana community.

According to the "Classification and Diagnostics of Soils of Russia" (1977) brown arid soils belong to the semi-desert zone and are characterized by the following profile: AKL horizon (1-3 cm) is represented by a large porous crust, below is a puffy light - gray horizon (10-12 cm); deeper is the BMK horizon - light - brown, coarse-compacted, with the capacity of 12-15 cm which is replaced by the BCA horizon - yellow-brown, dense, lumpy - walnut - carbonate emissions in the form of white soft spots, 25-40 cm power; even deeper is the BCA horizon, transitional to the rock, containing carbonates, gypsum, water-soluble salts; the C$_{Ca}$ horizon is non-structural, with gypsum and soluble salts secretions. Bubbling up from HCl is observed from the surface.

Efficiency of bio-preparation application was estimated by dynamics of nutrients before sowing and after harvesting, as well as its influence on yield. Table 2 shows the results of laboratory tests before and after the application of liquid fertilizer. According to the results, soil samples are classified as weakly alkaline soils, their pH varies from 8.0 to 8.2.

Humus content in soils of the control site is much higher (by 1%) in comparison with its content in the arable horizon of experimental sites. This may be due to the growth of herbaceous vegetation in these sites, which decomposes and converts to organic matter over time, increasing soil fertility. As can be seen from Table 2, after application of liquid fertilizer the amount of organic matter in soils is significant but increased, which shows good dynamics for future soil improvement.

The nitrogen content of the experimental site corresponds to a very low category of soil fertility before sowing and after harvesting. This category of nitrogen content is found in all soils of the Astrakhan region.

Prior to the application of mineral fertilizers and potassium humate, phosphorous was in a low supply category at all variants of the experimental site; after the harvest, phosphorous content varies from medium to high category.

There is more potassium in soils than nitrogen and phosphorus combined but the removal of potassium from crops is much higher than phosphorus and often nitrogen. Cucurbits react very
strongly to the lack of potassium in the soil, therefore, potassium fertilizers should be applied to the soil to maintain soil fertility and preserve crop yields.

Table 2. Comparative characteristics of agrochemical indicators of studied sites arable horizon.

| Option | Soil sampling period | Depth, cm | Water pH | Organic matter (humus), % | Nitrogen, mg/kg of soil | Mobile phosphorus, mg/kg soil | Potassium, mg/kg soil |
|--------|----------------------|-----------|----------|---------------------------|-------------------------|-----------------------------|----------------------|
| Reference sample | Before sowing | 0-10 | 8.1 | 0.41 | 28 | 25 | 204 |
| | | 10-30 | 8.2 | 0.38 | 26 | 24 | 201 |
| B1 | | 0-10 | 8.0 | 0.40 | 27 | 17 | 208 |
| | | 10-30 | 8.1 | 0.39 | 25 | 16 | 204 |
| B2 | | 0-10 | 8.0 | 0.48 | 35 | 27 | 212 |
| | | 10-30 | 8.1 | 0.45 | 34 | 25 | 211 |
| Reference sample | After the harvest | 0-10 | 8.1 | 0.51 | 20 | 63 | 324 |
| | | 10-30 | 8.1 | 0.45 | 18 | 50 | 280 |
| B1 | | 0-10 | 8.1 | 0.54 | 21 | 66 | 356 |
| | | 10-30 | 8.1 | 0.46 | 20 | 58 | 295 |
| B2 | | 0-10 | 8.1 | 0.58 | 14 | 43 | 276 |
| | | 10-30 | 8.2 | 0.49 | 12 | 41 | 261 |

The control area’s potassium exchange content was in a low supply category; the application of mineral fertilizers together with potassium humate had insignificant effect on its content.

The content of basic soil nutrition elements of experimental sites is typical for dry-step soil-climatic zone. This makes it possible to use a traditional fertilizer system that takes into account planned yields and actual fertility.

The 2018 vegetation season was characterized as hot, with frequent winds. The start of the growing season was accompanied by high average daily temperatures and no precipitation. Daytime rare daily temperature at the moment of fruit blossom reached +30 °C, at night the temperature was not lower than 17 °C, which impacted fruit blossom.

Plant nutrition during the growing season has significantly improved the visual condition of plants. The first spraying was carried out in the 3-4 phase of these leaves, which improved the fruit blossom in a hot climate. The second spraying was carried out 20 days after the first one, which allowed the plants to continue the fruit blossom in sufficient quantities. Crop accounting was carried out by dividing, with subsequent recalculation of yield per 1 hectare.

Yield of the crop was 35 tons/ha. Option number 1 showed a yield of 42 tons/ha, and option number 2 showed a yield of 40 tons/ha (Table 3).

Table 3. Crop yields after liquid humic treatment.

| Option | Yield, c/s sites | Recalculation of yield per 1 ha, centners per hectare | Difference with the reference sample centners per hectare | % |
|--------|----------------|---------------------------------------------------|------------------------------------------------------|---|
| R | 60 | 350 | - | - |
| B1 | 72 | 420 | 70 | 20% |
| B2 | 69 | 400 | 50 | 15% |
The use of the preparation allowed to increase the total yield of the crop by 15-20%. The best results were shown by plant fertilizers with a combined application of a full dose of mineral fertilizers during the growing season.

Fruit blossom is better in the period of flowering and have the right shape, development and ripening of the fruit was somewhat faster than in the untreated areas; the number of fruits is different: in the treated areas, the number of fruits from the bush was 4 pieces on average, while the number of fruits on the reference sample did not exceed 3 pieces.

4. Conclusion
Humic preparations had a positive effect not only on the soil cover of the study area but also on the yield. The study of physical and chemical properties of brown semi-desert showed a very low content of hydrolyzable nitrogen, low content of mobile phosphorus and potassium metabolism before the application of mineral fertilizers and liquid humic treatment. The application of humic preparation contributed to the increase of humus content in the soil in arable horizons at all depths of the study areas. The content of mobile forms of phosphorus and potassium metabolism increased and shifted to higher groups of categories. This increase was due to the application of complex mineral fertilizers. It should be noted that there is no horizon salinization in the soil after harvesting.

The application of humic fertilizer in the form of leaf fertilizers with the application of mineral fertilizers in 100% and lower options, increased the yield of crops in both options of potassium humate increased the total yield, which amounted to 20% in option 1 and 14% in option 2. The treated areas showed good fruit blossom.

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