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# The Influence of Humated Mineral Fertilizers on the Yield of Maize Hybrids

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**Abstract:**

This article shows the results of the study of quickly ripening Mashuk 170 and middle-late Eric maize hybrids at 4 different fertilizer schedules, namely control (without fertilization), use of complete minerals ($N_{110}P_{80}K_{80}$), humated carbamide ($N_{30}$), and carbamide ($N_{30}$). The conducted phenological observations have shown that the mineral nutrition background does not affect the rate of seedling emergence, but contributes to the increase in the duration of vegetation of the quickly ripening Mashuk 170 hybrid and the middle-late Eric hybrid when using the schedules with the implementation of complete and humated mineral fertilizers for 4 and 6 days, respectively, as well as for 3 and 5 days, when applying carbamide fertilizer. The conducted set of studies has shown that humated carbamide is superior to carbamide in terms of efficiency and gives an essential gain in maize hybrids' productivity compared to unfertilized background. At that, the significance of this gain is more pronounced in late ripening Eric hybrid.

**Keywords:** crop structure, development phases, Eric, maize, Mashuk 170, humated carbamide, hybrids, plant height, yielding capacity.

## INTRODUCTION

The issues of crop production enhancement, increasing yields, and creation of new productive varieties and hybrids, that is, providing people with food and plant raw materials are vital for humanity, which lives only due to the vegetation cover of the Earth. In this regard, it is necessary to pay special attention to one of the leading grain crops, namely maize (Zea mays). Our approach to the problem of highly profitable production of cheap grain follows from the premise that maize is a universal grain crop with a high productive and adaptive potential, which due to its high plasticity is able to efficiently utilize soil and climatic factors, well respond by additional yield to improving water and food regimes of the soil, and the general agricultural condition of crops.

Therefore, the biological requirements of maize can vary over a wide range due to the variation of the complex of interrelated biochemical, physiological, morphological, and other features [1].

Maize also is characterized by high level of nutrient consumption, which, according to D. Shpaaar et al., is directly related to the effective scheme for C4 photosynthesis [2].

At the same time, 20-30 kg of nitrogen, 7-10 kg of phosphorus, and up to 26 kg of potassium are taken out of the soil per 1 ton of grain, or respectively, 10-15, 4-5, and 12-13 kg per one ton of dry matter [3-5].

One of the possible ways to solve the problem of minimizing the impact of agriculture on the environment for maintaining soil fertility and producing environmentally friendly agricultural products consists in reduction of the total consumption of fertilizers by improving the efficiency of assimilation of mineral nutrients by plants. New types of complex organomineral fertilizers, containing organic humic acids (in particular, lingo-humates) and having recently appeared in agriculture, meet this requirement. With a relatively small (up to 2%) content of the humic component in these fertilizers, the strength and water resistance of granules are improved, while the washout of easily soluble nutrients in the composition of fertilizers is reduced [6, 7].

This is very important in the current context for the development and implementation of advanced technologies of grain crops' cultivation, where it is necessary to use optimally material, monetary, and energy costs per unit area. This is due to the recent weakening of the intensification of production and a decrease in the energy intensity of products, which, with certain restrictions on the growth rate of energy consumption, can significantly restrain the increase in gross output [8-10].

Under these circumstances, maize, as one of the leading grain crops, acquires special importance, because due to its high plasticity, maize is able to efficiently utilize soil and climatic factors, well respond by additional yield to improving water and food regimes of the soil, and the general agricultural condition of crops. In particular, nitrogen fertilizers contribute to the increase in corn yield by 12-30% [11].

## MATERIALS AND METHODS

The climate of the test plot is moderately continental. Hydrothermal index varies within the range between 1.1 and 1.3. The average annual precipitation ranges from 550 to 650 mm, while during the period with temperature above +10°C it amounts to 350-400 mm. Frost-free period is 180-190 days. The sum of active temperatures is 2800-3000°C. The soil cover of the test plot is represented by leached chernozem, medium and medium-humus, medium- and heavy-loamy soil. The content of mobile phosphorus by Machigin is 22-26 mg, of exchangeable potassium – 290-315 mg per kg of soil. The reaction of the soil solution in the upper horizons is close to neutral, the pH is 6.6-6.7 [12].

The study of quickly ripening Mashuk 170 hybrid and middle-late Eric hybrid was carried out at 4 fertilization backgrounds: control (no fertilizer), use of complete minerals ($N_{110}P_{80}K_{80}$), humated carbamide ($N_{30}$) and carbamide ($N_{30}$) applied as presowing cultivation. The experiments were repeated 4-fold. The total area of the test plot in the experiments was 28 $m^2$, the record plot was 14 $m^2$. The experiments were conducted based on the method of blocks with systematic placement of the second-order plots.

## RESULTS

The conducted phenological observations have shown that the background of mineral nutrition does not affect the date of seedlings' emergence. When seeding on May 3 for all test options, the germination was noted on the same day from May 16 to 19 depending on year of conducted research. However, when considering the onset of the following development phases, it was revealed that there was trend of later flowering of panicles and maturation at improved plant nutrition, i.e. at the application of mineral fertilizer, which was common feature for both hybrids.

The revealed regularities of the dates of the emergence of main development phases of maize were fully reflected when considering the duration of maize plants' germination period (Table 1).

Table 1– Effect of fertilizers on the duration of interstage periods of maize plants' germination, days

| Hybrid | Fertilizers' application option | Germination periods | | | |
|---|---|---|---|---|---|
| | | sowing - germination | germination - flowering panicles | flowering panicles - full ripeness | sprouts - full ripeness |
| Mashuk 170 | Control (no fertilizers) | 15 | 53 | 47 | 100 |
| | $N_{110}P_{80}K_{80}$ | 15 | 54 | 50 | 104 |
| | Humated carbamide ($N_{30}$) | 15 | 54 | 50 | 104 |
| | Carbamide ($N_{30}$) | 15 | 54 | 49 | 103 |
| Eric | Control (no fertilizers) | 15 | 71 | 70 | 141 |
| | $N_{110}P_{80}K_{80}$ | 15 | 73 | 74 | 147 |
| | Humated carbamide ($N_{30}$) | 15 | 73 | 74 | 147 |
| | Carbamide ($N_{30}$) | 15 | 73 | 73 | 146 |

Thus, the application of mineral fertilizers does not affect the rate of germination. The duration of interstage period of "sowing-germination" was 15 days in all experimental options.

The following periods of maize plant germination for both hybrids were dependent on mineral fertilizers. In this case the longer the plants' germination was, the greater was the impact. Thus, the duration of the period of "germination - flowering panicles" in quickly ripening Mashuk 170 hybrid in all studied options had increased by 1 day, while in middle-late Eric hybrid – by 2 days regardless of the fertilizers used.

The duration of the next period of "flowering panicles - full ripeness" at application of complete minerals and humated carbamide increased, respectively, by 3 days in Mashuk 170 hybrid and by 4 days in Eric hybrid. When applying carbamide as presowing cultivation, this increase in duration was 2 and 3 days, respectively. As a result, the duration of vegetation of quickly ripening Mashuk 170 hybrid and middle-late Eric hybrid in options with the application of complete fertilizer and humated mineral fertilizer increased by 4 and 6 days, respectively. When applying carbamide, these figures were 3 and 5 days, respectively.

The application of complete minerals credibly led to the increase in the average plant height by 25 cm in the quickly ripening Mashuk 170 hybrid, and by 26 cm in the middle-late Eric hybrid. These figures were higher than those corresponding to the use of humated carbamide, where the increase in plant height was 21 and 19 cm, respectively, while at application of carbamide, the height had increased by 10 and 9 cm, respectively (Table 2).

Table 2 – Effect of fertilizers on the height of maize plants, cm

| Hybrid | Fertilizers' application option | | | |
|---|---|---|---|---|
| | Control (no fertilizers) | Complete minerals ($N_{110}P_{80}K_{80}$) | Humated carbamide ($N_{30}$) | Carbamide ($N_{30}$) |
| Mashuk 170 | 180 | 205 | 201 | 190 |
| Eric | 224 | 251 | 243 | 233 |
| Average | 202 | 228 | 222 | 121 |

The use of complete minerals contributed to the formation of the maximum area of the leaf surface of maize plants, providing an increase in relation to the control on average by 4.9 thousand $m^2$/ha. The application of humated carbamide led to increase by 3.8 thousand $m^2$/ha, while application of carbamide led to the lowest effect – just 1.9 thousand $m^2$/ha (Table 3).

Table 3 – Effect of fertilizers on the leaf surface area of maize plants, thousand $m^2$/ha

| Hybrid | Fertilizers' application option | | | |
|---|---|---|---|---|
| | Control (no fertilizers) | Complete minerals ($N_{110}P_{80}K_{80}$) | Humated carbamide ($N_{30}$) | Carbamide ($N_{30}$) |
| Mashuk 170 | 34.7 | 39.7 | 38.6 | 36.5 |
| Eric | 37.7 | 42.4 | 41.4 | 39.8 |
| Average | 36.2 | 41.1 | 40.0 | 38.1 |

Presowing mineral fertilizers' application did not affect the number of grain rows, the number of grains in a row, and the total number of grains in the cob. Differences were noted only between hybrids (Table 4).

Thus, weight of grain per one cob of quickly ripening Mashuk 170 hybrid at the application of complete minerals increased by 33.7% relative to the control, when applying humated carbamide the increase amounted to 26.5%, and at using just carbamide the increase was 13.3 %. Corresponding figures for middle-late Eric hybrid at various applications of fertilizers were 37.9, 30.3, and 14.4 %, respectively.

The weight of 1000 seeds of quickly ripening Mashuk 170 hybrid at the application of complete minerals increased by 34.1% relative to the control, when applying humated carbamide the increase amounted to 26.4 %, while at application of carbamide – 12.6 %. Corresponding figures for middle-late Eric hybrid at various applications of fertilizers were 37.3, 29.5, and 13.9 %, respectively.

On average, for two studied hybrids, the additional yield of maize crop, resulted from the application of complete minerals, amounted to 2.12 t/ha, of humated carbamide – to 1.66 t/ha, while of carbamide – to 0.75 t/ha (Table 5).

Table 4 – Effect of mineral fertilizers on the main economically valuable characteristics of maize hybrids

| Hybrid | Fertilizers' application option | Per one cob | | | | Weight of 1000 grains,g |
|---|---|---|---|---|---|---|
| | | number of grain rows, pcs. | number of grains in a row, pcs. | total number of grains, pcs. | Total grain weight, g | |
| Mashuk 170 | Control (no fertilizers) | 12 | 38 | 456 | 83 | 182 |
| | $N_{110}P_{80}K_{80}$ | 12 | 38 | 456 | 111 | 244 |
| | Humated carbamide ($N_{30}$) | 12 | 38 | 456 | 105 | 230 |
| | Carbamide ($N_{30}$) | 12 | 38 | 456 | 94 | 205 |
| Eric | Control (no fertilizers) | 16 | 34 | 544 | 132 | 244 |
| | $N_{110}P_{80}K_{80}$ | 16 | 34 | 544 | 182 | 335 |
| | Humated carbamide ($N_{30}$) | 16 | 34 | 544 | 172 | 316 |
| | Carbamide ($N_{30}$) | 16 | 34 | 544 | 151 | 278 |

Table 5 – Effect of mineral fertilizers on the yield of maize hybrids, t/ha

| Hybrid, factor A ($LSD_{05}$ = 0.14) | Fertilizer application option, factor B ($LSD_{05}$ = 0.17) | | | | Average |
|---|---|---|---|---|---|
| | Control (no fertilizers) | Complete minerals ($N_{110}P_{80}K_{80}$) | Humated carbamide ($N_{30}$) | Carbamide ($N_{30}$) | |
| Mashuk 170 | 5.81 | 7.79 | 7.34 | 6.55 | 6.87 |
| Eric | 5.96 | 8.20 | 7.73 | 6.79 | 7.17 |
| Average | 5.88 | 8.00 | 7.54 | 6.67 | 7.02 |
| | | | | Sx, % | 1.06 |
| | | | | $LSD_{05}$, t/ha | 0.18 |

When considering in detail the influence of the studied factors, it should be noted that the most significant positive effect from the application of mineral fertilizer was observed in the middle-late Eric hybrid in the studied experimental options, amounting to +2.24, +1.77, and +0.83 t/ha, respectively. Similar figures for quickly ripening Mashuk 170 hybrid were +1.89, 1.53, and 0.74 t/ha, respectively.

## DISCUSSION

Growth and development are among the most important manifestations of the organisms' life. Vegetative growth and reproductive development are the main integral processes that make up plant ontogenesis [13]. The conducted phenological observations have shown that the mineral nutrition background does not affect the seedling emergence rate, but contributes to the increase in the duration of vegetation of the quickly ripening Mashuk 170 hybrid and the middle-late Eric hybrid when using complete and humated mineral fertilizers for 4 and 6 days, respectively, and for 3 and 5 days, when using carbamide fertilizer. The positive response of maize plants to the studied factors was noted when analyzing plant height. Similar patterns were revealed when considering the next indicator, namely "leaf surface area". Application of mineral fertilizers in the soil does not affect the number of grains formed, but increases their weight. Moreover, humated carbamide is a more effective fertilizer in comparison with carbamide. When considering the indicator of "grain yield", a significant impact of mineral fertilizers was revealed. The application of complete minerals was the most productive. The humated carbamide was superior to carbamide in terms of efficiency, and contributed to a significant increase in the yield gain of maize hybrids in comparison with both unfertilized background, and the application of carbamide. At that, this effect was manifested stronger in the late ripening Eric hybrid.

## CONCLUSIONS

Thus, the conducted set of studies shows that humated carbamide is superior to carbamide in terms of efficiency, and contributes to a significant increase in the yield gain of maize hybrids in comparison with unfertilized background. At that, this effect is stronger in the late ripening Eric hybrid.

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