EFFECTS OF COMPLEX FERTILIZER ON YIELD COMPONENTS AND YIELD OF SOME SOYBEAN GENOTYPES

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Abstract

Fertilization is one of the main economic and health-promoting factors in crop cultivation. Field trials were carried out in 2019, in the experimental field of Soybean Breeding Laboratory from Agricultural Research and Development Station in Turda (ARDS Turda), based on a subdivided parcel design with two replications, using plots of 5 m^2. The biological material used in this study was created at ARDS Turda, 13 semi-early, early and very early soybean genotypes being evaluated: 7 varieties (Perla, Onix, Felix, Carla, Caro TD, Ada TD, Raluca TD) and 6 perspective lines (T-161, T- 295, T-165, T-6126, T-6117 and T-166). Fertilization was carried out with NPK 16:16:16 complex fertilizer applying the following doses: 150 kg/ha, 200 kg/ha, 250 kg/ha and unfertilized (Control). At the end of the growing season the genotypes were characterized by: plant height (cm), number of pods/plant, number of seeds/plant, seeds weight/plant (g), TKW (g), yield (kg/ha). The reported data is the average of 10 measurements. Statistical calculations were accomplished in Excel 2013 (Microsoft, USA) highlighting differences between studied genotypes and applied doses. The average of the seed/plant had small variations, in this year's conditions; the grain size varied between 122 g and 162 g and the maximum yield was about 3 to/ha at the dose of 200 kg/ha complex fertilizer.

Keywords: soybean, complex fertilizer, yield components, nutrient supply

Soybean *Glycine max (L.) Merrill* is apparently one of the most important cultivated crops worldwide in its agro-economic value and diverse utilities in both agriculture and industry (Choi H.K., Cook D.R., 2011). Soybean is one of the important oil grain legume crops in the world. In the international world trade market, soybean is ranked number one among the major oil crops such as rapeseed, groundnut, cotton seed, sunflower, linseed, sesame and safflower (Chung G., Singh RJ., 2008). Soybean seed composition and yield are a function of genetics, environment, and management practices, but contribution of each factor to seed composition and yield are not well understood (Yared *et al*, 2019).

Fertilization is one of the main economic and health-promoting factors in crop cultivation. High yielding soybeans require large amounts of nitrogen (N), phosphorus (P), and potassium (K) as well as a smaller amount of sulfur (S) and some micronutrients (Kahraman, 2017). Fertilization is recommended to be applied only when the soil is known to be deficient in basic nutrients (https://unctad.org/).

The aim of this study was to estimate the effects of complex fertilizer NPK 16:16:16 on quantitative traits in four different doses and the correlation between the studied traits.

MATERIAL AND METHOD

Field trials were carried out in 2019, in the experimental field of Soybean Breeding Laboratory from Agricultural Research and Development Station in Turda (ARDS Turda), based on a subdivided parcel design with two replications, using plots of 5 m^2. The biological material used in this study was created at ARDS Turda, 13 semi early, early and very early soybean genotypes being evaluated: 7 varieties (Perla, Onix, Felix, Carla TD, Caro TD, Ada TD, Raluca TD) and 6 perspective lines (T-161, T-295, T-165, T-6126, T-6117 and T-166).

Fertilization was carried out with NPK 16:16:16 complex fertilizer applying the following doses: 150 kg/ha, 200 kg/ha, 250 kg/ha, and unfertilized (Control). At the end of the growing season ten plants randomly selected from each plot were used to record data six quantitative traits: plant height (cm), number of pods/plant, number of seeds/plant, seeds weight/plant (g), TKW (g), and yield (kg/ha). The reported data, except the yield, was the average of 10 measurements. Statistical calculations were accomplished in Excel 2013

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(Microsoft, USA) highlighting differences between studied genotypes and applied doses.

Figure 1 **Study location and fertilization levels**

RESULTS AND DISCUSSIONS

Meteorological conditions have a major impact on plant growth (Popovićet *et al*., 2013a, Ikanović *et al*., 2014). Atypical climatic conditions between 1st April –30st September 2019, may be considered less favourable for soybean crop for the reference area, with consequences on yield and yield components. Temperatures and rainfall recorded a large or very large variation from one day to another and from one month to another, with large differences from the multinational average. The drought of July and September, correlated with the high temperatures of the last month of summer and the first month of autumn, forced the ripening of the genotypes taken into study (*table 1*, *table 2*).

Analyzing the average values of the yield and its main components, it can be observed that there are no significant differences between the three doses of fertilization and the control variant. It seems that the plant height was influenced by the applied fertilizer doses, with a small coefficient of variability in all four experimental variants. The values of the coefficients of variation calculated for the number of pods/plant respectively the number of seeds/plant indicates a small or medium variability of these characters within the analyzed biological material. Along with the number of seeds/plant, the weight of the seeds/plant and the mass of a thousand grains, they are the most important elements of yield, which contributes substantially in determining the grain production of a genotype. The coefficient of variation (CV) for the yield and 5 yield components varied from 6% to 31%, respectively. The minimum value of CV came from TKW (6%) and the greater from grain yield per plant (31%). According to Larissa Barbosa de SOUSA *et al*. (2015) the grain weight per plant had also the higher variation (CV 37.71%). The fertilizer doses impact on soybean genotypes yield in the climatic conditions of this year reveals that in average the nutritional support offered did not determine the increase of the yield.

Table 1

Temperature in Turda during 1st April 2019 – 30st September 2019

Temperature (°C)							
Month		April	May	June	July	August	September
Monthly average		11	14	22	20	22	17
Range		11.4	15.5	9.7	11.9	9.7	12.90
Range	Minimum	7	4.9	15.9	14.1	17	9.80
	Maximum	18.4	20.4	25.6	26	26.7	22.70
Monthly multiannual average (60 years)		9.9	15	17.9	19.7	19.3	15.1
Deviation from multiannual average		1.4	-1.4	3.9	0.7	2.8	1.6
Characterization of the month		warm	cool	warm	normal	warm	warm

Table 2

Rainfall in Turda during 1st April 2019 – 30 st September 2019

Rainfall (mm)							
Month		April	May	June	July	August	September
Monthly average		4.82	7.26	5.73	3.50	9.11	3.12
Range		13.8	24.2	24.8	15	24.4	14.40
Range	Minimum	0.4	0.2	0.2	0.2	1.2	0.00
	Maximum	14.2	24.4	25	15.2	25.6	14.40
Monthly multiannual average (60 years)		45.9	68.7	84.8	77.1	56.5	42.5
Deviation from multiannual average		16.7	83.7	-16	-42.1	7.2	-12.7
Characterization of the month		very rainy	excessive rainfall	slightly dry	excessive drought	slightly rainy	dry

Analyzing the average values of the yield and its main components, it can be observed that there are no significant differences between the three doses of fertilization and the control variant. It seems that the plant height was influenced by the applied fertilizer doses, with a small coefficient of variability in all four experimental variants. The values of the coefficients of variation calculated for the number of pods/plant respectively the number of seeds/plant indicates a small or medium variability of these characters within the analyzed biological material. Along with the number of seeds/plant, the weight of the seeds/plant and the mass of a thousand grains, they are the most important elements of yield, which contributes substantially in determining the grain production of a genotype. The coefficient of variation (CV) for the yield and 5 yield components varied from 6% to 31%, respectively. The minimum value of CV came from TKW (6%) and the greater from grain yield per plant (31%). According to Larissa Barbosa de SOUSA *et al*. (2015) the grain weight per plant had also the higher variation (CV 37.71%). The fertilizer doses impact on soybean genotypes yield in the climatic conditions of this year reveals that in average the nutritional support offered did not determine the increase of the yield (*table 3*, *table 4*). The correlation coeficient is a statistical estimate which measures how linear is the association between two variables (Ramalho *et al*, 2012). By analyzing the relationship between yield components and yield there can be observed some strength correlation between studied characters with positive sign.

Table 3

Data analysis for plant height (cm), number of pods/plant and number of seeds/plant (complex fertilizer NPK 16:16:16)

	Plant height (cm)				Number of pods/plant				Number of seeds/plant			
	150 kg/ha	200 kg/ha	250 kg/ha	Control	150 kg/ha	200 kg/ha	250 kg/ha	Control	150 kg/ha	200 kg/ha	250 kg/ha	Control
Mean	64	66	67	67	22	25	25	25	54	61	62	62
Standard Deviation	5.10	5.16	4.27	4.13	3.25	5.30	2.79	3.32	8.57	15.12	8.35	9.91
Range	17	19	15	13	11	19	8	10	28	51	24	32
Minimum	57	56	60	60	17	18	22	20	38	42	51	49
Maximum	74	75	76	73	28	37	30	30	66	93	76	81
CV%	8	8	6	6	15	21	11	13	16	25	13	16

Table 4

Data analysis for seeds weight/plant (g), TKW (g) and yield (kg/ha) (complex fertilizer NPK 16:16:16)

	Seeds weight/plant (g)				TKW (g)				Yield (kg/ha)			
	150 kg/ha	200 kg/ha	250 kg/ha	Control	150 kg/ha	200 kg/ha	250 kg/ha	Control	150 kg/ha	200 kg/ha	250 kg/ha	Control
Mean	7	9	9	8	140	143	141	137	2069	2277	2078	2280
Standard Deviation	1.34	2.67	1.50	1.58	9.83	12.30	12.73	10.48	256.81	400.65	365.73	148.41
Range	5	10	5	5	33	33	37	31	844	1465	1294	540
Minimum	5	5	7	6	122	129	125	122	1694	1533	1532	1924
Maximum	10	15	11	11	154	162	162	153	2538	2998	2827	2464
CV%	18	31	17	19	7	9	9	8	12	18	18	7

The sumarized data for 13 soybean genotype (*table 5, table 6)* showed that the highest values for correlation coefficient were obtained at the 200 kg/ha fertilizer doses. The positive correlations were observed for number of seeds/plant that corelates significant with: plant height (cm) (r=0.75) and number of pods/plant (r=0.98). The seeds weight/plant presented a pozitive correlation with the plant height (r=0.75), number of pods/plant (r=0.97) and number of seeds/plant (r=0.96).

Table 5

Correlation coefficients (r) for yield and yield components at 13 soybean genotypes (fertilized with NPK 16:16:16)

Quantitative traits	150 kg/ha						200 kg/ha					
	Plant height (cm)	Number of pods/ plant	Number of seeds/ plant	Seeds weight /plant (g)	TKW (g)	Yield (kg/ ha)	Plant height (cm)	Number of pods/ plant	Number of seeds/ plant	Seeds weight/ plant (g)	TKW (g)	Yield (kg/ ha)
Plant height (cm)	1						1					
Number of pods/ plant	0.12	1					0.70**	1				
Number of seeds/ plant	0.11	0.96***	1				0.75**	0.98***	1			
Seeds weight/ plant (g)	0.17	0.89***	0.87***	1			0.75**	0.97***	0.96***	1		
TKW (g)	-0.10	0.12	0.00	0.43	1		0.34	0.51	0.43	0.63*	1	
Yield (kg/ha)	0.59*	0.07	0.09	0.14	0.02	1	-0.13	-0.11	-0.15	-0.24	0.47	1

Table 6

Correlation coefficients (r) for yield and yield components at 13 soybean genotypes (fertilized with NPK 16:16:16)

Quantitative traits	250 kg/ha						0 kg/ha (Control)					
	Plant height (cm)	Number of pods/ plant	Number of seeds/ plant	Seeds weight / plant (g)	TKW (g)	Yield (kg/ha)	Plant height (cm)	Number of pods/ plant	Number of seeds/ plant	Seeds weight / plant (g)	TKW (g)	Yield (kg/ ha)
Plant height (cm)	1						1					
Number of pods/ plant	0.66*	1					0.67*	1				
Number of seeds/ plant	0.62*	0.96***	1				0.82**	0.89**	1			
Seeds weight/ plant (g)	0.39	0.80**	0.87***	1			0.65*	0.83**	0.89***	1		
TKW (g)	-0.31	-0.28	-0.20	0.20	1		-0.02	0.23	0.14	0.55	1	
Yield (kg/ha	0.30	0.01	0.06	-0.30	-0.44	1	0.56	0.17	0.28	-0.05	-0.46	1

The fertilization dose influenced the yield level differently, in the genotypes studied, the best results being recorded by Raluca TD variety and the T-166 line at the 200 kg/ha, NPK 16 16 16 complex fertilizer, with an increase of production of 534 kg/ha respectively 849 kg/ha compared to the unfertilized variant (*table 7*). It is observed that between the control and the dose of 150 kg/ha there are no significant differences between the obtained yields. The genotypes: Raluca TD, T-166 and T-6126 have achieved the maximum yields at the fertilization dose of 250 kg/ha (*figure 2*).

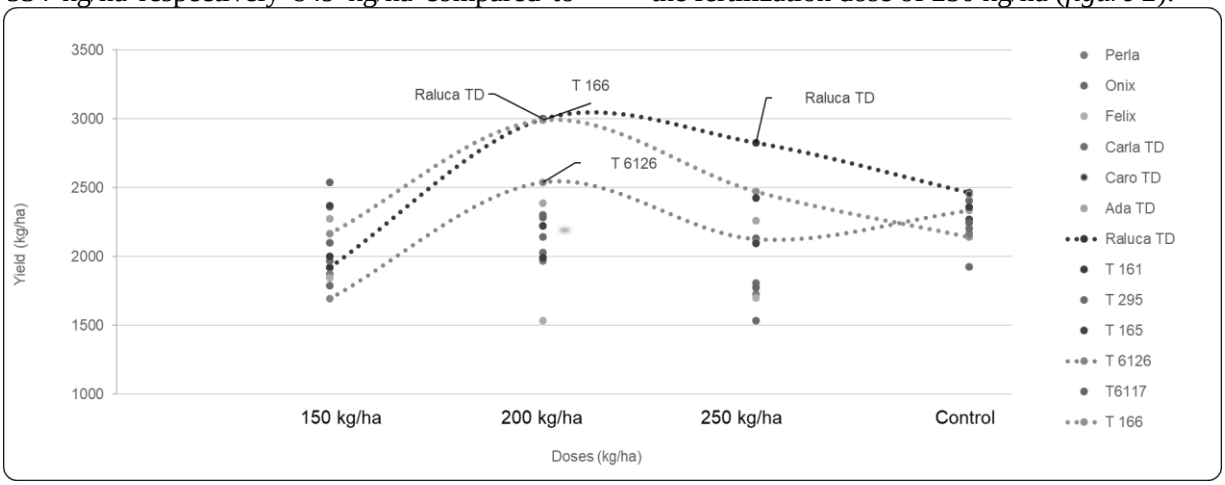

Figure 2 **Effect of complex fertilizer NPK 16:16:16 with four levels of fertilization on yield (kg/ha)**

Table 7

Effect of complex fertilizer NPK 16:16:16 with four levels of fertilization on yield (kg/ha)

Nr. Crt.	Genotype	150 kg/ha		200 kg/ha		250 kg/ha		0 kg/ha Control
		Yield (kg/ha)	Difference (kg/ha)	Yield (kg/ha)	Difference (kg/ha)	Yield (kg/ha)	Difference (kg/ha)	Yield (kg/ha)
1	Perla	1874	-290	1967	-197	1727	-436	2164
2	Onix	2102	-306	2302	-107	2132	-276	2408
3	Felix	1847	-497	1533	-811	1701	-643	2344
4	Carla TD	1966	-235	2029	-173	1805	-396	2201
5	Caro TD	2361	-92	2221	-232	2104	-349	2453
6	Ada TD	2272	-68	2386	46	2259	-81	2340
7	Raluca TD	1921	-544	2998	534	2827	362	2464
8	T 161	1998	-359	1993	-364	2426	68	2357
9	T 295	1790	-134	2143	219	1532	-392	1924
10	T 165	2371	101	2224	-45	2095	-174	2270
11	T 6126	1694	-640	2539	205	2126	-207	2334
12	T6117	2538	294	2284	39	1776	-469	2245
13	T 166	2164	24	2989	849	2471	331	2140

CONCLUSION

Given the climate change and the growing interest in soybean culture, monitoring the reaction of soybean varieties to fertilization becomes essential.

Atypical climatic conditions of the 2019 year may be considered less favorable for the soybean crop, for the reference area, with consequences on yield and yield components.

Plant height varied between 56 cm and 76 cm. Maximum number of pods/plant was 37 within the dose of 200 kg/ha complex fertilizer. Except for the dose of 150 kg/ha, in the other experimental variants, the plants had an average of 62 seeds/plant.

The average of the seed/plant had small variations, in this year's conditions; the grain size varied between 122 g and 162 g and the maximum yield was about 3 to/ha at the dose of 200 kg/ha complex fertilizer.

Genotypes that have responded positively to fertilization are Raluca TD variety and lines T166 respectively T6126.

The reaction of the genotypes to fertilization doses is different, so it is recommended to continue the experiment and the choice of genotypes and dose should be based on the results of the multiannual research.

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