Environmental aspects of the application of mineral fertilizers

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Abstract. To increase crop production, it is practically important to study the influence of micro fertilizers in the context of organic fertilizers (compost). The effect of micro fertilizers on the yield, quality, and chemical composition of the fruit of the pepper variety was studied in a compost-based cropping trial. It was found that the combined use of organic and micro fertilizer increased pepper yield by 6.67-19.37%. The sugar content in the optimum varieties increased by 1.07-1.31 times, vitamin C by 1.01-1.14 times, ash by 1.02-1.17 times, and cellulose by 1.06-1.44 times compared to the background. The influence of different concentrations of trace element salts on the chemical composition of pepper fruits was also studied. The concentration and chemical properties of micro fertilizing salt solutions were found to influence both the content and accumulation of TE in pepper fruits.

1 Introduction

An excess of various salts, for geological reasons related to the uneven distribution of substances on the surface and in the underlying soil horizons, contributes to soil salinization. Factors such as uneven processes of water supply to soils and water evaporation also play a role. At the same time, rising temperatures and decreasing rainfall are accelerating the processes of salinization and further desertification [1].

Armenia is located in the northern part of the subtropical climate zone. It is no coincidence that this makes its territory one of the most vulnerable to climate change, as it is a potential risk zone for the degradation of fertile soils [2,3]. The situation is aggravated by the anthropogenic factor of environmental impact, which is expressed in the negative effect of excess salts in the soil on various biological objects (high osmotic pressure, alkaline reaction of the environment, toxic effect of easily soluble salts, increased mineralization of organic matter) [4]. As a result of such a multi-component effect on the natural soil structure, a lower level of potential fertility is observed in it, and the availability of macro- and trace

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elements (TE) for plants decreases [5]. The result is a decrease in agricultural yields and the development of food risks to ensure their availability [6].

TE are essential nutrients found in plants in concentrations ranging from a few thousandths to a few hundred thousandths of a percent. Some of them (Cu, Zn, Mo, Mn) are associated in plants with the metabolism of carbohydrates, proteins and phosphates, as well as with the formation of auxin, DNA and ribosomes, playing an important role in photosynthesis, respiration, carbohydrate redistribution, restoration of nitrogen fixation, protein metabolism [7,8]. Under the influence of TE in the leaves photosynthesis improves and the assimilation activity of the whole plant increases [9]. Many TE are contained in the active centers of enzymes and vitamins [10]. On the other hand, deficiency of TE causes a number of plant diseases and often leads to their death [11]. In this context, the use of micro fertilizers on soils with a low supply of TE makes it possible to increase the yield and quality of crops [12]. Anthropogenic pollution of soil causes changes in the concentration of very dangerous TE in soil [13].

Therefore, it is of great scientific and practical importance to study the influence of micro fertilizers in the context of organic fertilizers (compost) to increase crop production. One of the main objectives of our research is to study the antagonistic/synergistic nature of the interaction of certain microelements with the use of micro fertilizers.

2 Objects and methods of research

The research was carried out using field and office work, vegetation experiments and laboratory agrochemical analyses of soil and plant samples. The sweet pepper variety *Capsicum annuum L*. (Bulgarian 79) was used. The influence of TE-containing salts with organic fertilizer (compost - Baikal EM-1) on yield and chemical composition of fruits of sweet pepper variety was studied. Vegetation experiments were carried out on irrigated residual meadow brown soils from the arable horizon of the village of Janfidan (Armavir region, Republic of Armenia with coordinates 40°02′44″N 44°01′15″E). 10 kg of soil was placed in the vessel and the following was added per 1 kg of dry soil: N - 0.15; P2O5 - 0.10; K2O - 0.35 g. A mixed sample was taken from the sampled soil for agrochemical analysis. The experiments were repeated 4 times [14].

The gross content of TE was determined by the spectral emission and neutron activation method, and the mobile content of TE was determined by the atomic absorption method on the AAS-1 apparatus. The humus content was determined by Tyurin's method, the sum of absorbed bases and cations - by Ivanov's method, the mechanical composition of the soil - by Kachinsky's method, the pH - by the standard electro potentiometric method, the content of carbonates - by Kudrin's method, the content of exchangeable cations (Ca, Mg, Na) - according to Bagramyan's method, the quality of total nitrogen - according to Kjeldahl, as well as phosphorus and potassium - according to Lorenz, mobile nitrogen - according to Tyurin and Kononova, phosphorus - according to Michigan, sugar content - according to Bertrand. The highlighted methods are explained in [15].

3 Results and discussion

The meadow-brown irrigated soils have a different mechanical composition and mineralization. This is due to complex lithological and hydrolytic conditions. These soils occupy the lower part of the middle reaches of the river basin. Araks, where the agricultural complex of the region is intensively developed. According to the obtained agrochemical indicators, the studied soil samples had an average humus content (2.0%), absorbed bases (Ca+2, Mg+2, Na) of 33.8 mg/eq per 100 g of soil, CaCO3 predominates in the composition of carbonates, amounting to 9.4%. Furthermore, the studied soil was characterized by an alkaline reaction of the environment (pH 8.2) and had a heavy loamy mechanical composition (47.8%). It was found that the studied soil was rich in total phosphorus - 0.39% and potassium - 1.5%, but poor in total nitrogen (0.15 mg/100 g of soil) and easily hydrolyzed nitrogen (3.1 mg/100 g of soil), as well as mobile phosphorus (1.5- 3.0 mg/100 g of soil) and well supplied with potassium.

When determining the content of both gross and mobile forms of TE in soil samples, fluctuations in total boron (29.7 mg/kg), manganese (3858.4 mg/kg), copper (72.2 mg/kg) were revealed that exceeded their Clark concentrations (CC); zinc concentrations were noted the value (60.4 mg/kg) is close to value of CC, and in terms of molybdenum concentration it is lower than the value of CC (2.1 mg/kg) [15]. According to the Armenian soil supply scale, the studied soils was moderately and well supplied with boron and molybdenum (B - 2.8, Mn - 335.2, Cu - 15.9, Zn - 4.7, Mo - 0.35 mg per 100 g of soil). They were relatively rich in wet meadow-brown soils, associated with groundwater levels (1.2-1.5 m) and alkalinisation processes [17].

According to the results obtained (Table 1), the yield of pepper depended on the dose of TE and the chemical properties of its water-soluble salts, which caused the variation of its values with respect to the background (BG) by 6.67-19.37%. The most effective of the studied options is BG + 0.03% zinc sulphate, where the pepper yield exceeds the pure BG by 1.2 times. The maximum sugar content (3.8%) was recorded in the option BG + 1% manganese sulphate, which was 1.31 times higher than pure BG. A high concentration of vitamin C was observed in the variants BG + 0.03% zinc sulphate and BG + 1% borax solution. Both ash and cellulose content were higher in the case of BG + 0.02% copper sulphate.

Table 1. Influence of water-soluble salts of microelements on yield and quality indicators of the sweet pepper variety.

Experiment options	**Average yield, q/ha**	**Increase in value**		**Sugar, %**	**Vitamin C, mg %**	**Ash, %**	**Cellulose, %**
		q/ha	**%**				
Compost - 20 t/ha (BG)	315.0	-	-	2.9	22.8	0.48	0.18
BG + 1% $Na_2H_20B_4O_{17}$	346.0	31	9.84	3.0	26.0	0.51	0.15
BG + 1.5% $MnSO_4$	360.0	45	14.29	3.1	23.1	0.54	0.16
BG + 1% $MnSO_4$	350.0	35	11.11	3.8	23.4	0.50	0.18
BG + 0.5% $MnSO_4$	338.0	23	7.30	2.9	21.6	0.52	0.21
BG + 0.02% $ZnSO_4$	336.0	21	6.67	3.2	23.8	0.56	0.26
BG + 0.03% $CuSO_4$	376.0	61	19.37	2.6	24.7	0.49	0.19
BG + 0.05% $(NH_4)_6Mo_7O_{24}*4H_2O$	353.0	38	12.06	3.0	23.0	0.46	0.19

Note: The minimum significant difference in Fisher's figure (at 0.95) was 16.6; the experimental errors were no more than 2.9%.

An important conclusion was drawn from the studies on foliar spraying with solutions of TE salts: the latter does not have a general scenario for the accumulation of TE in pepper fruits (Table 2). For example, when a pepper plant was sprayed with a 1% solution of borax, the concentration of boron in the pepper fruit increased by 22%, copper by 23.68%, molybdenum by 3.57% compared to the background, and the increase in the amount of manganese and zinc was not significant (0.59 and 0.56%). When was used 1.5 and 1.0% manganese sulphate solutions, the amount of boron in fruits increased by 2.0 and 6.2%, manganese - by 26.7 and 15.3%, copper - by 15.8 and 13.2% and molybdenum - by 3.57 and 7.14%, while the accumulation of zinc was not significant (1.1 and 0.37%). In the case using BG + 0.5% manganese sulphate solution the amount of manganese in fruits increased by 13.53%, copper by 10.53% and the accumulation of boron, zinc and molybdenum were not significant. Foliar application of the case BG + 0.03% zinc sulphate solution increased the accumulation of manganese by 8.8%, copper by 13.16% and zinc by 35.19%, the increase in boron accumulation compared to pure BG was not significant (2.0%), as well as the molybdenum content was lower.

Table 2. Effect of micro fertilizers on the accumulation of TE in pepper fruits.

Experiment options	**Concentration trace element, mg/kg**				
	B	**Mn**	**Zn**	**Mo**	**Cu**
Compost-20 t/ha (BG)	5.01 ± 0.24	34.12 ± 1.63	5.41 ± 0.26	0.28 ± 0.01	3.81 ± 0.18
BG + 1% $Na_2H_20B_4O_{17}$	6.11 ± 0.29	34.24 ± 1.64	5.43 ± 0.26	0.29 ± 0.03	4.72 ± 0.23
BG + 1.5% $MnSO_4$	5.12 ± 0.24	44.13 ± 2.12	5.46 ± 0.27	0.29 ± 0.01	4.46 ± 0.21
BG + 1% $MnSO_4$	5.31 ± 0.25	39.22 ± 1.88	5.42 ± 0.26	0.31 ± 0.04	4.31 ± 0.24
BG + 0.5% $MnSO_4$	5.06 ± 0.24	38.64 ± 1.85	5.43 ± 0.26	0.28 ± 0.01	4.25 ± 0.19
BG + 0.02% $ZnSO_4$	-4.72 ± 0.23	38.61 ± 1.86	5.42 ± 0.26	0.32 ± 0.02	5.34 ± 0.25
BG + 0.03% $CuSO_4$	5.13 ± 0.24	37.18 ± 1.78	7.31 ± 0.35	0.27 ± 0.01	4.36 ± 0.18
BG + 0.05% $(NH_4)_6Mo_7O_{24}$*$4H_2O$	-4.61 ± 0.22	38.92 ± 1.87	6.22 ± 0.29	0.36 ± 0.02	4.27 ± 0.12

Spraying the plant with a 0.05% ammonium molybdate solution increased the manganese concentration in the fruit by 14.41%, zinc by 14.81%, molybdenum by 28.57%, copper by 10.53%, the boron content was below BG (-8.0%). A positive effect was also observed when a 0.02% copper sulfate solution. The accumulation of manganese increased by 13.53%, molybdenum by 14.29%, and copper by 5.26%, but harmed the accumulation of boron (-6.0%), the accumulation of zinc was insignificant (Table 2).

4 Conclusion

Soil is a unique natural formation in the biosphere, possessing properties of both living and non-living matter that distinguish it from its parent rock. Its primary function is to act as a biological sink for various pollutants. In the Armavir region of the Republic of Armenia, the main source of anthropogenic input of trace elements (TE) into agrocenoses was through the use of organic fertilizers in agricultural production. The results show that the levels of total and mobile forms of TE in soils vary widely. Total manganese, copper, cobalt, and boron are above the CC. Moist meadow-brown soils was relatively rich in these elements, which is associated with the region's groundwater level (1.2-1.5 m) and alkalinization processes. Residual meadow-brown irrigated soils and its subtypes was characterized by an average humus content, low in gross and mobile nitrogen and phosphorus, but high in gross potassium and mobile phosphorus. The micro fertilizers used in residual meadow-brown irrigated soils increased pepper yield by 21-61 c/ha. The quality indicators of pepper also improved under the influence of micro fertilizers. The concentration and chemical properties of micro fertilizer salt solutions to impact as well the content as the accumulation of TE in pepper fruits were found.

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