

EFFECT OF THE PLANT DENSITY AND FOLIAR FERTILIZATION ON THE YIELD FROM NEW BULGARIAN HUBRIDS OF SUNFLOWER (*HELIANTHUS ANNUUS* L.)

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ABSTRACT

During 2014–2015 a field experiment was conducted with three new sunflower hybrids (Veleka, Vokil and Sava) in the trial field of Dobrudzha Agricultural Institute. The aim was to determine the effect of the plant density 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) Lebosol Mg-S; 7) Lebosol Mn; 8) Yara Vita Brassitrel pro. The foliar treatment was done by sprinkling the leaf mass at stage 6-7th pair of leaves. Each hybrid was sown at four densities – 35 000, 45 000, 55 000 and 65000 plants/ha. The soil in the experimental field was leached chernozem (*Luvic phaeosem*) with 3.30% humus content classified as very suitable for sunflower growing. Based on the data obtained, it was found that the factor sowing norm had greater effect on the seed yield than foliar fertilization. This factor enhanced seed yield with 5 to 10 %, 1000 seed weight decreased with the higher sowing norm with 12 to 19 %, while oil content in seed did not change. The factor fertilization did not affect significantly the three followed indices. The reason for this result was the amount of rainfalls. During the first year they were abundant and during the second – scare; as a result from these deviations from the precipitation norm of the region the differences between the individual variants were leveled up.

Key words: sunflower, sowing norms, foliar fertilization, yield, oil content

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 indices of the produce.

The aim of this investigation was to determine the effect of some main agronomy factors such as the plant 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.

MATERIAL AND METHODS

During 2014 – 2015, 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 soil fertilization with norm N₆₀P₁₂₀K₈₀, active matter per ha; foliar treatment with: 3) Root; 4) Siapton; 5) Lebosol B (boron); 6) Lebosol Mg-S (magnesium - sulfur); 7) Lebosol Mn (manganese); 8) Yara Vita Brassitrel pro (YVB). The foliar treatment was done by sprinkling the leaf mass at stage 3rd pair of leaves with the bio stimulant Root, and at stage 6th - 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 component fertilizer	one- 11% B	Uniform flowering and maturation.
Lebosol MgS	Foliar fertilizer	combined 24.1% MgO и 16.6% S	Higher plant vigor.
Lebososl Mn	Foliar component fertilizer	one- 6% Mn	Enhances immunity
YVB (Yara Vita Brassitrel Pro)	Foliar fertilizer	combined 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 DAI, these hybrids

underwent three-year testing according to a scheme approved for this crop. The first hybrid **Veleka** is medium early, with vegetation period 120-123 days. Plants are medium high, 155 – 160 cm, with head diameter 18-22 cm, absolute weight of seeds 55 – 65 g, oil seed content 48 – 49 %, and the percent of kernel is within 72 – 76 %. The number of seeds per head is between 1060 and 1530, and the weight of seeds per plant is 61.5 – 89.3 g. The duration of flowering is 11-13 days. **Veleka** is shorter than the other Bulgarian hybrids distributed up to now. It gives stable yields in climatically unfavorable years. This hybrid exceeded the mean standard by seed and oil yield during the preliminary testing in the experimental fields of DAI. The exceeding by seed yield was within the range 12.7 – 21.1 %, and by oil yield – from 14.5 to 25.8 %. The maximum seed yield obtained from the new hybrid in the experimental fields was 4837 kg/ha and the oil yield was 2370 kg/ha, oil percent in seed reaching up to 49.0 %. Hybrid **Veleka** was acknowledged as clearly distinct from all other varieties, sufficiently uniform and stable with a technical testing report of the National Executive Agency of Variety Testing, Field Inspection and Seed Control of Bulgaria. Following three-year official testing, hybrid **Veleka** was registered also in Romania and was included in the European catalog of field and vegetable crop varieties.

The second hybrid **Vokil** is medium early, with vegetation period of 122 – 125 days, plant height 150 – 160 cm and head diameter 18 – 21 cm. Oil of seeds is of linoleic type, and its content is 49 – 51 %. Thousand seed weight is 53 – 58 g, number of seeds per head is 1180 – 1360, and their weight per plant is 81 – 91 cm. The percent of the kernel in the seed is 72 – 75 %. The duration of flowering is 11 – 13 days. During the three years of testing the hybrid exceeded the mean standard with 4.9 – 14.9 %, the maximum obtained seed yield being 4570 kg/ha, and the maximum oil yield – 2344 kg/ha. Oil content in seed reached up to 51.7 %.

Hybrid **Vokil** was officially registered in Romania in 2013 and was enlisted in the European catalog of field and vegetable crop varieties.

The last tested hybrid **Sava** is early. Its vegetation period is shorter in comparison to the other two hybrids with 10 to 12 days. The height of plants is 140 – 150 cm. Head diameter is 24 – 27 cm. The vegetation period is 109 – 112 days. Oil content in seeds is 49 – 50 %. It is resistant to downy mildew race 731 and to *Orobanche* races from A to F.

In 2012 hybrid **Sava** was presented for official testing within the structures of the Romanian varietal commission at 10 locations. During the three years of official testing the new hybrid exceeded the Romanian standard with averagely 2.2 % by the index seed yield. The mean seed yield per hectare for the three years of testing was 3273 kg/ha. Hybrid **Sava** was officially registered in Romania in 2015 and was enlisted in the European catalog of field and vegetable crop varieties under the name **Sevar**.

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 (Klochov 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 growth and development of sunflower in 2014 can be described as very favorable. The autumn-and-winter rainfalls of 323.5 mm exceeded their referential values and were a prerequisite for excellent moisture reserves in soil. The amount

of vegetation rainfalls (370.5 mm) and their distribution during the respective growth stages were also entirely sufficient and suitable to meet the demands of the crop.

Highest vegetation rainfalls were registered in June - 192.5 mm, i.e. during the month when sunflower undergoes intensive vegetation growth. These rainfalls were accompanied by stormy winds and caused lodging of the plants to various degrees. Hybrid Veleka was affected most, and hybrid Sava – least. The degree of lodging was determined by the growth stage of the respective hybrids at the moment of this unfavorable occurrence. Lodging lead to formation of a non-uniform crop (deviations from the row, the height, instances of curved stems, etc.).

The vegetation conditions for growth and development of sunflower during the second year can be described as relatively unfavorable. The rainfalls at the beginning of the growth season were scarce, significantly below the mean monthly referential values (Table 2). The August rainfalls were too late and did not have significant economic effect on yield, especially on the earlier hybrid Sava.

Comparatively, the total amount of vegetation rainfalls during this growth season (158.9 mm) was 2.3 times lower than the rainfalls in 2014 (370.5 mm). The autumn-and-winter rainfalls, however, were abundant - 372.9 mm, considerably exceeding their referential values, and created excellent moisture reserves in soil.

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

Month	Years		Averaged for 2 years	Averaged for 60 years
	2014	2015		
April	29.6	46.3	37.9	49.1
May	78.2	12.9	45.5	50.6
June	192.5	31.3	111.9	65.4
July	50.9	27.2	39.5	49.2.
August	19.3	41.2	30.2	40.3
Amount for Apr- Aug	370.5	158.9	264.7	254.0
Autumn-and- winter rainfalls for Oct-Mar	323.5	372.9	348.2	294.0

With regard to air temperatures, the growth season of sunflower in 2014 was not interrupted by any disturbances. The growth season of 2015 occurred under recurrently high air temperatures exceeding the norm (above 32-35°C). Such temperatures were registered during 25th – 30th July and 12th – 15th August. The combination of scarce rainfalls and extreme high temperatures caused severe soil drought during May – July. Under these meteorological conditions seed yield was formed mainly at the expense of the autumn-and-winter moisture reserves in soil.

RESULTS AND DISCUSSION

The results presented in Table 3 show that the variants of treatment with the set of micro fertilizers, bio stimulants and mineral fertilization had zero effect on seed yield. The

better and more vigorous vegetative growth observed during the growth season was not expressed on seed yield. What is more – the seed yield from the check variant was higher than the treated variants. This phenomenon can be explained by the greater lodging and the more severe stress which, however, the plants with better supply of nutrients suffered in these variants.

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

Hybrid	Variant of treatment	Crop density		Year		
Veleka	Check	3363	35000	2930	2014	2711
	N ₆₀ P ₁₂₀ K ₈₀	2996*	45000	3185*	2015	3307**
	Root	2911*	55000	3005 NS		
	Siapton	3000*	65000	2928 NS		
	Lebosol B	3000*				
	Lebososl Mg-S	2891**				
	YVB [#]	2897**				
	Lebososl Mn	3029*				
Vokil	Check	3465	35000	3250	2014	3398
	N ₆₀ P ₁₂₀ K ₈₀	3344 NS	45000	3427 NS	2015	3393 NS
	Root	3274 NS	55000	3445*		
	Siapton	3496 NS	65000	3461*		
	Lebosol B	3482 NS				
	Lebososl Mg-S	3244NS				
	YVB	3497 NS				
	Lebososl Mn	3367 NS				
Sava	Check	3414	35000	3211	2014	3482
	N ₆₀ P ₁₂₀ K ₈₀	3387 NS	45000	3490**	2015	3214*
	Root	3331 NS	55000	3382*		
	Siapton	3380 NS	65000	3289 NS		
	Lebosol B	3364 NS				
	Lebososl Mg-S	3283 NS				
	YVB	3392 NS				
	Lebososl Mn	3271 NS				

*, **, *** - Significance of differences at $p < 0.05$, $p < 0.01$, $p < 0.001$ respectively;

NS – not significant; # - Yara Vita Brassitrel

The factor sowing norm had significantly higher effect on the seed yield in comparison to the variants with fertilization. The variation from the lowest to highest yield caused by this factor by hybrids was the following: hybrid Sava – 279 kg/ha, hybrid Veleka – 257 kg/ha and hybrid Vokil – 211 kg/ha. Hybrids Veleka and Sava realized highest yield at crop density of 45000 plants/ha. In hybrid Vokil, the higher sowing norms gave higher seed yield than the check variant, without significant differences being observed between themselves.

The respective year conditions had more significant effect on the size of the seed yield from hybrids Veleka (a difference of 59 kg/ha) and Sava (a difference of 27 kg/ha), and did not have any effect on hybrid Vokil. In hybrid Veleka, the lodging of the crop in 2014 played a considerable role for this high variation in yield and lead to its logical decrease.

Hybrid Veleka realized highest 1000 seed weight in the variants with Lebosol Mg-S, Yara Vita Brasitrel and Lebososl Mn, respectively. The exceeding of the values of the index in these variants was from 3.2 to 5.4 g, respectively (Table 4).

In hybrid Vokil, only the treatment with Lebosol Mn significantly exceeded the check variant. The value of the index for the variants with N₆₀P₁₂₀K₈₀, Root, Siapton, Lebosol Mg-S and Lebosol B was even lower than the check variant with about 2.5 g.

Table 4. 1000 seed weight (g) according to the variants of the experiment averaged for two years,

Hybrid	Variant of treatment		Crop density		Year	
Veleka	Check variant	60.5	35000	69.0	2014	65.0
	N ₆₀ P ₁₂₀ K ₈₀	59.1 <i>NS</i>	45000	62.8***	2015	58.0**
	Root	59.1 <i>NS</i>	55000	58.5***		
	Siapton	59.8 <i>NS</i>	65000	55.7***		
	Lebosol B	58.9 <i>NS</i>				
	Lebososl Mg-S	63.7*				
	YVB [#]	64.6*				
	Lebososl Mn	65.9**				
Vokil	Check variant	64.9	35000	58.0	2014	62.8
	N ₆₀ P ₁₂₀ K ₈₀	62.5*	45000	55.8**	2015	64.3 <i>NS</i>
	Root	61.9*	55000	52.1***		
	Siapton	63.6 <i>NS</i>	65000	50.9***		
	Lebososl B	62.1*				
	Lebosol Mg-S	62.5*				
	YVB	64.6 <i>NS</i>				
	Lebosol Mn	66.6*				
Sava	Check variant	53.6	35000	58.0	2014	54.9
	N ₆₀ P ₁₂₀ K ₈₀	53.1 <i>NS</i>	45000	55.8*	2015	53.2 <i>NS</i>
	Root	52.2 <i>NS</i>	55000	52.1***		
	Siapton	53.6 <i>NS</i>	65000	50.9***		
	Lebososl B	53.6 <i>NS</i>				
	Lebososl Mg-S	52.6 <i>NS</i>				
	YVB	55.7**				
	Lebososl Mn	58.2***				

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

Highest 1000 seed weight in the third hybrid Sava was registered for the variants Lebosol Mn and Yara Vita Brasitrel, the exceeding being with about 2-5 g.

The higher crop density gradually and definitely decreased 1000 seed weight, i.e. the correlation between them was inversely proportional.

The conditions of the respective year did not significantly change the value of 1000 seed weight of hybrids Vokil and Sava. In hybrid Veleka, 1000 seed weight was significantly higher during the first year of the experiment. The reason for this could be the thinning of the crop as a result from its lodging; at the expense of this, however, larger and more plums seeds were formed.

The results for the index oil content in seed are given in Table 5. The data clearly show that this index is a strong genetic peculiarity of the hybrid hardly affected by the factors of the trial. Variation was within extremely 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		Year	
Veleka	Check variant	51.50	35000	50.23	2014	50.98
	N ₆₀ P ₁₂₀ K ₈₀	51.14 <i>NS</i>	45000	51.00 <i>NS</i>	2015	51.25 <i>NS</i>
	Root	51.04 <i>NS</i>	55000	51.42 <i>NS</i>		
	Siapton	50.89 <i>NS</i>	65000	51.30 <i>NS</i>		
	Lebososl B	51.35 <i>NS</i>				
	Lebososl Mg-S	51.18 <i>NS</i>				
	YVB [#]	51.02 <i>NS</i>				
	Lebososl Mn	51.74 <i>NS</i>				
Vokil	Check variant	52.59	35000	51.66	2014	52.35
	N ₆₀ P ₁₂₀ K ₈₀	52.47 <i>NS</i>	45000	52.20 <i>NS</i>	2015	52.65 <i>NS</i>
	Root	52.01 <i>NS</i>	55000	52.87 <i>NS</i>		
	Siapton	52.22 <i>NS</i>	65000	52.68 <i>NS</i>		
	Lebososl B	52.58 <i>NS</i>				
	Lebososl Mg-S	52.75 <i>NS</i>				
	YVB	52.45 <i>NS</i>				
	Lebososl Mn	52.75 <i>NS</i>				
Sava	Check variant	50.53	35000	49.85	2014	50.38
	N ₆₀ P ₁₂₀ K ₈₀	49.96 <i>NS</i>	45000	50.60 <i>NS</i>	2015	50.95 <i>NS</i>
	Root	50.83 <i>NS</i>	55000	50.57 <i>NS</i>		
	Siapton	49.94 <i>NS</i>	65000	50.50 <i>NS</i>		
	Lebososl B	49.90 <i>NS</i>				
	Lebososl Mg-S	50.40 <i>NS</i>				
	YVB	50.73 <i>NS</i>				
	Lebososl Mn					

*, **, *** - 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 factor crop density of the plants had higher strength of effect on seed yield than the foliar fertilization. The first factor increased seed yield with 5 to 10 %, 1000 seed weight decreased with 12 to 19 % with the higher sowing norms, while oil percent in seed did not change. The factor fertilization did not have a significant effect on the three followed indices.

The significant deviation from the precipitation norm during the growth season of sunflower played a major role for the low effect of the investigated factors, fertilization in particular. During the first year the rainfalls were abundant, and during the second – scarce; as a result these deviations in both years of investigation neutralized the differences between the individual variants.

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