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# Fertilization of wheat with liquid organic fertilizers under the conditions of a pot vegetation experiment

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**Abstract:** Vegetation experiment was carried out to determine the efficiency of liquid organic fertilizers application in the initial phases of wheat development. Three types of liquid organic fertilizer with single and double application (in 14 days) were tested -"Extra force", "Zinovii Corn" and "Zinovii Oil". All studied fertilizers application have a positive results. Compared to the control treatment, tested organic fertilizers show good results with one application and significantly better results with two applications. "Extra force" and "Zinovii Corn" when applied twice had double effect on yields and height of wheat plants.

**Keywords:** wheat; fertilization; liquid organic fertilizers

## INTRODUCTION

Agricultural intensification and chemigation provokes the annual introduction of ever higher amounts of inorganic fertilizers leads to contamination of soil, groundwater and plant production. Environmentally harmful chemical elements are selectively accumulated with longer use, which cause a number of diseases in animals and man (Draganov et al., 1988; Brady & Weil, 2002; Das, 2011; Mukhtar et al., 2013).

An alternative to chemigation in agriculture is the introduction and use of organic products that are used in organic farming not only as a substitute for inorganic fertilization (Vlahova, 2013), but also as a means of biological protection of plants from diseases (Yankova et al., 2009).

Nowdays, fertilizerformulationsnearly always are enrichedwithmicro-elements. According to Ivanov et al. (2019), application of foliar fertilizer containing Zn showed positive effects on maize yield and quality. Application of foliar fertilizers showed an improvement on maize aboveground and underground parts (Balawejder et al., 2019). Thus, soil deficiency in micro-elements can be successfully managed by foliar fertilizing and must be the preferred way to apply microelements (Tejada et al., 2018). In some cases, fertilizers and herbicides can be combined in order to help crops to overcome possible herbicide stress (Brankov et al., 2020).

In general, under the influence of foliar input of macro- and micronutrients, yields increase and the quality of the resulting production is improved (Fernandez & Eichert, 2009; Haytova, 2013).

The aim of the study is to determine the effectiveness of organic liquid fertilizers "Extra force", "Zinovii Corn" and "Zinovii Oil". They were obtained by extraction of humic substances from biocompost under appropriate conditions (pH, temperature, homogenization) allowing their more complete extraction and enrichment with trace elements.

## MATERIALS AND METHODS

The experiment wascarried out in the period September 2019 – September 2020.

The soil is Leached Cinnamon Forest Soil, typical for the area of the Sofia area (550m altitude). These soils were found to be medium to heavy in mechanical composition. The water-physical properties of this soil subtype are on average for the layer 0-50 cm depth they are as follows: Field capacity (FC) – 22.0% by weight of the absolutely dry soil; soil volume weight– 1.47 g/cm³ and wilting point humidity – 10.00% of the weight of the absolutely dry soil.

The vegetation experience is set and derived to establish the efficiency of liquid organic fertilizers application in the initial stages of wheat development. The pots have a capacity of -1800 g soil. Test crop is wheat sown in October 2019.

The liquid organic fertilizer "Extra force" was obtained by alkaline extraction of humic substances from manure with litter under appropriate conditions (pH, temperature, homogenization) allowing their more complete extraction. On the basis of this fertilizer, a formulation with seven trace elements (Mg, Zn, Cu, Mo, B, Fe and Mn) "Zinovii grand" was prepared. An increased content of Zn and B was added to the basic formulation of the trace elements "Zinovii Corn" and "Zinovii Oil".

Treatments with two foliar applications in 14 days during wheat growing season were applied. The results of the experiments carried out are the basis for the effectiveness assessment of the products and for determining recommended fertilization rates.

Inorganic complex fertilizer nitrogen, phosphorus and potassium (NPK = 1:1:1) was applied into the soil at the rate of N (100mg.kg$^{-1}$ soil)

A total of seventreatments with three replicates and four plants in each pot were studied.

Treatments:

1. Control –(Soil + NPK)

**Table 1.** Increase in wheat fresh weight and height under influence of applied liquid organic fertilizers

| Treatments | Weight Mean g | Weight difference, g | % | Height Mean cm | Height difference, cm | % |
|---|---|---|---|---|---|---|
| Control – (Soil + NPK) | 0,237 | | | 14,3 | | |
| "Extra force" – one treatment | 0,328 | 0,090 | 38,1 | 18,1 | 3,8 | 26,9 |
| "Extra force" – two treatments | 0,470 | 0,233 | 97,9 | 22,9 | 8,6 | 60,3 |
| "Zinovii Corn" – one treatment | 0,323 | 0,085 | 35,9 | 17,6 | 3,3 | 23,2 |
| "Zinovii Corn" – two treatments | 0,432 | 0,195 | 82,0 | 21,1 | 6,8 | 48,0 |
| "Zinovii Oil" – one treatment | 0,354 | 0,117 | 49,2 | 19,2 | 5,0 | 34,7 |
| "Zinovii Oil" – two treatments | 0,347 | 0,110 | 46,2 | 19,4 | 5,2 | 36,3 |

**Table 2.** Descriptive statistics for the weight of wheat plants (g/pot) depending on the fertilization treatment

| Treatments | *Mean* | *Stand. deviation* | *Coeff. of variation* | *Minimum* | *Maximum* |
|---|---|---|---|---|---|
| Control – (Soil + NPK) | 0,237412 | 0,1248830 | 52,6018% | 0,022 | 0,440 |
| "Extra force" – one treatment | 0,327875 | 0,0715829 | 21,8324% | 0,207 | 0,464 |
| "Extra force" – two treatments | 0,469938 | 0,1738440 | 36,993% | 0,172 | 0,888 |
| "Zinovii Corn" – one treatment | 0,322600 | 0,0801666 | 24,8502% | 0,185 | 0,477 |
| "Zinovii Corn" – two treatments | 0,432167 | 0,1754760 | 40,6038% | 0,144 | 0,717 |
| "Zinovii Oil" – one treatment | 0,354267 | 0,0812091 | 22,9232% | 0,223 | 0,480 |
| "Zinovii Oil" – two treatments | 0,347000 | 0,0800275 | 23,0627% | 0,228 | 0,480 |

2. "Extra force" – one treatment (EF1)
3. "Extra force" – two treatments (EF2)
4. "Zinovii Corn" – one treatment (ZC1)
5. "Zinovii Corn" – two treatments (ZC2)
6. "Zinovii Oil" – one treatment (ZO1)
7. "Zinovii Oil"– two treatments (ZO2)

Data were processed statistically with ANOVA.

## RESULTS AND DISCUSSION

The Increase in wheat fresh weight and height under influence of applied liquid organic fertilizers is double when applied twice for „Extra force" and "Zinovii Corn". No difference exists for "Zinovii Oil" with one and two treatments (Table 1).

Table 2 presents statistics analyses of plant weight variation in the fertilization treatments studied. The variation coefficient for the total data is just over 38% and is relatively low, which shows of a satisfactory accuracy of the experiment.

The results in Table 3 show statistical indicators of the wheat plants weight in each of the 7 treatments of the experiment. The one-factor analysis ANOVA was designed to compare the mean values of the different treatments.

**Table 3.** ANOVA table for weight of wheat plants at different fertilization treatments

| *Source* | *Sum of squares* | *Mean squared* | *F-Ratio* | *P-Value* |
|---|---|---|---|---|
| Between groups | 0,581908 | 0,0969847 | 6,50 | 0,0000 |
| In the groups | 1,58155 | 0,0149203 | | |
| Total (Corr.) | 2,16346 | | | |

**Table 4.** Mean values for weight of wheat plants from one fertilization treatment to another at the 95.0% confidence interval

| *Treatments* | *Mean* | *Std. Error* | *Lower Limit* | *Upper limit* |
|---|---|---|---|---|
| Control – (Soil + NPK) | 0,237412 | 0,0296254 | 0,19588 | 0,278944 |
| "Extra force" – one treatment | 0,327875 | 0,0305371 | 0,285065 | 0,370685 |
| "Extra force" – two treatments | 0,469938 | 0,0305371 | 0,427127 | 0,512748 |
| "Zinovii Corn" – one treatment | 0,354267 | 0,0315386 | 0,310052 | 0,398481 |
| "Zinovii Corn" – two treatments | 0,347 | 0,0305371 | 0,30419 | 0,38981 |
| "Zinovii Oil" – one treatment | 0,3226 | 0,0315386 | 0,278386 | 0,366814 |
| "Zinovii Oil" – two treatments | 0,432167 | 0,0287907 | 0,391805 | 0,472529 |

**Table of Means for Weight, g by Treatment with 95.0 percent LSD intervals**

| ***Treatments*** | ***Count*** | ***Mean*** | ***Stnd. error (pooled s)*** | ***Lower limit*** | ***Upper limit*** |
|---|---|---|---|---|---|
| **Control** | 17 | 0,237412 | 0,0296254 | 0,19588 | 0,278944 |
| **EF1** | 16 | 0,327875 | 0,0305371 | 0,285065 | 0,370685 |
| **EF2** | 16 | 0,469938 | 0,0305371 | 0,427127 | 0,512748 |
| **ZC1** | 15 | 0,354267 | 0,0315386 | 0,310052 | 0,398481 |
| **ZC2** | 16 | 0,347 | 0,0305371 | 0,30419 | 0,38981 |
| **ZO1** | 15 | 0,3226 | 0,0315386 | 0,278386 | 0,366814 |
| **ZO2** | 18 | 0,432167 | 0,0287907 | 0,391805 | 0,472529 |
| **Total** | 113 | 0,356504 | | | |

**Table 5.** Multi-rank Wheat Plant Weight Test by Treatment
**Method:** 95.0 percent LSD

| *Treatments* | *Mean* | *Homogeneous Groups* |
|---|---|---|
| Control – (Soil + NPK) | 0.237412 | A |
| "Zinovii Oil" – one treatment | 0.3226 | AB |
| "Extra force" – one treatment | 0.327875 | B |
| "Zinovii Corn" – two treatments | 0.347 | B |
| "Zinovii Corn" – one treatment | 0.354267 | BC |
| "Zinovii Oil" – two treatments | 0.432167 | CD |
| "Zinovii Oil" – two treatments | 0.469938 | D |

| *Contrast* | *Sig.* | *Difference* | *+/- Limits* |
|---|---|---|---|
| **Control - EF1** | * | -0,0904632 | 0,0843521 |
| **Control - EF2** | * | -0,232526 | 0,0843521 |
| **Control - ZC1** | * | -0,116855 | 0,0857884 |
| **Control - ZC2** | * | -0,109588 | 0,0843521 |
| Control - ZO1 | | -0,0851882 | 0,0857884 |
| **Control - ZO2** | * | -0,194755 | 0,0819024 |
| **EF1 - EF2** | * | -0,142063 | 0,0856207 |
| **EF1 - ZC1** | | -0,0263917 | 0,087036 |
| **EF1 - ZC2** | | -0,019125 | 0,0856207 |
| EF1 - ZO1 | | 0,005275 | 0,087036 |
| **EF1 - ZO2** | * | -0,104292 | 0,0832083 |
| **EF2 - ZC1** | * | 0,115671 | 0,087036 |
| **EF2 - ZC2** | * | 0,122937 | 0,0856207 |
| **EF2 - ZO1** | * | 0,147337 | 0,087036 |
| EF2 - ZO2 | | 0,0377708 | 0,0832083 |
| **ZC1 - ZC2** | | 0,00726667 | 0,087036 |
| **ZC1 - ZO1** | | 0,0316667 | 0,0884286 |
| **ZC1 - ZO2** | | -0,0779 | 0,084664 |
| **ZC2 - ZO1** | | 0,0244 | 0,087036 |
| **ZC2 - ZO2** | * | -0,0851667 | 0,0832083 |
| **ZO1 - ZO2** | * | -0,109567 | 0,084664 |

** indicates a statistically significant difference*

Since the P-value of the F-test was lower than 0.05, it had a statistically significant difference of wheat plants from one fertilizing treatments to another at the 95.0% confidence interval (Table 4). The analysis of these results using a multi-rank test shows us which pairs of treatments have a statistically proven difference (Table 5).

Table 5 for a multi-rank test shows the average weight of wheat plants for each fertilization treatment. The standard error for each mean is also shown, which is an indicator of the sampling variation. The table also shows the interval of variation at each average. The intervals shown are based on Fisher's least significant difference (LSD). They are designed so that if two middle ones are the same, then their intervals will be covered in 95.0% of cases. All treatments with organic fertilizer are statistically significant from the control. Following pairs of applied fertilizers have statistically significant difference: "Extra force" – one treatment and "Extra force" – two treatments; "Extra force" – one treatment and "Zinovii Oil" – two treatments; "Extra force" – two treatments and "Zinovii Oil" – one treatment; "Extra force" – two treatments and "Zinovii Corn" – one treatment; "Extra force" – two treatments and "Zinovii Corn" – two treatments; "Zinovii Oil" – one treatment and "Zinovii Oil" – two treatments.

In a multi-rank test, these intervals are used to determine which averages are different from which others. Graphically, these differences are presented in Figure 1.

Table 6 presents statistical analyses for the variation of plant height at different fertilization treatments. The coefficient of variation is relatively low (below 30%), the refore accuracy of the experiment is in the best range.

The results in Table 7 show statistical indicators of the height of wheat plants at each of the 7 fertilization treatments. As for plant weights one-factor analysis ANOVA was designed to compare the average values of the different treatments.

The one-factor analysis ANOVA decomposes plant height variation between two components: an intergroup component and an intragroup component. F-Ratio, which in this case is equal to 11.16. Since the P-value of the P-test was lower than 0.05 it therefore had a statistically significant difference of two mean of the height of maize plants from one fertilization treatment to anoth-

er at the 95.0% confidence interval (Table 8). All treatments with organic fertilizer are statistically significant from the control for plant height. Statistically significant difference exists for following pairs applied fertilizers: "Extra force" – one treatment and "Extra force" – two treatments; "Extra force" – one treatment and "Zinovii Oil" – two treatments; "Extra force" – two treatments and "Zinovii Oil" – one treatment; "Extra force" – two treatments and "Zinovii Corn" – one treat-

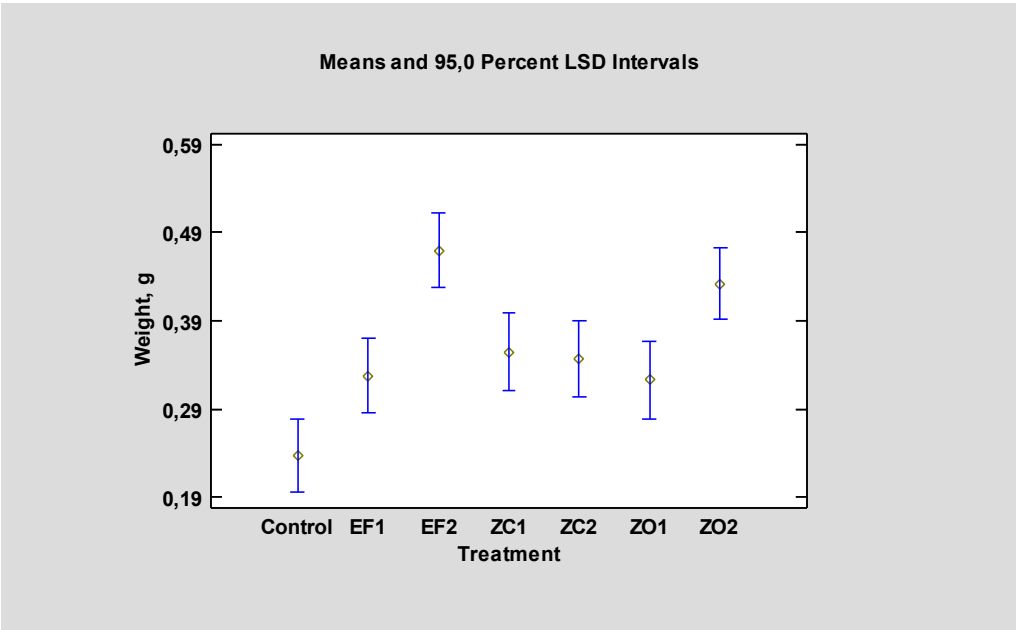


**Figure 1.**Weight of wheat plants under different fertilization treatments

**Table 6.** Descriptive statistics for the height of wheat plants (in cm) depending on the fertilizationoption

| *Treatments* | *Mean* | *Std. Unlock.* | *Coef. of variation* | *Minimum* | *Maximum* |
|---|---|---|---|---|---|
| Control – (Soil + NPK) | 14.2647 | 4.64044 | 32.5309% | 4.9 | 20.4 |
| "Extra force" – one treatment | 18.1063 | 1.41491 | 7.81446% | 15.3 | 20.0 |
| "Extra force" – two treatments | 22.8687 | 3.95941 | 17.3136% | 16.5 | 31.3 |
| "Zinovii Corn" – one treatment | 17.5733 | 1.59305 | 9.06516% | 15.5 | 20.0 |
| "Zinovii Corn" – two treatments | 21.1111 | 4.18413 | 19.8196% | 13.2 | 29.0 |
| "Zinovii Oil" – one treatment | 19.22 | 2.58324 | 13.4404% | 15.8 | 25.5 |
| "Zinovii Oil" – two treatments | 19.4437 | 3.13177 | 16.1068% | 11.5 | 25.0 |

**Table 7.** ANOVA table for height of wheat plants underdifferentfertilizationoptions

| *Source* | *Sum of squares* | *Mean squared* | *F-Ratio* | *P-Value* |
|---|---|---|---|---|
| Between groups | 747.769 | 124.628 | 11.16 | 0.0000 |
| In the groups | 1183.41 | 11.1643 | | |
| Total (Corr.) | 1931.18 | | | |

ment; "Extra force" – two treatments and "Zinovii Corn" – two treatments; "Zinovii Oil" – one treatment and "Zinovii Oil" – two treatments.

The analysis of these results using a multi-rank test shows us which pairs of treatments have a statistically proven difference (Table 9).

Table 8, for a multi-rank test shows the average plant height for each fertilization treatment. The standard error for each mean is also shown, which is an indicator of the sampling variation. The table also shows the interval of variation at each average. The intervals shown are based on Fisher's least significant difference (LSD). They are designed so that if two middle ones are the same, then their intervals will be covered in 95.0% of cases. In a multi-rank test, these intervals are used to determine which averages are different from which others. Graphically, these differences are presented in Figure 2.

## CONCLUSIONS

1. In the conditions of the experiment, the best effect on yields and plant height of wheat has "Extra Force" and "Zinovii Corn" applied twice.

**Table 8.** Mean values for wheat plant height from one fertilization treatment to another at 95.0% confidence interval

| Treatments | *Mean* | *Stand. error* | *Lower Limit* | *Upper limit* |
|---|---|---|---|---|
| Control | 14.2647 | 0.810384 | 13.1286 | 15.4008 |
| EF1 | 18.1063 | 0.835325 | 16.9352 | 19.2773 |
| EF2 | 22.8687 | 0.835325 | 21.6977 | 24.0398 |
| ZO1 | 17.5733 | 0.86272 | 16.3639 | 18.7828 |
| ZO2 | 21.1111 | 0.787552 | 20.007 | 22.2152 |
| ZC1 | 19.22 | 0.86272 | 18.0105 | 20.4295 |
| ZC2 | 19.4437 | 0.835325 | 18.2727 | 20.6148 |

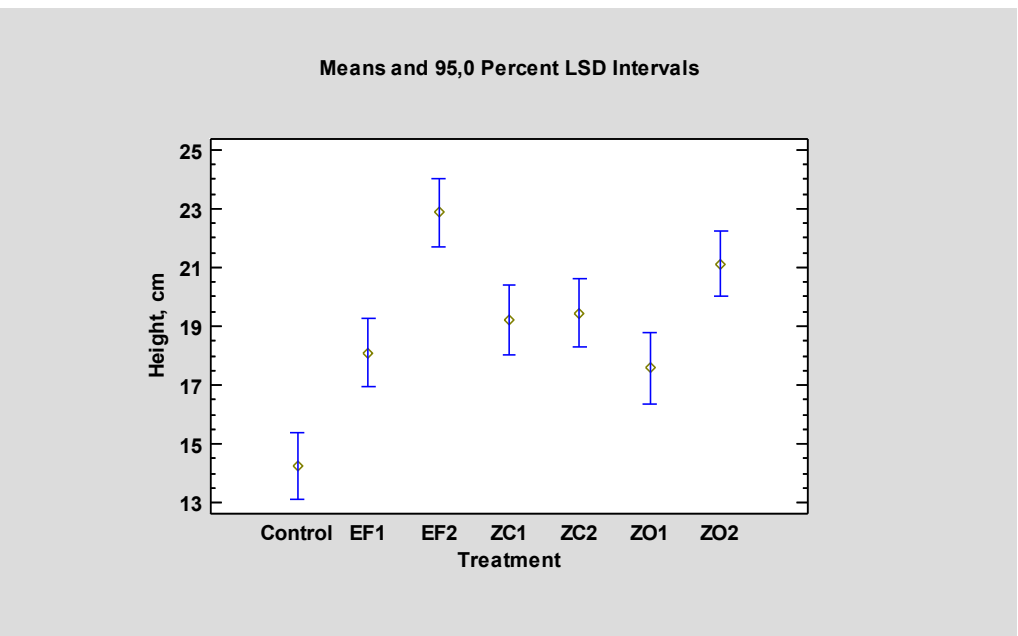


**Figure 2.** Height of wheat plants in different treatments of fertilizer1

2. The tested fertilizers and the different number of their application lead to positive results. The differences between control plants and plants influenced by the action of foliar fertilizers are statistically proven.

3. Compared to the control option, all tested organic fertilizers give good results with one treatment and significantly better results with two treatments.

**Table 9.** Multi-rank wheat plant height test by treatments.
**Method:** 95.0 percent LSD

| Treatments | Mean | Homogeneous Groups |
|---|---|---|
| Control – (Soil + NPK) | 14.2647 | A |
| "Zinovii Oil" – one treatment | 17.5733 | B |
| "Extra force" – one treatment | 18.1063 | B |
| "Zinovii Corn" – one treatment | 19.22 | BC |
| "Zinovii Corn" – two treatments | 19.4437 | BC |
| "Zinovii Oil" – two treatments | 21.1111 | CD |
| "Extra force" – two treatments | 22.8687 | D |

| *Contrast* | *Significance* | *Difference* | *+/- limits* |
|---|---|---|---|
| Control - EF1 | * | -3.84154 | 2.3074 |
| Control - EF2 | * | -8.60404 | 2.3074 |
| Control - ZO1 | * | -3.30863 | 2.34669 |
| Control - ZO2 | * | -6.84641 | 2.24039 |
| Control - ZC1 | * | -4.95529 | 2.34669 |
| Control - ZC2 | * | -5.17904 | 2.3074 |
| EF1 - EF2 | * | -4.7625 | 2.3421 |
| EF1 - ZO1 | | 0.32917 | 2.38082 |
| EF1 - ZO2 | * | -3.00486 | 2.27611 |
| EF1 - ZC1 | | -1.11375 | 2.38082 |
| EF1 - ZC2 | | -1.3375 | 2.3421 |
| EF2 - ZO1 | * | 5.29542 | 2.38082 |
| EF2 - ZO2 | | 1.75764 | 2.27611 |
| EF2 - ZC1 | * | 3.64875 | 2.38082 |
| EF2 - ZC2 | * | 3.425 | 2.3421 |
| ZO1 - ZO2 | * | -3.53778 | 2.31593 |
| ZO1 - ZC1 | | -1.64667 | 2.41891 |
| ZO1 - ZC2 | | -1.87042 | 2.38082 |
| ZO2 - ZC1 | | 1.89111 | 2.31593 |
| ZO2 - ZC2 | | 1.66736 | 2.27611 |
| ZC1 - ZC2 | | -0.22375 | 2.38082 |

** indicates a statistically significant difference*

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