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INFLUENCE OF MINERAL FERTILIZERS ON SWEET PEPPER YIELD IN THE SOUTHERN STEPPE OF UKRAINE

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The article presents and analyzes the results of a one-year field experiment with sweet pepper. where the reaction of the crop to different nutrient backgrounds was evaluated. Nutrient backgrounds for the vegetation of the crop were created by applying mineral fertilizers based on planned yields of 35 t/ha (Background 1 – application rate N118P62), 45 t/ha (Background 2 – application rate N145P75) and 55 t/ha (Background 3 – application rate N163P84). The application of mineral fertilizers based on the planned yield of 35 t/ha (Background 1) led to an increase in the number of fruits per plant – 5.5 fruits/plant; at Background 2 – 6.0 fruits/plant; and at Background 3 – 6.3 fruits/plant. The applied mineral fertilizers also had a directly proportional effect on the diameter of the fruit. The application of mineral fertilizers calculated for a yield of 35 t/ha resulted in a yield of 33.6 t/ha, while the application of fertilizers for a planned yield of 45 t/ha resulted in a productivity of 42.4 t/ha. The application of mineral fertilizers calculated for a yield of sweet pepper at 55 t/ha resulted in a yield of 51.4 t/ha. The application of mineral fertilizers for the calculated yield of sweet pepper at 35 t/ha (Background 1 N118P62) resulted in the lowest profitability in our experiment – 26.1 kg of sweet pepper fruits per 1 kg of active substance of the applied fertilizers. Increasing the application rate to N145P75 (Background 2 calculated for a yield of 45 t/ha) resulted in almost a threefold increase in the profitability of the applied mineral fertilizers – 61.4 kg/kg of active substance. The maximum profitability in our experiment was achieved with the application of fertilizers at the rate of N163P84 (Background 3 which was calculated for a yield of 55 t/ha of sweet pepper) – 91.1 kg/kg of active substance. It should be noted that the obtained results do not indicate an optimal variant. highlighting the need to include a variant with even higher rates of mineral fertilizers in the experimental scheme.

Key words: *sweet pepper, nutrient backgrounds, drip irrigation, yield, profitability of mineral fertilizers.*

Шепель А.В. Вплив мінеральних добрив на урожайність перцю солодкого в умовах південного Степу України

У статті наведені і проаналізовані результати однорічного польового досліду з перцем солодким, де оцінювали реакцію культури на фони живлення. Фони живлення для вегетації культури були створенні внесенням мінеральних добрив на заплановану врожайність у 35 т/га (Фон 1 – норма внесення N118P62), на 45 т/га (Фон 2 – норма внесення N145P75) і на 55 т/га (Фон 3 – норма внесення N163P84). Внесення мінеральних добрив на запланований врожай у 35 т/га (фон 1) призводило до зростання кількості плодів на рослину – 5.5 шт./рослину на фоні 2 – 6.0 шт./рослину. на фоні 3 – 6.3 шт./рослину. Внесенні мінеральні добрива також прямо пропорційно впливали на діаметр плоду культури. Внесення мінеральних добрив з розрахунку врожайності культури у 35 т/га дозволило отримати 33.6 т/га, а при внесенні добрив на заплановану врожайність у 45 т/га отримана продуктивність культури складала 42.4 т/га. Внесення мінеральних добрив з розрахунку врожайності перцю солодкого у 55 т/га дозволило отримати 51.4 т/га. Внесення мінеральних добрив на розрахований врожай перцю солодкого у 35 т/га (Фон 1 N118P62) дозволило отримати мінімальну окупність у нашому досліді – 26.1 кг плодів перцю солодкого на 1 кг діючої речовини використаних міндобрив. Збільшення норми внесення до N145P75 (Фон 2. розрахований на отримання врожайності у 45 т/га) призводило до майже 3-х кратного зростання окупності внесених мінеральних добрив врожаєм – 61.4 кг/кг д.р. Максимальну окупність у нашому досліді забезпечило внесення міндобрив у нормі N163P84. (Фон 3. який був розрахований на отримання 55 т/га плодів перцю солодкого) – 91.1 кг/кг д.р.

Треба відмітити, що отримані результаті не мають оптимального варіанту, що вказує на потребу внесення у схему досліду варіанту внесення мінеральних добрив у ще більшій нормі.

Ключові слова: *перець солодкий, фони живлення, краплинне зрошення, урожайність, окупність мінеральних добрив.*

Problem Statement. Pepper originates from South America, where it was used by the indigenous people as food and seasoning. It was introduced to Europe in the mid-16 th century and spread from Spain through the Balkans to Hungary, Romania and Bulgaria. In the wild pepper can be found in tropical regions of America. It is cultivated in southern, subtropical latitudes across all continents. Pepper emerged in the early 17-th century as a medicinal plant. and from the mid-19-th century, it has been recognized as a fruit vegetable. Currently. it is widely used in Ukraine, primarily in Crimea, where 500-600 hectares are allocated for its cultivation annually. The Southern Steppe of Ukraine is also a major region for growing pepper.

The Latin name for the crop. *Capsicum annuum*. was given by Linnaeus, derived from the Latin words: “capsa” meaning box, and “annum” meaning annual. The first botanical description of pepper was made by a physician of Columbus’s second expedition in 1494. Modern botanists believe that the diversity of pepper encompasses four species (according to V.L. Hazenbush. 1951): annual (or Mexican) pepper; Peruvian pepper; Colombian pepper; and pubescent pepper.

The most widely recognized species is the annual pepper or vegetable pepper – *Capsicum annuum* L. which, due to its ecological plasticity, has spread throughout the world. It has many varieties and cultivars.

The analysis of recent research and publications. Pepper is an annual plant. The fruit is a multi-seeded false berry, varying in shape, size, and weight. The color at the technical ripeness stage can be light green, dark green, white, yellow or cream; at biological ripeness, it is bright red, dark red, orange-red, yellow or dark. The flesh can taste sweet. spicy or mildly spicy; its texture can be tender, coarse or medium.

Pepper seeds are smooth, flat and slightly rounded, pale yellow, located at the base of the fruit, measuring 3-4 mm in length 2-3 mm in width and 0.5-1 mm in thickness. A ripe fruit contains between 100 to 150 seeds, with a total weight of about 1 g. The weight of 1000 seeds ranges from 3 to 8 kg. They retain high germination rates for 4-5 years, but under unfavorable storage conditions, this drops to just 1-2 years. The root system is taprooted and well-developed, with the majority of roots located in the upper soil layer.

The average nutrient uptake for pepper is 4-5 kg of nitrogen per ton, 1.2-2.2 kg of phosphorus per ton and 5.2-6.8 kg of potassium per ton. Magnesium is also very important for salad pepper. A deficiency of magnesium in the soil can lead to leaf dieback, reduced yield, and lower product quality. Therefore, soil diagnostics for magnesium content should be conducted; if it is lacking or at very low levels, soluble forms of magnesium should be applied [2].

In open ground, seedlings are planted when they are 45-50 days old and as soon as the threat of spring frosts has passed, with air temperatures rising to +13-15°C and soil temperatures at the planting depth not lower than +10-12°C. preferably above +15°C.

Root growth is most intense until the onset of fruit formation, after which the growth rate gradually slows down. The roots are the most sensitive part of the plant to cold. The stem of the pepper is herbaceous; it is soft in young plants but becomes coarse and woody in mature plants. It branches dichotomously. The leaves are solitary or arranged in rosettes with long petioles. In shape, they range from ovate to lanceolate with a pointed tip; in color, they vary from light and dark green to mottled olive-black.

The flowers of the pepper are perfect and white, forming in the leaf axils one at a time, or rarely two on each lateral shoot. Flowering occurs continuously until frost. The first flowers to open are on the first and second order shoots, followed by those on the main stem. The total number of flowers on a single plant during the growing season can reach 20-80 or more. Depending on the variety and growing conditions, pepper begins to flower 40-80 days after germination. Flowers appear continuously, meaning that they bloom as long as the plant is alive. They open in sunny weather in the morning from 6 to 10 AM, and in cloudy weather, they remain open throughout the daylight hours. As fruits develop, the appearance of new flowers slows down. After harvesting, flowering resumes. Therefore, it is important to systematically harvest fruits that have reached consumer ripeness.

Mixed plantings of sweet and hot peppers should be avoided to prevent cross-pollination, which can result in bitter fruits instead of sweet ones. In such cases, spatial isolation of up to 1 km should be maintained [3].

At temperatures above +30°C and below +10°C, fertilization is disrupted. In greenhouses, it is necessary to regulate the temperature. During the fruiting period, the appearance of new flowers slows down. After the first fruits are harvested, flowering resumes. Therefore, in temperate climates, fruits should be harvested as soon as they reach harvest maturity.

Early-maturing varieties of sweet pepper have a growing period (from germination to technical ripeness) of up to 120 days, mid-maturing varieties take 121 to 135 days, and late-maturing varieties take 136 to 150 days or more. Physiological ripeness in large-fruited varieties occurs no earlier than 140 to 150 days after germination.

Pepper strengthens the walls of capillaries. There are many capillaries in the body, and they need to be strong enough to nourish every cell and all organs and systems. Scientists studying pepper have identified vitamin P. which strengthens blood vessels. Therefore, pepper is a natural balm for the cardiovascular system. Red and orange peppers are rich in vitamin A, specifically carotene, while green and yellow peppers contain a significant amount of vitamin C – six times more than citrus fruits. Such peppers should be consumed fresh and not boiled or stewed [5].

Problem statement. Field studies with sweet pepper were conducted in 2023 under irrigated conditions at the agricultural enterprise “Mriya” in the Kherson district of Kherson region, using the “Methodology for Experimental Work in Vegetable Growing and Melon Cultivation” edited by H. L. Bondarenko. Seedlings of the culture, aged 45 days, were used for planting. The planting scheme for sweet pepper plants was (90+50)×35 cm. To assess the impact of nutrient backgrounds on the productivity of the crop, seedlings of the variety Lastochka were planted. This variety has a long history, beginning in 1975, when it was recommended for cultivation after being developed at the Pridnestrovskiy Scientific Research Institute of Agriculture (Republic of Moldova).

Characteristics of the variety: mid-maturing with a growing period of 116-121 days, suitable for universal use, and recommended for all soil and climatic zones of Ukraine (Steppe, Forest-Steppe, Polissia). This variety was chosen due to the low cost of seeds and quality characteristics that are still appreciated by producers and consumers of sweet pepper. Drip irrigation was used for watering the crop, with an artesian well as the source of irrigation water, having a mineralization of 0.6 g/l. The scheme of the single-factor experiment included variants with calculated rates of mineral fertilizer application based on the planned yield level of the crop. The establishment and conduct of this experiment were made possible by a contract with the agricultural enterprise for the creation of scientific and technical products (NTP) on the topic: “Productivity of Sweet Pepper under Different Nutrient Backgrounds.”

Presentation of the main material of the research. The application of mineral fertilizers led to a consistent increase in the biometric indicators of sweet pepper plants (Table 1). Specifically. the height of the plants increased from 35.3 cm in the control variant to 42.8 cm in background 3. The diameter of the plant stem also increased with the application of mineral fertilizers, rising from 7.0 mm to 8.9 mm.

The application of mineral fertilizers has a positive effect on yield structure indicators. In our experiment. we observed a similar pattern [7,8,9]. The number of sweet pepper fruits on the natural fertility background of the soil was 5.2 fruits per plant. The application of mineral fertilizers based on the planned yield of 35 t/ha (background 1) resulted in an increase in this indicator to 5.5 fruits per plant; in background 2, it reached 6.0 fruits per plant; and in background 3, it increased to 6.3 fruits per plant. The applied mineral fertilizers also had a directly proportional effect on the diameter of the fruits. This indicator grew from 6.5 cm in the control variant to 9.0 cm in background 3. Along with the diameter, the length of the fruit also increased. from 8.0 cm to 13.6 cm. It should be noted that the obtained results do not include an optimal variant, indicating the need to introduce a treatment with an even higher rate of mineral fertilizers into the experimental scheme.

Table 1

Biometric Indicators of Sweet Pepper Depending on Nutrient Backgrounds (2023)

Experimental Variants	Plant Height, cm	Stem Diameter, mm	Number of Fruits, cm	Fruit Diameter, cm	Fruit Length, cm
1. No Fertilizers – St	35.3	7.0	5.2	6.5	8.0
2. Background 1	37.0	7.6	5.5	7.4	10.7
3. Background 2	40.1	8.4	6.0	8.5	12.2
4. Background 3	42.8	8.9	6.3	9.0	13.6
LSD05	0.5	0.3	0.4	0.2	0.3

According to the set goal, three nutrient backgrounds were studied, calculated for the planned yield of the crop: background 1 – for 35 t/ha (application rate N118P62), background 2 – for 45 t/ha (application rate N145P75), and background 3 – for 55 t/ha (application rate N163P84). The obtained yield results for the crop are presented in Table 2.

As we can see, the yield of sweet pepper did not have a variant that would allow for the identification of the optimal rate of mineral fertilizer application. It should be noted that in the control variant, the yield of sweet pepper was logically the lowest in the experiment – 28.9 t/ha.

Table 2

Yield of Sweet Pepper Depending on Nutrient Backgrounds (2023)

Experimental Variants	Yield, t/ha
1. No Fertilizers – St	28.9
2. Background 1	33.6
3. Background 2	42.4
4. Background 3	51.4
LSD05, t/ha	2.3

The application of mineral fertilizers calculated for a yield of 35 t/ha resulted in a yield of 33.6 t/ha, while the application aimed at a planned yield of 45 t/ha produced a yield of 42.4 t/ha. The application of mineral fertilizers calculated for a yield of 55 t/ha resulted in a yield of 51.4 t/ha. It is important to note that all obtained increases in the yield of the crop across the experimental variants are statistically significant, as they exceed the calculated minimum significant difference (LSD05).

When evaluating the application of mineral fertilizers for agricultural crops, it is essential to determine the return on investment of the applied fertilizers based on the obtained yield (Table 3).

Table 3

Return on Investment of Applied Mineral Fertilizers Based on the Yield of Sweet Pepper (2023)

Experimental Variants	Return on Investment, kg/kg active ingredient
Background 1 (N118P62)	26.1
Background 2 (N145P75)	61.4
Background 3 (N163P84)	91.1

The application of mineral fertilizers calculated for a yield of sweet pepper at 35 t/ha (Background 1 N118P62) resulted in the minimum return on investment in our experiment – 26.1 kg of sweet pepper fruits per 1 kg of active ingredient used in fertilizers. Increasing the application rate to N145P75 (Background 2, calculated for a yield of 45 t/ha) led to nearly a threefold increase in the return on investment from the applied mineral fertilizers, reaching 61.4 kg/kg of active ingredient. The maximum return on investment in our experiment was achieved with the application of fertilizers at the rate of N163P84 (Background 3, which was calculated for a yield of 55 t/ha of sweet pepper) – 91.1 kg/kg of active ingredient. It is worth noting again that the obtained results do not include an optimal variant, indicating the need to incorporate a treatment with an even higher rate of mineral fertilizers into the experimental scheme.

Conclusions and recommendations. To achieve a yield of sweet pepper of the variety at the level of 55 t/ha, using drip irrigation on dark chestnut medium loam soils with an average content of NPK in the soil, it is necessary to apply mineral fertilizers at the calculated rate of N163P84. The results obtained in the field experiment require further study to draw practical recommendations for production.

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