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Increasing the Efficiency of Chili Pepper Cultivation through an Effective Fertilization System

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ABSTRACT

The irrigated brown meadow soils of the Ararat valley are poor in humus content and other important plant required nutrients; hence, the application of scientifically justified quantities of the fertilizers becomes a priority measure. Considering the afore stated fact, the effect of various fertilizers' combinations (*N; NP; NPK; NPK* + complexon via foliar feeding, thrice) on the plant growth, yield capacity and its quality has been studied. The best result has been recorded in the option of $N_{120}P_{120}K_{120}$+complexon. The fruit quality has also improved: the content of dry matters and sugars has increased, while the nitrate content has decreased.

Introduction

The sown areas of the vegetable crops in Armenia currently make up to 21 272 ha land area, out of which 1972 ha (9.2 %) are cultivated under sweet and hot/chili peppers (www.armstat.am, 2021). Pepper is a high value crop, which contains a great amount of vitamins *C* and *A* throughout its biological ripening period and is a source for the vitamins of *B* complex, particularly for vitamin B_6. It is also rich in potassium, magnesium and iron. Apart from capsaicin, 1.5 % essential oils and fats have also been detected in the fruits of hot pepper. Besides, a number of medications are manufactured from the chili pepper (Tilahun, et al., 2013, Mamedov, et al., 2009).

Pepper is a warm-weather/ heat-loving crop, and therefore, is mainly cultivated in the Ararat valley and piedmont zone, where, yet, the soils are poor in humus and macro (*NPK*) – and micro – nutrients (*B, Mo, Mn, Zn, Co*) required for the plants growth. Thus, in order to improve its growth and to increase its yield capacity, it is important to use complex fertilizers (Aliyeva, 2020, Aliyu, 2000, Tuti, et al., 2014). This is also justified upon the pepper's considerable demand for the main nutrients. So, for each 10 c yield and accessory mass the nitrogen yield makes 6.1 kg, phosphorus – 2.7 kg and the potassium yield – 8.2 kg. In case of harvesting 350-400 c/ha yield, the nitrogen yield makes 213-244 kg/ha, phosphorus – 94.5-108 kg/ha and potassium – 287-328 kg/ha. It is evident that the soils of

the Ararat valley do not contain such amounts of nutrients and hence, the application of fertilizers becomes an indispensable measure for the increase of pepper yield capacity in those soils.

There are a few research works regarding the pepper's fertilization methods in the Republic of Armenia, while the studies related to the foliar feeding are completely missing. It is known that in case of applying such a fertilization method, the fertilizers are actively imbibed by the leaves and consequently exert a rapid effect on the plant's nutrition, growing and yielding processes (Vasilyev, 2013, Glazova, 2018, Khoroshkin, 2015). Considering the significant role of the fertilizers in the increase of pepper's yield capacity in the nutrient-poor soils of the RA Ararat plain, an objective has been set up to study and recommend an efficient fertilization system for chili pepper to the production, which is implemented through the fertilizers' introduction in the soil and via foliar feeding. There are multiple popular study works about the crops foliar feeding, which indicate the significance of this system for the plants growth, yield capacity increase and improvement of the yield chemical composition. Such kind of investigations are also carried out in Armenia (Aslanyan, 1988).

Materials and methods

The field experiments were conducted throughout 2020-2021, in the soils of Arshaluys community in the Armavir region/marz, located to the right of Yerevan-Armavir highway. For the experiment a mid-ripening variety of chili pepper (*Capsicum annum L, Sp.Annuum*) "Artsiv" was selected; its ripening time from mass sprouting to technical maturity period lasts 100-110 days and the biological ripeness – up to 130-140 days. The mentioned pepper variety can be cultivated in the open field and protected ground. It is relatively resistant to the diseases, and the yield capacity, depending on the cultivation terms, fluctuates within 300-600 c/ha. In the stage of technical maturity its fruits are green and in that of biological ripeness they become red. The pepper variety "Artsiv" was sown on March 10 in solar greenhouse and transplanted to the field on May 5, in the phase of 4-5 leaves.

The experiment was implemented in four replications, the experimental beds in the field were arranged randomly through the following pattern:

1. Without fertilization (control)
2. N_{120}
3. $N_{120}P_{120}$
4. $N_{120}P_{120}K_{120}$
5. $N_{120}P_{120}K_{120}$ + complexon via foliar feeding, once
6. $N_{120}P_{120}K_{120}$ + complexon via foliar feeding, thrice with an interval of 10-12 days.

The size of an experimental bed was 64 m^2 (6.4m x 10m) and the feeding area of a plant was 0.21 m^2 (0.7m x 0.3m).

During the experiments double superphosphate and potassium chloride were applied in the soil pre-treatment period, while the ammonium saltpeter was applied twice in the plant vegetation period upon weeding and hilling procedures.

The complex water-soluble fertilizer (complexon), which contains macro – and micro-nutrients, was introduced during the vegetation period per the experimental scheme with the dose of 40 g per 10 L water.

The first treatment with the complexon was implemented 15 days after seedling on the eve of flowering, the second was introduced during the fruiting period, the third and the fourth – after every 10-12 days.

During the plant vegetation period observations, measurements and calculations were conducted (Melikyan, 2005). The chemical composition of the yield was also determined. The content of dry matters was determined through weighing method from the third harvest by drying them at 100-105 ^{0}C temperature, those of sugars were determined through Bertrand's method and vitamin *C* – per the Mohr's method (Yagodin, 1989). The yield was calculated per each replication by harvesting and weighing the yield of an experimental bed. Harvest was organized ten times with an interval of 10-12 days. The yield data were subjected to mathematical processing via the dispersion analysis method developed by Dospekhov. The experimental error (*Ex%*) and the least significant difference ($LSD_{0.95}$) between the variants was calculated (Khachatryan, 2020).

For the agrochemical description of the experimental plot, the humus content was determined via Turin's method, the mechanical composition – through the Kachinsky method (pipette method), soil reaction (*pH*) – by means of *pH*-meter, the content of *Ca* and *Mg* in water solution through the trilonometric method (Yagodin, 1987). The plants available nitrogen was determined through Turin-Kononova's method, phosphorus – through Machigin's method and potassium content was determined in the extraction of Machigin's solution (Yagodin, 1987). The soil nutrients supply rate was assessed per the threshold values for the soil nutrients provision adopted in the Republic of Armenia.

Table 1. Agrochemical description of the experimental plot*

Soil type	Depth, cm	Humus, %	Carbonates ($CaCO_3$), %	pH	Content of physical clay, %	Available nutrients mg in 100 g soil		
						N	P_2O_5	K_2O
Irrigated brown meadow	0-31	2.11	3.7	7.7	48.4	3.43	1.41	21.6
	31-44	0.96	4.8	7.8	49.3	132	0.92	19.4

*Composed by the authors.

Results and discussions

The experiments were conducted in the irrigated brown meadow soils, where the humus content makes only 2.15 %, the mechanical texture is clay and sandy, heavy, the soil reaction is weakly alkaline, while the content of carbonates makes 3.7 %-4.8 %. The calcium-magnesium ratio in the soil solution is favorable and the content of soluble salts are in permissible limits. The mentioned soils are poorly provided with plant available nutrients-nitrogen and phosphorus, while the content of potassium is at the medium level (Table 1). It is obvious that under such soil conditions when the supply of nutrients is rather poor, it is not likely to receive economically justified yield without applying fertilizers.

As the table data indicate (Table 2), the application of fertilizers has somehow affected the developmental phases and transitional periods, while the effect is more significant on the plants yielding time. So, in case of individual application of nitrogenous fertilizers or the application of complexon on the background of fertilizers, the developmental phases have been partially delayed amounting to the highest index when complexon was used thrice. The effect of complexon and fertilizers is obvious on the plant fruiting times. So, in the control variant this time period makes 75 days, in the fertilized variant it is 83-85 days, and in the variant where complexon has been applied, this period lasts 95-115 days.

The effect of fertilizers on the plant growth is introduced in Table 3. According to the table data the fertilizers have promoted the plant growth and emergence of the yield elements, whereas the effect size is related to the fertilization variant. So, in the fertilized variants the plants height has exceeded the control variant by 12-21 cm, the mean shrub width – by 18-31 cm, while the highest result has been recorded, when complexon on the background of mineral fertilizers was applied thrice during the vegetation period. Whereas, in case of applying only mineral fertilizers or when using complexon on that background only once, the plants growing index is much lower. The

Table 2. The effect of different fertilizers' combinations on the phenological peculiarities of chili pepper*

Variants	Days to 50 % anthesis (DAT)	Days to 50 % maturity	Days to first harvesting (DAT)	Fruiting period, day
Without fertilization (control)	34	41	65	75
N_{120}	36	42	64	83
$N_{120}P_{120}$	34	41	63	83
$N_{120}P_{120}K_{120}$	33	40	63	85
$N_{120}P_{120}K_{120}$ + complexon via foliar feeding, once	37	43	66	95
$N_{120}P_{120}K_{120}$ + complexon via foliar feeding, thrice	37	45	67	111

Note. DAT-days after transplanting.

*Composed by the authors.

mentioned exuberant plants developed more and relatively larger fruits (Table 3). The number of fruits per a plant and the average weight of a fruit is higher in the variant where complexon on the background of mineral fertilizers was applied thrice. The same indices are much lower in the control variant. In the variants where only nitrogen, nitrogen-phosphorus or nitrogen-phosphorus-potassium patterns are used the number of fruits per a plant and the average weight of a fruit are all the same lower.

According to the data of Table 3, the fertilizers have affected the fruiting times as well. This is significant, since the yield capacity is also related to the fructification time. It is known that nutrient-rich and healthy plants stay biologically active for a rather long time, which can last

until the onset of cold weather. As to the data of Table 3, the fruiting period of a plant is remarkably longer in the variant where complexon on the background of $N_{120}P_{120}K_{120}$ was applied thrice throughout the vegetation period. While in the control variant the mentioned time period lasted only 75 days, and in the variant where only mineral fertilizer was applied it lasted 83-85 days.

Table 3. The effect of different fertilizers' combinations on the growing peculiarities of chili pepper*

Variants	Average plants height, cm	Average shrub width, cm	Average weight per a fruit, g	Number of fruits per a plant, n	Fruiting period, day
Without fertilization (control)	36	33	7.9	75.1	75
N_{120}	48	51	8.8	81.2	83
$N_{120}P_{120}$	49	51	9.1	84.5	83
$N_{120}P_{120}K_{120}$	48	55	9.6	86.6	85
$N_{120}P_{120}K_{120}$+ complexon via foliar feeding, once	52	58	9.7	89.9	95
$N_{120}P_{120}K_{120}$ + complexon via foliar feeding, thrice	57	64	10.8	95.7	151

*Composed by the authors.

The application of fertilizers promotes the plants growth and the increase of fruits number and weight per a plant which entails to yield increase (Table 4). Besides, the fruit size completely depends on the fertilization variant and the mentioned pattern holds true irrespective of the experimental year. So, according to the two-year average data, the yield amount makes 249 c/ha in the control variant, while in the fertilized variants it fluctuates within the range of 312-468 c/ha. Among the fertilized variants the highest yield (468 c/ha) was harvested in the variants where complexon on the background of *NPK* was applied in the form of foliar feeding thrice throughout the vegetation period. The other fertilization variants irrespective of their combinations provided much lower yield (312-396 c/ha), which exceeds the control variant by 63-147 c/ha, whereas compared to the variant of $N_{120}P_{120}K_{120}$+complexon (thrice) it stays behind by 72-156 c/ha.

Table 4. The effect of different combinations of fertilizers on the yield capacity of chili pepper*

Variants	2020	2021	Average yield, c/ha	Yield surplus, c/ha
	Yield, c/ha	Yield, c/ha		
Without fertilization (control)	269	229	249	-
N_{120}	326	299	312	63
$N_{120}P_{120}$	352	328	340	91
$N_{120}P_{120}K_{120}$	381	341	361	112
$N_{120}P_{120}K_{120}$ + complexon via foliar feeding, once	412	380	396	147
$N_{120}P_{120}K_{120}$ + complexon via foliar feeding, thrice	490	446	468	219
$LSD_{0.95}$ Ex%	4.55 1.22	4.18 1.24	-	-

Table 5. The effect of different fertilizer combinations on the fruit's chemical composition*

Variants	Dry matters, %	Vitamin C, mg/%	Sugars, %	mg/kg in fresh mass
Without fertilization (control)	5.2	76.5	2.9	39
N_{120}	5.9	83.6	2.5	65
$N_{120}P_{120}$	6.2	88.1	3.4	48
$N_{120}P_{120}K_{120}$	6.4	88.3	4.0	37
$N_{120}P_{120}K_{120}$+ complexon via foliar feeding, once	6.5	94.1	4.0	35
$N_{120}P_{120}K_{120}$ + complexon via foliar feeding, thrice	7.6	141.6	4.7	24

*Composed by the authors.

The effect of fertilizers on the fruit qualitative indicators has also been studied, where the content of dry matters, vitamin C and sugars has been considered as prior indices (Table 5). It is apparent that the increase of dry matter content in the fruits ensures the storage of more nutrients

in a unit mass, whereas the increase in vitamin *C* amount enhances its nutritional value, since the latter is of vital significance for the human organism. The results are summarized in Table 5. Per the table data it can be inferred that the fruit's chemical composition to some extent is related to the applied fertilization variant. Thus, the contents of dry matters, vitamin *C* and sugars are higher in the option where complexon on the background of *NPK* was applied thrice during the vegetation period. Accordingly, in the mentioned variant the content of dry matters amounted to 7.6 %, vitamin *C* – 141.6 mg/%, sugars – 4.7 %, while the nitrate content declined to 24 mg per one kg of fresh mass. In the control and other fertilization variants the mentioned indicators are considerably lower, while the nitrate content is rather high, which affects the fruit quality.

Conclusion

Based on the experimental results it can be concluded that the application of fertilizers has produced a considerable effect on the growth, yield capacity and fruit quality of the chili pepper. To ensure higher yield and yield quality it is necessary to use water-soluble complex fertilizer (complexon) on the background of the main mineral fertilizers in the form of foliar feeding thrice during the vegetation period with 10-12-day of interval.

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