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# Effect of the plant density and foliar fertilization on the yield from new Bulgarian hybrids of sunflower (*Helianthus annuus* L.)

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## Abstract

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During 2016–2017 a field experiment was conducted with three new sunflower hybrids (Vilia, Enigma and Linzi) in the trial field of Dobrudzha Agricultural Institute. The aim was to determine the effect of the sowing norm and of a set of foliar fertilizers on the quantitative and qualitative indices of seed yield as a part of determining the elements forming the optimum agronomy practices for growing of the above hybrids. The variants of the experiment were the following: 1) check (untreated); 2) mineral fertilization at norm N60P120K80 (active matter/ha); foliar fertilization with: 3) Root; 4) Siapton; 5. Lebosol B; 6) Aminosol; 7) Aminosol mix; 8) Yara Vita Brassitrel pro. The foliar treatment was done by sprinkling the leaf mass at stage 6-7th pair of leaves. The soil in the experimental field was leached chernozem (Luvic phaeosem) with 3.30% humus content classified as very suitable for sunflower growing.

The averaged two-year results for seed yield showed that sunflower hybrid Vilia realized highest seed yield, regardless of the variants of the experiment, followed by hybrids Enigma and Linzi. Depending on the crop density (main action of the factor), hybrid Vilia had a positive response to higher densities, hybrid Enigma was indifferent, while hybrid Linzi decreased its seed yield with the higher crop densities. Depending on the tested variants of macro and micro fertilization (main action of this factor), the results were positive for hybrids Vilia and Enigma, and

in hybrid Linzi there was no change in the size of yield. Hybrid Vilia was with the highest 1000 kernel weight, regardless of the tested variants, flowed by Linzi and Enigma. Thousand kernel weigh was influenced much more by the crop density than by the variants of foliar fertilization. The inverse proportional dependence remained the same, namely 1000 kernel weight decreased with the higher crop densities. The foliar fertilization with the tested products, considered a main action of this factor, did not have significant effect on the value of the parameter "1000 kernel weight". The oil content in the seeds of the hybrids during the investigation was not influenced significantly by the factors involved in this experiment.

**Key words:** Foliar fertilization, Oil content, Sowing norms, Sunflower, Yield.

## Introduction

Investigations on the topic of this presentation are being permanently carried out in Bulgaria and abroad since sunflower is an important major oil seed crop in many agro ecological regions worldwide. New hybrids and promising lines of sunflower are being constantly introduced in practice, which have various peculiarities and growing requirements (Georgiev et al., 2006; Georgiev et al., 2013; Nenova et al., 2013).

Therefore constant studies on the agro technology of this crop are needed. Such studies would give an answer to the question what are the values of certain factors under which the tested hybrid can express to a maximum degree its biological potential. These particular factors are the parameters of the sowing norm (Amjed et al. 2011; Petcu et al. 2000; Sin & Partal, 2011; Yankov et al., 2009), the mineral macro and micro fertilization (Nankova and Tonev, 2004; Tonev, 2005,a; Tonev, 2005 b, Suzes, 2010), the use of bio stimulants (Ebrahimian et al., 2011; Milev, 2015), etc.

The topicality and significance of this problem consists in searching for the optimal combination of the agronomy practices related to the introduction of new sunflower hybrids developed at DAI – General Toshevo in production, with regard to both yield and the quality parameters of the produce.

The aim of this investigation was to determine the effect of some main agronomy factors such as the crop density, the macro and micro fertilization and the use of bio stimulants on the quality and quantity of production from new Bulgarian oil seed sunflower hybrids.

## Materials and Methods

During 2016 – 2017, a field experiment was carried out with oil seed sunflower in the trial field of Dobrudzha Agricultural Institute – General Toshevo (DAI), Bulgaria. The experiment was designed according to the split plot method, in

four replications of the variants, the size of the harvest plot being 12.6 m. The three hybrids were planted in the first-order plots, using 4 plant densities for each hybrid – 35 000, 45 000, 55 000 and 65 000 plants/ha. The following variants of treatment were positioned across the first-order plots: 1) check (untreated); 2) mineral fertilization at norm $N_{60}P_{120}K_{80}$ (active matter/ha); foliar fertilization with: 3) Root; 4) Siapton; 5. Lebosol B; 6) Aminosol; 7) Aminosol mix; 8) Yara Vita Brassitrel pro.

The foliar treatment was done by sprinkling the leaf mass at stage 3rd pair of leaves with the bio stimulant Root, and at stage 6-7th pair of leaves with the rest of the products. The applied doses were in accordance with the recommendations of the producers. Brief description of the tested products is given in Table 1.

Table 1. Characteristics of the tested products

| Name | Type | Active substance | Action |
|---|---|---|---|
| Root | Bio stimulant for foliar application | Molecular complex similar to chlorophyll | Alters the energy balance in favor of yield. Accelerates rooting. |
| Siapton | Bio stimulant for foliar application | Natural hydrolyzed proteins | Accelerates the formation of amino acids and the uptake of nitrate nitrogen from soil. |
| Lebosol B | Foliar one-component fertilizer | 11% B | Uniform flowering and maturation. |
| Aminosol | Foliar organic fertilizer | 20 amino acids and peptides, 9.4% organic nitrogen bound | Reduces stress. Increases yield. |
| Lebosol mix | Foliar microfertilizer | B 4.1 %, Mn 4.8 %, Mo 0.5 % | Improves initial development, stress resistance, yield quality. |
| YVB (Yara Vita Brassitrel Pro) | Foliar combined fertilizer | 6.9% amide nitrogen, MgO 11.6%, B 6%, Mn 7%, Mo 0.4%, CaO 8.9% | Higher yield and quality of production |

Three new oil seed sunflower hybrids developed through interlinear hybridization were tested in the field experiment carried out. In the breeding field of Dobrudzha Agricultural Institute, these hybrids underwent three-year testing according to a scheme approved for this crop.

**The first hybrid Vilia** is mid-early, with duration of the vegetative growth 112-115 days. Plants are medium high, 160 – 165 cm, with head diameter 26-29 cm, absolute weight of seeds 48 – 56 g, oil seed content 49 – 50 %, and the percent of kernel is within 76 – 78 %. The number of seeds per head is between 1150 and

1300, and the weight of seeds per plant is 65 – 80 g. The hybrid is resistant to downy mildew race 731.

Maximum average yield in the DAI trial fields - 4300 kg/ha.

**The second hybrid Enigma** is mid-early, with duration of the vegetative growth 115 – 120 days, plant height 180 – 190 cm and head diameter 20 – 22 cm. Oil of seeds is of linoleic type, and its content is 46 – 47 %. The seeds are black with slight grey stripes on their edges. Thousand seed weight is 62 – 64 g, number of seeds per head is 1180 – 1360, and their weight per plant is 81 – 91 g. The percent of the kernel in the seed is 72 – 75 %. The hybrid is resistant to downy mildew race 731. It possesses moderate resistance to phoma and phomopsis.

The hybrid is suitable for the so-called „clearfield" technology, which controls the annual cereal and broad-leaved weeds during the vegetative growth, as well as the parasite *Orobanche*. Maximum average yield obtained in the trial field of DAI - 4270 kg / ha.

**The last tested hybrid is Linzi**. It is a conventional mid-maturity sunflower hybrid. The duration of vegetative growth is 118 days. The plants height is 140-145cm. The head diameter is 25-27 cm. The position of the head is vertical and it is slightly convex. The seeds are black, with slight grey stripes on their edges. Thousand seeds weight is 60g. The percentage of hull content is 20%.

The hybrid is high-yielding and the seed oil content is 51.3%. It is resistant to downy mildew race 731 and *Orobanche* race G. It possesses moderate resistance to phoma and phomopsis.

The new Bulgarian hybrid "Linzi", developed in Dobrudzha Agricultural Institute – General Toshevo is registered with certificate No 11125P2 of the Patent office of Republic of Bulgaria. The hybrid "Linzi" was tested for two years in Moldova, and registered in 2017.

The hybrids were sown in mid-April, within the optimal dates for this agro-ecological region. Sowing was manual, and the number of plants per unit area was in accordance with the methodological requirements. All other elements of the agro technology of the hybrids in this experiment, which were not the aim of this investigation, were performed according to the traditional agronomy practices applied to sunflower production in the region (Klochkov et al., 1988).

The soil in the trial field was leached chernozem (*Luvic phaeozem*) with humus content 3.30 %, with neutral reaction, and can be classified as very suitable for growing of sunflower.

The vegetation conditions for sunflower growth and development in 2016 can be defined as moderately favorable. Precipitation at the beginning of the vegetative growth was sufficient to form a lush vegetative mass. After flowering and harvesting, there were no rainfalls of economic value.

Autumn and winter rainfalls, however, were plentiful - 315.3 mm (significantly above the referential values) and contributed to excellent soil moisture. Despite the drought in July and August, thanks to the accumulated soil moisture from the previous period on the one hand, and the drought resistance of the plants on the other, the seed yield was high (from 2820 to 3410 kg/ha depending on the variety).

In temperature terms, the vegetative growth of sunflower occurred at temperatures typical for the respective months, without extremely high values (exceeding 32° C) over an extended period of time (more than 4-5 days). The relative air humidity also did not reach critical levels causing disturbances in flowering and pollination.

The phytosanitary status of the hybrids was very good - there were no significant infections caused by sunflower-specific diseases.

Table 2. Vegetative and autumn-and-winter rainfalls during the investigated period, mm

| Month | Year | | Averaged for 2 years | Averaged for 60 years |
|---|---|---|---|---|
| | 2016 | 2017 | | |
| April | 20.8 | 38.4 | 29.6 | 48.3 |
| May | 117.1 | 16.7 | 67.1 | 49.6 |
| June | 55.7 | 87.7 | 71.7 | 64.0 |
| July | 2.8 | 66.3 | 34.5 | 51.8 |
| August | 5.0 | 12.4 | 8.7 | 40.3 |
| Amount for Apr-Aug | 201.4 | 221.5 | 211.4 | 254.0 |
| Autumn-and-winter rainfalls for Oct-Mar | 315.3 | 252.8 | 284.0 | 294.0 |

The conditions for growth and development of sunflower in 2017 can be defined as favorable. Vegetative rainfall and autumn-winter moisture reserves were sufficient to form abundant vegetative mass. After flowering and harvesting, there were no rainfalls of economic value. The autumn and winter rainfalls, however, were close to the norm - 252.8 mm and created conditions for good soil moisture.

Despite the drought in August, thanks to the accumulated moisture in the soil from the previous period on the one hand and the drought resistance of sunflower on the other, the seed yield was high - from 3307 to 3735 kg/ha depending on the variety.

In temperature terms, the vegetative growth of sunflower occurred at temperatures typical for the respective months, without extremely high values (exceeding 32°C) over an extended period of time (more than 4-5 days). The relative air humidity also did not reach critical levels causing disturbances in flowering and pollination.

The phytosanitary status of the hybrids was very good - there were no significant

infections by the sunflower-specific diseases.

At a later stage of the sunflower vegetative growth (stage of seed feeling), the plants were damaged by heavy rainfalls accompanied by a storm. This phenomenon affected most hybrid Linzi and, to a lesser extent, hybrid Enigma. The plants of these variants were scattered by the wind and were subsequently lost (about 5-7% of yield) during harvesting.

## Results and Discussion

### *Seed Yield*

The average seed yield (Table 3) for the hybrids tested in the study showed that the highest seed yield, regardless of the variants of the experiment, was obrained from hybrid Vilia - 3575 kg /ha, followed by hybrids Enigma 3355 kg/ha and Linzi 3063 kg/ha.

Depending on the density of the crop (considered the main action of the factor), hybrid Vilia showed a positive reaction to higher crop density, hybrid Enigma was indifferent and hybrid Linzi reduced its seed yield with increasing the crop density.

Depending on the tested macro and micro-variants, the results were positive for hybrids Vilia and Enigma, and the yield value of hybrid Linzi did not change.

The most efficient combinations „density x variant of fertilization“ for hybrid Vilia was 65000 plants/ha x Lebozol-mix - 3962 kg/ha; for hybrid Enigma the best combination was 45000 plants/ha x YVB-pro - 3632 kg/ha; and for hybrid Linzi – 45000 plants/ha x Lebozol B - 3272 kg/ha.

In the second year, the seed yield from all hybrids was higher and statistically significant.

From the presented seed yield data (dependent variable), it becomes clear that the response of the individual hybrids to the tested factors (the independent variable) was quite specific. This is because the favorable combinations of abiotic and experimental factors for the three tested hybrids were different.

In this respect, differences in the occurrence of the individual phenophases between the hybrids, as well as the size and slope of the leaf mass, are important. The latter directly affects the amount of working solution on its surface, the ability of the leaf surface to absorb nutrients at the hybrid level, etc. Frequently, several-day differences in the occurrence of the vegetation phases between the hybrids are critical for the positive or negative influence of a factor on the seed yield test, for example.

### *Thousand kernel weight*

The impact of the crop density on the kernel weight was much more expressed than the variants of leaf fertilizer. The higher crop density gradually and definitely decreased 1000 kernel weight, i.e. the correlation between them was inversely

proportional. The decrease in the 1000 kernel weight (from the smallest to the highest crop density) was in the range from 6.0 g for hybrid Vila, to 13.0 g for hybrid Enigma to 10.0 g for hybrid Linzi (Table 4).

Table 3. Seed yield according to the major action of the factors, averaged for two years, kg/ha

| Hybrid | Variant of treatment | | Crop density plants per ha | | Year | |
|---|---|---|---|---|---|---|
| Vilia | Check | 3398 | 35000 | 3490 | 2016 | 3416 |
| | $N_{60}P_{120}K_{80}$ | 3576* | 45000 | 3542$^{NS}$ | 2017 | 3735* |
| | Root | 3582* | 55000 | 3554$^{NS}$ | | 3575 |
| | Siapton | 3565* | 65000 | 3721* | | |
| | Lebosol B | 3495$^{NS}$ | | | | |
| | Aminosol | 3688* | | | | |
| | Lebosol-mix | 3594* | | | | |
| | YVB$^{\#}$ | 3718** | | | | |
| Enigma | Check | 3183 | 35000 | 3315 | 2016 | 3244 |
| | $N_{60}P_{120}K_{80}$ | 3278 | 45000 | 3434$^{NS}$ | 2017 | 3467* |
| | Root | 3434* | 55000 | 3266$^{NS}$ | | 3355 |
| | Siapton | 3469* | 65000 | 3413$^{NS}$ | | |
| | Lebosol B | 3398* | | | | |
| | Aminosol | 3370* | | | | |
| | Lebosol-mix | 3328* | | | | |
| | YVB$^{\#}$ | 3396* | | | | |
| Linzi | Check | 3058 | 35000 | 3113 | 2016 | 2819 |
| | $N_{60}P_{120}K_{80}$ | 3084$^{NS}$ | 45000 | 3125$^{NS}$ | 2017 | 3307** |
| | Root | 3063$^{NS}$ | 55000 | 2978$^{NS}$ | | 3063 |
| | Siapton | 3093$^{NS}$ | 65000 | 3042$^{NS}$ | | |
| | Lebosol B | 3107$^{NS}$ | | | | |
| | Aminosol | 3004$^{NS}$ | | | | |
| | Lebosol-mix | 3032$^{NS}$ | | | | |
| | YVB$^{\#}$ | 3092$^{NS}$ | | | | |

**, **, *** - Significance of differences at p<0.05, p<0.01, p<0.001 respectively; NS – not significant; # - Yara Vita Brassitrel*

Foliar fertilization, considered the main effect of this factor, did not have a significant effect on the parameter 1000 kernel weight. The highest 1000 kernel weight during this experimental period was measured in hybrid Vilia - 66.2 g, followed by Linzi - 65.4 g and Enigma - 64.1 g.

The conditions of the respective year significantly changed the 1000 kernel

weight of hybrids Vilia and Enigma and did not affect the 1000 kernel weight of hybrid Linzi.

Table 4. 1000 kernel weight according to the major action of the factors of the experiment averaged for two years, g

| Hybrid | Variant of treatment | | Crop density plants per ha | | Year | |
|---|---|---|---|---|---|---|
| Vilia | Check | 67.1 | 35000 | 69.9 | 2016 | 68.0 |
| | $N_{60}P_{120}K_{80}$ | 63.7 | 45000 | 66.5* | 2017 | 64.2* |
| | Root | 65.5 | 55000 | 64.9* | | 66.10 |
| | Siapton | 63.7 | 65000 | 63.5** | | |
| | Lebosol B | 67.4 | | | | |
| | Aminosol | 67.0 | | | | |
| | Lebosol-mix | 66.7 | | | | |
| | YVB# | 68.4 | | | | |
| Enigma | Check | 65.9 | 35000 | 69.0 | 2016 | 61.7 |
| | $N_{60}P_{120}K_{80}$ | 65.0 | 45000 | 66.4* | 2017 | 66.3* |
| | Root | 62.4 | 55000 | 62.0* | | 64.00 |
| | Siapton | 62.2 | 65000 | 57.9** | | |
| | Lebosol B | 63.0 | | | | |
| | Aminosol | 62.2 | | | | |
| | Lebosol-mix | 67.3 | | | | |
| | YVB# | 64.3 | | | | |
| Linzi | Check | 68.5 | 35000 | 70.9 | 2016 | 65.8 |
| | $N_{60}P_{120}K_{80}$ | 63.8 | 45000 | 65.7* | 2017 | 64.3 |
| | Root | 66.6 | 55000 | 63.2** | | 65.05 |
| | Siapton | 64.0 | 65000 | 61.7** | | |
| | Lebosol B | 64.7 | | | | |
| | Aminosol | 64.1 | | | | |
| | Lebosol-mix | 65.6 | | | | |
| | YVB# | 66.3 | | | | |

**, **, *** - Significance of differences at p<0.05, p<0.01, p<0.001 respectively; NS – not significant; # - Yara Vita Brassitrel*

***Oil content***

The results for the parameter oil content in seed are given in Table 5. The data clearly show that this parameter is a strong genetic peculiarity of the hybrid hardly affected by the factors of the trial. Variation was within extremely wide range even during the individual years and was not statistically significant.

Table 5. Oil content in seed averaged for two years, g

| Hybrid | Variant of treatment | | Crop density plants per ha | | Year | |
|---|---|---|---|---|---|---|
| Vilia | Check | 53.08 | 35000 | 53.41 | 2016 | 54.08 |
| | $N_{60}P_{120}K_{80}$ | 52.49 | 45000 | 52.74 | 2017 | 52.31 |
| | Root | 53.20 | 55000 | 52.81 | | 53.19 |
| | Siapton | 53.63 | 65000 | 53.81 | | |
| | Lebosol B | 53.10 | | | | |
| | Aminosol | 53.80 | | | | |
| | Lebosol-mix | 52.85 | | | | |
| | YVB# | 53.44 | | | | |
| Enigma | Check | 49.45 | 35000 | 49.21 | 2016 | 50.05 |
| | $N_{60}P_{120}K_{80}$ | 49.37 | 45000 | 50.74 | 2017 | 50.33 |
| | Root | 50.42 | 55000 | 50.49 | | 50.19 |
| | Siapton | 50.32 | 65000 | 50.32 | | |
| | Lebosol B | 50.25 | | | | |
| | Aminosol | 51.24 | | | | |
| | Lebosol-mix | 50.05 | | | | |
| | YVB# | 50.00 | | | | |
| Linzi | Check | 53.70 | 35000 | 52.84 | 2016 | 53.74 |
| | $N_{60}P_{120}K_{80}$ | 53.18 | 45000 | 54.41 | 2017 | 54.64 |
| | Root | 54.59 | 55000 | 54.92 | | 54.19 |
| | Siapton | 54.70 | 65000 | 54.85 | | |
| | Lebosol B | 54.60 | | | | |
| | Aminosol | 54.02 | | | | |
| | Lebosol-mix | 54.31 | | | | |
| | YVB# | 54.51 | | | | |

**, **, *** - Significance of differences at p<0.05, p<0.01, p<0.001 respectively; NS – not significant; # - Yara Vita Brassitrel*

## Conclusion

Based on the obtained data, it was found that:

The highest seed yield, regardless of the variants of the trial, was realized by hybrid Vilia, followed by hybrids Enigma and Linzi.

Depending on the density of the crop (considered the main action of the factor), hybrid Vilia showed a positive reaction to higher crop density, hybrid Enigma was indifferent, while hybrid Linzi reduced its seed yield with the higher crop density.

Depending on the tested variants of macro and micro-fertilizers, the results were positive for hybrids Vilia and Enigma, and there was no change in the yield value of hybrid Linzi.

The impact of the crop density on 1000 kernel weight was much better expressed than the effect of the foliar fertilization. Reverse-proportional dependence was determined, namely with the increase of the crop density, 1000 kernel weight decreased.

Foliar fertilization, considered the main action of this factor, had no significant effect on the parameter 1000 kernel weight.

The highest 1000 kernel weight during this experimental period was of hybrid Vilia, followed by Linzi and Enigma.

The seed oil content of the tested hybrids during the studied period was not significantly influenced by the experimental factors.

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