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IMPROVING PRODUCTION YIELD OF LONG PEPPER CROP GROWN IN UNHEATED SOLAR THROUGH SUSTAINABLE FERTILIZATION

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ABSTRACT

Pepper (Capsicum annum L.) is a cultivated legume species belonging to the Solanaceae family, widely cultivated in many regions of the world, due to its important nutritional and economic qualities. Adequate plant nutrition plays an important role for vigorous growth, increased production yield and fruit quality. This study aimed to identify essential elements for the nutrition of a long pepper crop established in an unheated solar, in the Dobreni locality, Giurgiu county. In this regard, soil samples were taken both before the establishment of the crop and after its dismantling. The analysis of the first soil sample recorded a low ammonium content, high amounts of sodium, calcium, phosphorus, nitrates and nitrites. Fertilization recommendations were made to correct the amounts of the main nutrients analyzed. After applying the recommended fertilizers, a soil sample was taken again to compare the results with the first sample.

INTRODUCTION

Sweet pepper (*Capsicum annum* L.) is a widely cultivated vegetable crop belonging to the *Solanaceae* family (Dinu et al., 2024; Stoleru et al., 2023) in many parts of the world (Diaz-Perez, 2013). Pepper culture has played an essential role in human civilization, including human nutrition and culturallysignificant medicinal values (Luna-Romero et al., 2022; Yasin et al., 2023). Adequate nutrition plays an important role for vigorous plant growth, increased yield and fruit quality (Shehata et al., 2019).

The increase of soil productivity is one of the major key factors, attributing to substantial increase in agricultural yield. In order to achieve higher and quality yields, soil health is a critical factor (Alkhaportly, 2018).

Fertilization is a critical component of modern agricultural practices, and the use of different types of fertilizers can significantly affect the production and quality of sweet peppers. Fertilization can be categorized into chemical, biological, and organic types. Chemical fertilizers are widely used in modern agriculture, but they can have negative environmental impacts and can also affect the quality of crops.

It is important to know the role of nutrients in plant life and their influence on the harvest, because it underpins the measures that are required to ensure optimal plant growth and development and the production of superior quality plant products

(Budoi, 2000).For instance, in a study done by Hallmann et al. (2019), the content of dry matter, total flavonoids and phenolic acids were significant lower in chemically fertilized peppers than in organic fertilized peppers

Nutrient absorption depends on the plant phenological stage and is enhanced during flowering, fruit formation and growth (Marcussi et al., 2004).

Regarding the negative impact on environment, chemical fertilization is responsible for soil acidification, emission of greenhouse gases, accumulation of mineral salts, imbalances in the soil microbiota, eutrophication of water bodies (Nadarajan and Sukumaran., 2021).

The aim of this study was to establish an optimal fertilization plan, based on chemical analyses performed at the Agrochemical Analysis Laboratory, Holland Farming Agro SRL end provide valuable information on the potential of organic and chemical fertilizers used in the cultivation of long pepper, the Kaptur F1 hybrid, grown in an unheated greenhouse, with the aim of increasing production and correcting certain wrong techniques applied in fertilization management.

MATERIAL AND METHODS

The experiment was carried out at a farmer from Dobreni locality, Giurgiu county, to sweet pepper crop cycle II, the Kaptur F1 hybrid, planted on July 17 (the planting density being 35 000 plants/ha), in an unheated solar.

The first soil sample was collected end of 01.07.2021 and sent to the Holland Farming Agro (HFAGRO) laboratory, in order to perform analyses for the nutritional elements. The following analyzed: pH, K, P, N-NO3, N-NH4, Ca, Mg, Na, Cl-, $SO4^{2-}$, Fe, Mn, Zn, Cu, Mo, B and content humus.

Preparation of soil samples

The soil was pretreated and air-dried at a maximum of 40 °C in accordance with the standard ISO 11464:2006. For determinations, the ICP-OES (inductively coupled plasma optical emission spectrophotometry) and SFA (discontinuous flow colorimetric analysis method) methods were used.

The pH was determined from an aqueous suspension of soil in a ratio (mass/volume) of 1:2.5.

Na, K, Ca, Mg, B, N-NH_4 and N-NO_2 + N-NO_3 were determined from the aqueous extract, soil:ultrapure water in a ratio of 1:2.5.

Microelements (Fe, Mn, Zn, Cu, Mo) were extracted in DTPA buffered solution in accordance with SR ISO 14870:2002 and P was extracted in 0.5 mol/L sodium bicarbonate solution in a ratio of 1:20 in accordance with SR ISO 11263:1998.

The humus content was determined indirectly, depending on the organic carbon content, by multiplying it by a coefficient of 1.7241.

On the basis of the obtained results were fertilization recommendations were made for the entire vegetation period, with the following products: Biocat 15 L, Sodial 2 L, BeneSol 4-3-3, Atlante, PeKacid, Mapliq, Razormin, Cropmax, Agroleaf Power High N 31-11-11, Microcat Ca-B, Microcat Fe and Agroleaf High K 15-10-31.

Biocat 15 (total humic extract 15 % + humic acids 7 % + fulvic acids 8 % + water-soluble potassium oxide (K_2O) 4.5 %) is a liquid humic corrector of plant origin specially designed to be applied through the irrigation system and acts on the soil structure. It has a biological effect, increasing the microbial population that degrades organic matter. It also improves nutrient absorption through the root, after the release of microelements.

Sodial (40 % polyhydroxyphenyl carboxylic acid + 7 % water-soluble calcium oxide - CaO) is a soil salinity corrector based on calcium complexed with organic acids. Calcium replaces the sodium present in the soil, forming sodium sulfate, which can be easily eliminated through the root zone.

BeneSol 4-3-3 is an organic fertilizer that can help the plant have a high yield and better quality of vegetables, fruits and flowers.

Atlante is a liquid product, rich in potassium (in the form of potassium phosphonate), which completes fertilization and ensures maximum absorption and translocation in the plant. It can also be included in some disease control programs (fungi) on various crops.

PeKacid is a potassium phosphate fertilizer with a strong acidifying effect. It improves nutrient absorption and can be used to clean irrigation systems. Advantages: lowers the pH of the water, which improves nutrient availability.

Mapliq is a binary liquid fertilizer designed to cover the fundamental needs of soil and irrigation tanks, including pH regulation. It provides nitrogen and phosphorus in an easily assimilable form. It increases the absorption capacity of plants of the foliar applied solution, while also regulating the pH of the solution when using water with an alkaline pH, thus reducing the risk of phytotoxicity.

Razormin induces branching and vigorous development of the root system, vegetative mass and ultimately the quantity and quality of yield. It also stimulates the development of root absorbing hairs that are responsible for the uptake of nutrients into the plant.

Cropmax is a super-concentrated foliar fertilizer, containing growth stimulants, plant vitamins, polysaccharides, enzymes, macro and microelements. The application of Cropmax ensures rapid development of the root system and activates the development of leaf mass, helping plants to realize their biological potential and also allowing the applied dose of basic NPK fertilizer to be reduced by 10–30 %.

Agroleaf Power High N 31-11-11 is a foliar fertilizer that prevents and corrects nutritional deficiencies and improves crop productivity. It can be used in every phase of growth and can correct major nutritional imbalances as well as minor deficiencies.

Microcat Ca-B is a foliar fertilizer for correcting boron deficiencies in different plant species.

Microcat Fe contains 8 % water-soluble iron (Fe), 1.3 % total nitrogen (N), 2.5 % free amino acids and 7 % organic acids, being used to correct iron deficiencies.

Agroleaf High K 15–10-31 + TE is a water-soluble foliar fertilizer that prevents and corrects nutritional deficiencies and improves crop productivity.

Tron pH was also used, a pH regulator with a coloring effect on the solution and a non-ionic adjuvant with the effect of uniformly distributing the foliar treatment solution on the leaf surface.

At the end of the vegetation period, another soil sample (Sample 2) was taken to verify the changes that occurred as a result of fertilization with recommended products.

Therefore, by evaluating the relationship between fertilization with the assortment of products recommended by this study and the response of long pepper plants, this study aims to provide valuable information for the development of sustainable agricultural practices for cultivation long pepper in solar.

Furthermore, the results of this research will contribute to a better understanding of the role of fertilization in the production of long pepper production.

RESULTS AND DISCUSSIONS

Following the physicochemical analyses, sample 1 (table 2), we found that in the first sample the pH level and the level of some nutrients in the soil are very high, causing phytotoxicity to the pepper plants. Thus, products were recommended to reduce excesses and restore balance in the soil.

Recommendations for growing sweet pepper in unheated solar are they find each other in Table 1.

Table 1

Nutrition recommendations for sweet pepper crop

Growing stage	How to apply	Product	Dose
Before planting	basic fertilization (it is incorporated 5-6 cm deep and 5 cm away from the plant)	Benesol 4-3-3	100 kg/ 1000 sq.m.
	drip irrigation system	Sodial (1 treatment)	1.5 L/ 1000 sq.m.
Stage II (weeks 2,3,4,5) since planting	drip irrigation system	Atlante (1 treatment)	0.3 L/ 1000 sq.m./ week
	drip irrigation system	Pekacid 0-60-20 (weeks 2, 4)	0.015%
	drip irrigation system	Mapliq + Razormin (1 treatment)	0.5 L/1000 sq.m. + 0.3 L/1000 sq.m.
	drip irrigation system	Biocat 15 (1 treatment)	0.5 L/1000 sq.m
	foliar	Cropmax (2 treatments) + Agroleaf High N 31-11-11 + TE (2 treatments)	0.2% + 0.3%
	foliar	Microcat Ca-B (1 treatment)	0.3%
	pH regulator and antifoam for foliar solution	Tron - pH	50 mL/ 100 L water
Stage III (weeks 6,7,8,9) since planting	drip irrigation system	Razormin + Biocat 15 (1 treatment)	0.3 L/ 1000 sq.m. + 1 L/ 1000 sq.m.
	drip irrigation system	Mapliq (1 treatment)	0.5 L/ 1000 sq.m.
	drip irrigation system	Sodial (1 Treatment)	0.5 L/ 1000 sq.m.
	drip irrigation system	Atlante + Pekacid 0-60-20 (weeks 6,8)	0.3 L/ 1000 sq.m. + 0.015%
	Foliar	Cropmax (1 treatment) + Agroleaf Total 20-20-20 + TE (1 treatment)	0.2% + 0.3%
	Foliar	Microcat Fe (1 treatment)	0.3%
	pH regulator and antifoam for foliar solution	Tron - pH	50 mL/ 100 L water
Stage IV (weeks 10, 11, 12 until the end of the harvest)	drip irrigation system	Sodial (1 treatment)	0.5 L/1000 sq.m.
	drip irrigation system	Atlante (1 treatment)	0.3 L/1000 sq.m.
	drip irrigation system	Razormin + Biocat 15 (1 treatment)	0.3 L/1000 sq.m. + 1 L/ 1000 sq.m.
	foliar	Agroleaf High K 15-10-31 + Te (2 treatments)	0.5%
	pH regulator & antifoam for foliar solution	Tron - pH	50 mL/ 100 L water

pH values indicate that the soil is too alkaline which can reduce nutrient availability and microbial activity (Table 2).

The nitrogen deciency can limit plant growth, especially in early stages. In sample 1, the value for N is very low and in sample 2 a higher value was obtained but still below normal limits.

The potassium level in sample 2 is low and may reduce flowering/fruiting. The first symptoms typically appear on the older leaves, as potassium is a mobile nutrient and the plant will mobilize potassium from older leaves to supply younger growth.

Table 2

Soil sample analysis results
(Sample 1 – before planting and Sample 2 – after applying fertilizer) (*)

Parameters	Sample 1 Values obtained	Sample 2 Values obtained	Normal range	Interpretation for both samples
pH	8.24	8.13	6.2 – 6.8	Above normal
EC	0.29	0.35	0.11 – 1.5	Normal
N-NH_4 (mg/kg)	<2.5	6.2	20.1 – 40.0	Below normal
K (mg/kg)	82.4	61.1	66.1 – 132.0	Sample 1 is within range; Sample 2 is slightly below
Na (mg/kg)	124.4	129.8	5.0 – 10.0	Above normal
Ca (mg/kg)	131.2	144.3	48.0 – 85.0	Above normal
Mg (mg/kg)	62.0	64.7	25.0 – 70.0	Normal
P (mg/kg)	145.5	230.1	18.1 – 36.0	Above normal
NO_2^- + N-NO_3^- (mg/kg)	63.5	69.6	20.1 – 40.0	Above normal
Fe (mg/kg)	11.9	13.8	15.0 – 50.0	Below normal
Mn (mg/kg)	7.2	6.6	5.1 – 20.0	Normal
Zn (mg/kg)	7.0	9.0	1.51 – 3.0	Above normal
Cu (mg/kg)	9.5	10.1	0.51 – 1.5	Above normal
B (mg/kg)	0.7	0.5	0.26 – 0.40	Above normal
Humus (%)	4.91	4.99	2.5 – 4.0	Slightly above

*physicochemical analysis results (HAGRO laboratory)

The Na is toxic to plants and can cause soil structure breakdown and poor water uptake. High sodium levels in the root zone lead to osmotic stress, meaning the plant can't take up enough water from the soil, even if there’s adequate moisture available. This results in wilting, leaf scorch, necrosis, and stunted growth.

Excess Ca can raise pH, interfere with other nutrient uptake (e.g. Mg, K, Zn, Fe) and adequate Mg levels support chlorophyll production and enzyme activity.

Excess P can cause micronutrient deficiencies and environmental runoff risk. There is compulsory to adapt phosphorous nutrition schemes by using fertilizers containing phosphorous protection technologies – coated with new generation of polymers and other technologies or by using beneficial microbes (phosphate solubilizing bacteria) (Popescu and Dinu., 2018).

Risk of nitrogen leaching and pollution, may not be fully usable by plants.

Low iron can cause deficiency symptoms like chlorosis (yellowing leaves). The youngest leaves acquire a yellowish-green color, then the areas between the veins become yellow or yellowish-white, with only the main veins and sometimes the secondary veins remaining green (Budoi, 2000).

The values obtained in both samples fall within the normal range and Mn in sufficient quantities is good for enzyme activation and photosynthesis.

Zinc toxicity risk – stunts root growth, damages seed germination. Zinc application should be considered after foliar analysis like in the case of other deficient micronutrients (Popescu and Dinu 2018). Also, symptoms of zinc toxicity are similar to iron deficiency, but appear on both young leaves at the top and old ones at the base (Budoi, 2000).

In both samples Cu is very high, beeing a toxic level that can harms plant metabolism and microbial life in soil.

The boron is very high which means boron toxicity leads to leaf burn and stunted growth.

Extra organic matter boosts fertility, but may raise pH and bind nutrients.

Based on the fertilization recommendations, the farmer for the Kaptur F1 hybrid, a yield of 30 tons per hectare was obtained (second short crop cycle).

CONCLUSIONS

In conclusion, this study provides valuable information on the potential of organic and chemical fertilizers used in the cultivation of sweet peppers, the Kaptur F1 hybrid, cultivated in a cold greenhouse with the aim of increasing production yield and correcting certain wrong techniques applied in fertilization management.

The present study paves the way for further research aimed at reducing fertilization doses and pesticides used in protected cultivation by intelligently managing fertilizer application.

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