The efficiency of using synthesized fertilizers via foliar feeding and drip irrigation in various soil and climatic zones of the Republic of Armenia

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Abstract. In the current research paper, a new water-soluble combined fertilizer (WCF) is introduced, the composition of which is determined via the agrochemical composition of the soils of Armenia, and besides, its effectiveness has been further investigated. It has been established that when applying the recommended fertilizer through foliar feeding or soaking the seeds, the yield is significantly increased and its quality is improved. Under the impact of WCF, the yield increase compared to the NPK variant was as follows: for winter wheat under non-irrigated conditions – 5.1 c/ha, for tomato – 49 c/ha, for grapevine – 20 c/ha, while when using 20:20:20 the increase in yield capacity was 10.0 c/ha, 3.7 c/ha, and 8.0 c/ha, respectively.

1 Introduction

The use of fertilizers plays an important role in maintaining soil fertility and increasing crop yield capacity [1,2]. Since 1991, mineral fertilizers have not been produced in Armenia, but they have been imported, and among them, fertilizers used for foliar feeding and drip irrigation are of high priority [3]. However, it should be noted that their composition does not stem from the chemical composition of the soils of the Republic of Armenia. Taking into account the importance of fertilizers applied in the agriculture of the Republic of Armenia for foliar feeding, similar fertilizers have been synthesized in the Scientific Center of Soil Science, Agrochemistry and Melioration named after H. Petrosyan (branch of the Armenian National Agrarian University). At the same time, the chemical composition of fertilizers has been identified taking into account the agrochemical composition of the soils of the republic, which enabled it to ensure much higher efficiency as compared to that recorded in the case of imported fertilizers [4]. Meanwhile, it is worth mentioning that the application of the mentioned fertilizer will grow up since the prices of the soil-introduced fertilizers have grown by 2.5-3 times, while the financial capacities of many farmers in the republic are rather low.

Numerous research works designate the significance of applying fertilizers through the method of foliar nutrition [5,6]. Such studies were carried out still in the 30s of the twentieth century in the United States [7]. However, very few studies have been carried out in the Republic of Armenia so far.

It is known that the method of applying foliar fertilizers makes it possible to faster affect plant nutrition, hence, accelerating the formation of fruit buds, reducing fruit drop, and increasing fruit size and yield capacity [8]. For instance, it has been found, that using applying foliar nutrition to the cereal crops in

the tillering stage or even later, the plant growth improves, the yield capacity, weight of 1000 grains, and protein content grow up, while seed germination capacity and energy are increased [9].

For vegetable crops, it is possible to reduce (prevent) the drop of the flowers and fruits through foliar feeding, which also promotes the increase of the fruit size and quality [10]. When used in vineyards, along with the noticeable increase in the crop's yield capacity, it is also possible to change the ratio of sugar and acids in favor of sugar [11].

2 Materials and methods

Water-soluble combined fertilizer (WCF) is a complex organo-mineral fertilizer that contains macro (N, P, K, Fe) and micro (B, Mo, Mn, Zn, Cu, Co) elements and is highly soluble in water. It is used for foliar nutrition, by soaking seeds before sowing or earlier, as well as through drip irrigation. It is also allowed for use in organic agriculture.

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The effectiveness of the WCF was studied upon field experiments and chemical analysis of soils and plants (fruits) for 2020-2021. Experiments on winter wheat were carried out in non-irrigated conditions in the dry steppe zone, on chestnut soils. Here, the amount of annual precipitation is 410-450 mm and the average air temperature is 8.5-9.5^{0}C. The experiments were carried out according to the scheme indicated in diagram 1; the area of the experimental plot is 98 m^2.

Experiments on tomatoes were carried out in the semi-desert zone of the Ararat Valley on irrigated meadow-brown soils in irrigated conditions. Here the amount of annual precipitation is only 250-320 mm, while the average annual air temperature is 11.5-12.5^{0}C. The experiments were carried out according to the scheme indicated in diagram 2. The experiment on the grapevine was also carried out in a semi-desert zone on meadow-brown irrigated soils under irrigation conditions according to the scheme indicated in diagram 3. All experiments were carried out in four replications.

Agrochemical analysis of soils of experimental plots and the yield chemical analysis were carried out according to the accepted methods in agrochemical studies [12, 13, 14, 15].

The main mineral fertilizers (ammonium nitrate, double superphosphate, and potassium chloride) were applied by introducing them to the soil, while water-soluble combined fertilizer (WCF) and N:P: K=20:20:20 (standard) were applied via foliar feeding. For winter wheat, this was carried out in spring in the full tillering phase of plants with an application rate of 2.5 kg/ha. In the experiment on tomatoes, water-soluble fertilizers were applied after 2 weeks of transplanting seedlings to the field, three times with an application interval of 10-12 days. The rate of application of WCF each time was 2.5 kg/ha. The application rate of 20:20:20 was 5 kg for each time.

3 Results and discussion

Field experiments were carried out in different natural and climatic zones, on soils with different agrochemical parameters.

According to the data obtained, in the upper horizons (0-30 cm) of the soils of the experimental plots, the humus content is low (2.51–3.12%), which is typical for these soil types, and the soils are calcareous (3.06–4.45%), the reaction is slightly or medium alkaline (pH = 7.9–8.3), the mechanical composition is heavy loamy (physical clay - 47.6–51.6%). According to the scale of soil provision with available nutrients adopted in Armenia, the experimental plot of winter wheat and tomato is poorly supplied with nitrogen and phosphorus and well supplied with potassium (N-3.14–3.61, P_2O_5-1.16–1.58, K_2O-39.5–51.1 mg for 100 g soil). The soil of the experimental plot of the grapevine is poorly provided with nitrogen, moderately - with phosphorus, and well - with potassium (N-3.06, P_2O_5-2.76, K_2O-49.8 mg for 100 g soil). The use of the main mineral fertilizers and WCF or N:P:K = 20:20:20 on their background has exerted a remarkably positive effect on the yield capacity and chemical composition of grain, as well as on the germination capacity and germination energy of winter wheat seeds. At the same time, it is worth noting that the relatively low yield is due to dry weather conditions in non-irrigated areas. Regardless of the weather conditions, the highest grain yield (35.7 c/ha) has been obtained where WCF against the background of $N_{90}P_{60}K_{60}$ has been applied. In this variant, the grain yield was 35.7 c/ha, which is 5.1 c/ha more than the background option, and 3.7 c/ha more than the option of background + N:P:K = 20:20:20 (Figure 1).

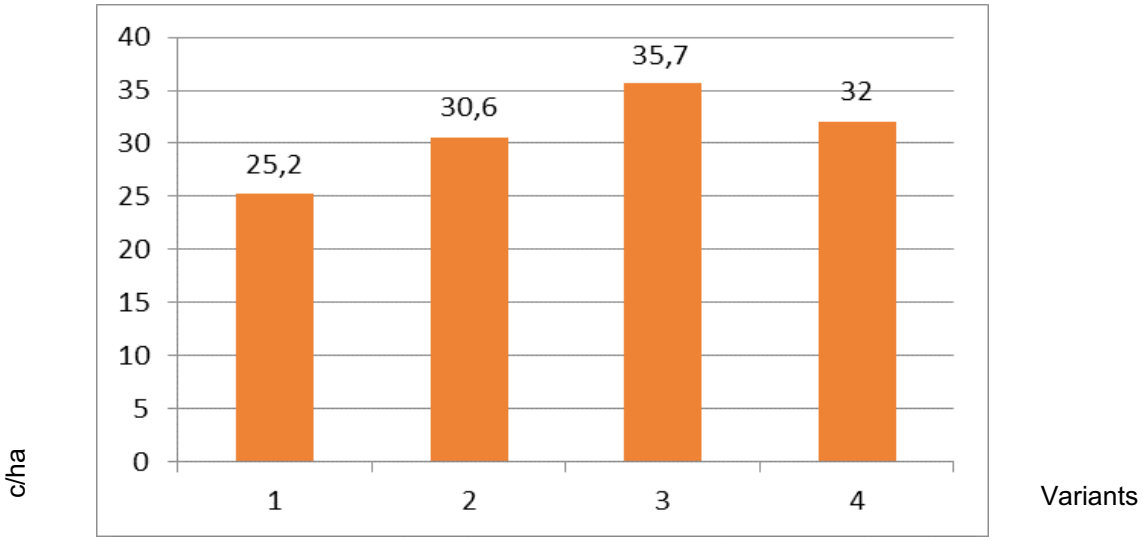

Fig. 1. The effect of water-soluble combined fertilizers on the yield of winter wheat, c/ha. **Variants**: 1. 0; 2. $N_{90}P_{60}K_{60}$, 3. $N_{90}P_{60}K_{60}$ + WCF – 2.5 kg/ha, 4. $N_{90}P_{60}K_{60}$ + 20:20:20 -5 kg/ha **Soil content**: humus – 3.12 %; pH- 7.3; mobile nitrogen (N) - 3,14 mg, phosphorus (P_2O_5) – 1.58 mg, potassium (K_2O) – 47.8 mg for 100 g soil.

The positive effect of water-soluble combined fertilizers is also perceptible in the chemical composition of the grain, the germination capacity, and the vigor of seed germination. Herewith, the highest result has been received where WCF against the background of $N_{90}P_{60}K_{60}$ has been applied. In this variant, the weight of 1000 grains is 1.2–1.6 g more than in the control and background variants, whereas the content of nitrogen exceeds by 0.34–0.38%, phosphorus - by 0.147–0.21%, and potassium – by 0.07–0.08%.

When using WCF, the germination energy is 70.4%, and the germination capacity is 95.9%, while when using 20:20:20, these indicators are 56.7% and 93.2%, respectively and in the variant of $N_{90}P_{60}K_{60}$ (background), they make 45.9-56.0 and 88.4-90.3%, respectively.

In the experiments on tomatoes, the highest yield has been obtained when, against the background of main mineral fertilizers, a water-soluble combined fertilizer or 20:20:20 (Figure 2) was applied. The highest fruit yield has been harvested (650 c/ha) when using the background ($N_{90}P_{90}K_{60}$) + WCF, which is higher than the control variant by154 c/ha (31.0%) and compared to the background variant – by 49 c/ha (8.2%).

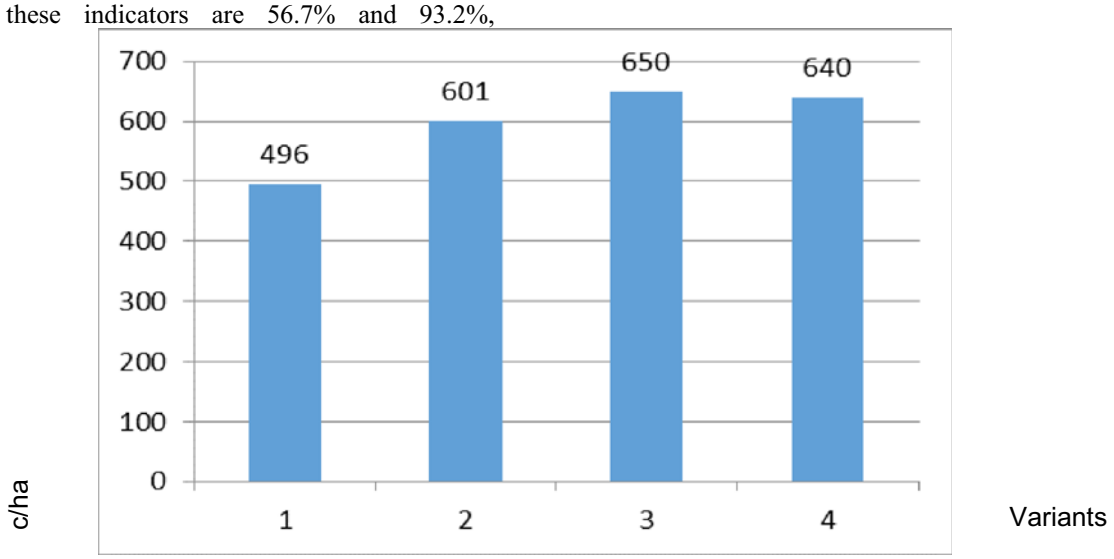

Fig. 2. The effect of foliar feeding on the yield capacity of tomatoes, c/ha. **Variants**: 1. 0; 2. $N_{90}P_{90}K_{60}$, 3. $N_{90}P_{90}K_{60}$ + WCF – 2.5 kg/ha (3 times), 4. $N_{90}P_{90}K_{60}$ + 20:20:20 – 5 kg/ha (3 times). **Soil content**: humus–2.71 %; pH-7.8; mobile nitrogen (N)–3.61 mg, phosphorus (P_2O_5)–1.12 mg, potassium (K_2O) – 51.14 mg for 100 g soil.

Regarding the efficiency of water-soluble fertilizers, similar results have been obtained in experiments with a grapevine (Figure 3), that is, the highest fruit yield has been obtained in the variant of background ($N_{90}P_{90}K_{60}$) + WCF – 144 c/ha, which is higher than the background variant by 20 c/ha (16.1%) and exceeds the background variant + 20:20:20 by 8.0 c/ha (5.9 %).

Water-soluble combined fertilizers affected the content of sugar and acids in fruits. At the same time, under the influence of WCF, the sugar content in fruits makes 19.4%, acidity - 4.1%, while in the background variant the sugar content is 17.8%, acids - 6.2%, and in the option of background + 20:20:20, these indices make 18.6% and 4.6%, respectively.

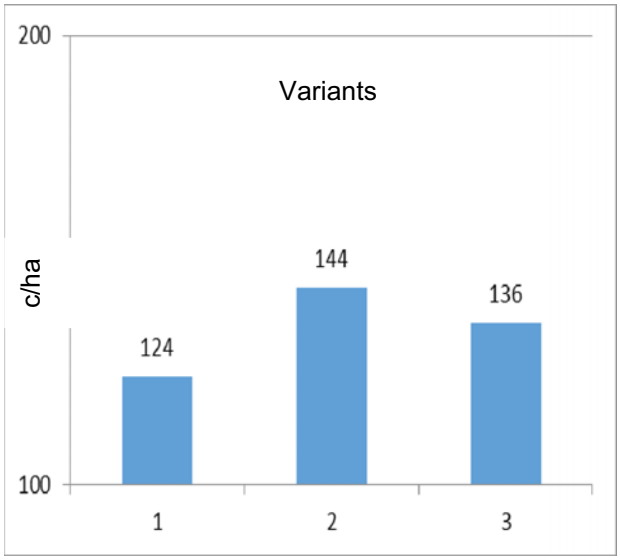

Fig. 3. The effect of foliar feeding with water-soluble fertilizer on the yield capacity of grapevine, c/ha. **Variants**: 1. 0; 2. $N_{90}P_{90}K_{60}$, 3. $N_{90}P_{90}K_{60}$ + WCF – 2.5 kg/ha (3 times), 4. $N_{90}P_{90}K_{60}$ + 20:20:20 - 5 kg/ha (3 times) **Soil content**: humus – 2.51 %; pH-7,5; mobile nitrogen (N) – 5.13 mg, phosphorusa (P_2O_5) – 4.58 mg, potassium (K_2O) – 71.61 mg for 100 g soil.

4 Conclusion

Thus, studies on the effect of water-soluble fertilizers (WCF and 20:20:20) on winter wheat, tomato, and grapevine have designated the following.

In Armenia, the yield capacity of the mentioned crops can be still increased if WCF or 20:20:20 via foliar feeding is also included in the system of fertilizers application. In winter wheat, the increase in yield capacity occurred due to the enhancement of productive tillering and weight of thousand grains, besides, the quality of seeds improved. The content of nitrogen, phosphorus, and potassium in the seeds increased, while in tomatoes the germination capacity and germination energy improved. The yield capacity increase was due to an increased number and weight of plant fruits, and the improvement of fruit quality occurred due to an increase in dry matter and sugar content in fruits. In the grapevine, the increase in yield capacity occurred due to an increased weight of bushes and fruits, as well as due to the growth of sugar content in the fruits.

When applying WCF, the yield increase compared to the control variant makes 10.5 c/ha (41.7%) for winter wheat, for tomato it makes 154 c/ha (31.0%), and for grapevine ($N_{90}P_{60}K_{60}$) 20.0 c/ha (16.1%), while as compared to the background variant, it makes 5.1 c/ha (16.7 %), 49 c/ha (8.2%) and 20c/ha (16.1%), respectively and against the option of background + 20:20:20 the mentioned indices equaled to 3.7 c/ha (11.6%), 10 c/ha (1.6 %) and 8.0 c/ha (5.9 %), respectively.

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