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SOYBEAN AGRONOMIC PERFORMANCE IN RESPONSE TO MINERAL FERTILIZATION

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Abstract

Soybean is in high demand for both human and animal consumptions because of its nutritional values and potential use of biodiesel product. This crop is broadly cultivated on world arable soils with low nutritive elements. Investigation of soybean yield and related yield component traits with different types of fertilizer and different doses will help improve field management to optimize soybean production. The paper aimed to present the effects of different mineral fertilizers rates on soybean yield and yield components in 13 soybean cultivars from 3 different maturity groups: very early (000), early (00) and semi-early (0) genotypes. The results from this study reveals that positive response to mineral fertilization was mostly influenced by genotype and also maturity group (MG). A positive yield response to fertilization was observed in semi-early soybean genotypes at the 150 kg/ha rate of fertilization with an increase of production of 175 kg/ha compared to the mean of the experimental variants. Data obtained in this experiment showed that it is possible to achive high soybean yields without supplying fertilizers on soils with good nutrient content.

***Key words**: fertilization, soybean, yield.*

INTRODUCTION

Soybean is an herbaceous annual legume which was first cultivated in China as an oilseed (Akparobi, 2009), categorizes as an ancient crop plant in the agriculture history (Jandong et al., 2011) being an essential source of dietary protein, oil and minerals for humans and animals. Several challenges of soybean yield need to be overcome for soybean production to sustain the predicted global population growth rate.

The current yield increase rate is of 1.3%, but, required increase is around 2.4% for satisfaction of demands by 2050 (Ray et al., 2013; Rocha et al., 2015).

This crop is broadly cultivated on world arable soils with low nutritive elements. Application of fertilizers to soybean remains a complicated issue owing to conflicting results of previous research.

Investigation of soybean yield and related yield component traits with different fertilizers rates will help improve field management to optimize soybean production (Appiah et al., 2014).

The use of fertilizer is considered to be one of the most important factors to increase crop yield.

Fertilizers are used to supply soil and plant nutrients, maximize yield and return on investment (Rebeca, 2016). Most compound fertilizers will contain three essential elements for plant growth: NPK which stands for nitrogen (promotes leaf growth), phosphorus (root, flower, and fruit), and potassium (stem and root growth and protein analysis). Soybean nitrogen (N) requirements are met in a complex manner, as this crop is capable of utilizing both soil N (mostly in the form of nitrate) and atmospheric N (through symbiotic nitrogen fixation) (Vera et al., 2002). Sharma & Dixit (1987) reported that the effect of N fertilizer in general caused significant increase in growth and yield of soybean but highest seed yield.

Jat & Nepalia (1995) conducted a field experiment to study the effect of N and P application on productivity of soybean and reported that the yield attributing characters like pods/plant, seeds/pods and test weight increases significantly upon the application of 60 kg N/ha.

Varvel & Peterson (1992) found that soybean plants act as a sink for soil-N and effectively use N regardless of source. Therefore, N fertilization could bring benefits to soybean. Nitrogen fertilizer has had positive effects on soybean growth and yield (Brevedan et al., 1978; Sorensen and Penas, 1978). However, lack of response or even negative effects have also been observed with fertilizer-N applications to soybean (Diebert et al., 1979; Ham et al., 1975).

Phosphorous has been shown to be an essential element, and its application has been shown to be important for growth, development, and yield of soybean (Kakar et al., 2002). Phosphorus deficiency is probably one of the greatest constraints for agriculture.

Obtaining maximum yield is only possible when the plant's nutritional requirements are met and environmental stress is limited. Maintaining a fertile growing environment is a risk management strategy that produces higher yield and healthier plants that are often better suited to withstand the yieldrobbing effects of biotic and abiotic stress. A well planned soil fertility program is a management strategy that leads to profitable soybean production. A knowledge of what the nutrients do, which ones are needed, how much to apply, and when to apply them is an important part a successful management strategy (McGrath et al., 2013).

The interest in soybean has been increased, and research work on soybean has been reactivated, this was due to increasing demand for soybean as an industrial crop.

The objective of this study was to investigate the effects of different mineral fertilizers rates on soybean yield and yield components (plant height, first pod height, number of pods per plant, number of grain per plant, grain yield per plant, 1000-grain weight) in 3 different maturity groups.

MATERIALS AND METHODS

Field trials were carried out in 2019, in the experimental field of Soybean Breeding Laboratory from Agricultural Research and Development Station Turda (ARDS Turda). The experiment had an area of 57 x 17 m and was based on a subdivided parcel design with three replications, using plots of 5 m^2. The soil is characterized as faeozem vertical, loam clay texture, with pH 6.7. Two factors were analyzed in the experiment: soybean maturity group with 3 graduations (Table 1); NPK 27:13.5:0 complex fertilizer with 4 doses: unfertilized (Control), 150 kg/ha, 200 kg/ha and 250 kg/ha (Figure 1).

Table 1. Soybean varieties and their maturity groups

Maturity group (MG)	Variety
MG 000	Perla Carla TD
MG 00	Felix Onix Caro TD T 161 T 295 T 165 T 6117 T 166
MG 0	Ada TD Raluca TD T 6126

The soybean genotypes selected for the study are traditional cultivars and were bred at the ARDS Turda. At the end of the growing season 10 randomly selected plants from each plot were evaluated for: height, insertion of the basal pods, number of pods/plant, number of grain/plant, grain weight/plant, thousand kernel weight (TKW) and yield. The experimental data was analyzed in Polifact using ANOVA test and Duncan's test at the 0.05 probability level. The data matrix for correlation coefficient and linear regression was prepared and processed in Excel (Microsoft, USA).

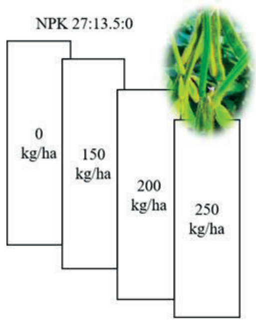


Figure 1. Mineral fertilizers rates

RESULTS AND DISCUSSIONS

Field experiment is located in area with a warm, calm climate, with moderate variations temperature along seasons and with mild rainfall.

The rainfall and average temperature of each month are indicated in Figure 2. The yield and yield components of the studied soybean genotypes were influenced by the fertilization dose and also by atypical climatic conditions of this year.

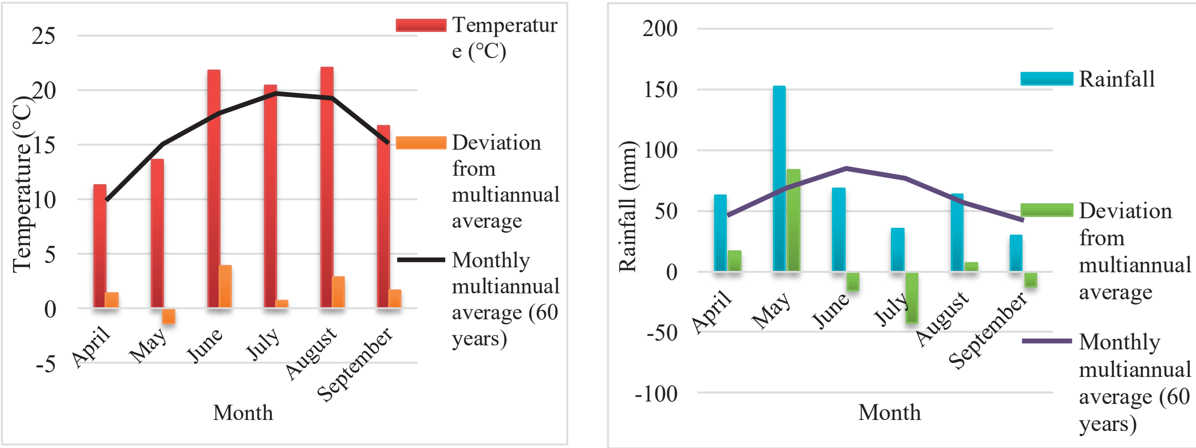


Figure 2. Climatic conditions during the soybean growing stages (Turda, 2019)

Table 2 reveals the estimates of the correlation coefficients evaluated for the seven traits of agronomic importance for soybean leading to values which expose a close correlation between number of pods/plant and number of seeds/plant (r = 0.95).

A very high positive statistical proven correlation was established (r > 0.83) between the seeds weight/plant and number of pods per plant and number of seeds per plant. These results are also supported by Siddiqui et al. (2007).

Statistically, strong negative correlation between the height insertion of first pods and number of pods/plant, number of seeds/ plant and grain weight/plant was proven. These findings are in accordance with the results obtained by Samia et al. (2012).

Table 2. Correlation coefficients of seven agronomic traits for the 13 very early, early and semi early

	Plant height (cm)	Insertion	No. of pods /plant	No. of seeds /plant	Seeds weight /plant (g)	TKW (g)	Yield (kg/ha)
Plant height (cm)	1						
Insertion	0.44	1					
No. of pods/plant	-0.09	-0.78**	1				
No. of seeds/plant	0.02	-0.65*	0.95***	1			
Seeds weight/plant (g)	-0.06	-0.80**	0.85***	0.83***	1		
TKW (g)	-0.43	-0.34	-0.18	-0.34	0.19	1	
Yield (kg/ha)	-0.01	-0.25	0.38	0.49	0.36	-0.10	1

The variance analysis of grain yield of soybean genotypes form three maturity groups fertilized with four different levels of NPK 27:13.5:0 mineral fertilizer showed that maturity group and the double interaction between maturity group and fertilizer doses, significantly affected the grain yield (Table 3). The insignificant value of F-test calculated for the factor level of fertilization, shows that in the climatic condition of 2019, in the experimental field of SCDA Turda, fertilization did not change grain yield for the studied biological material.

Table 3. Analysis of variance for grain production

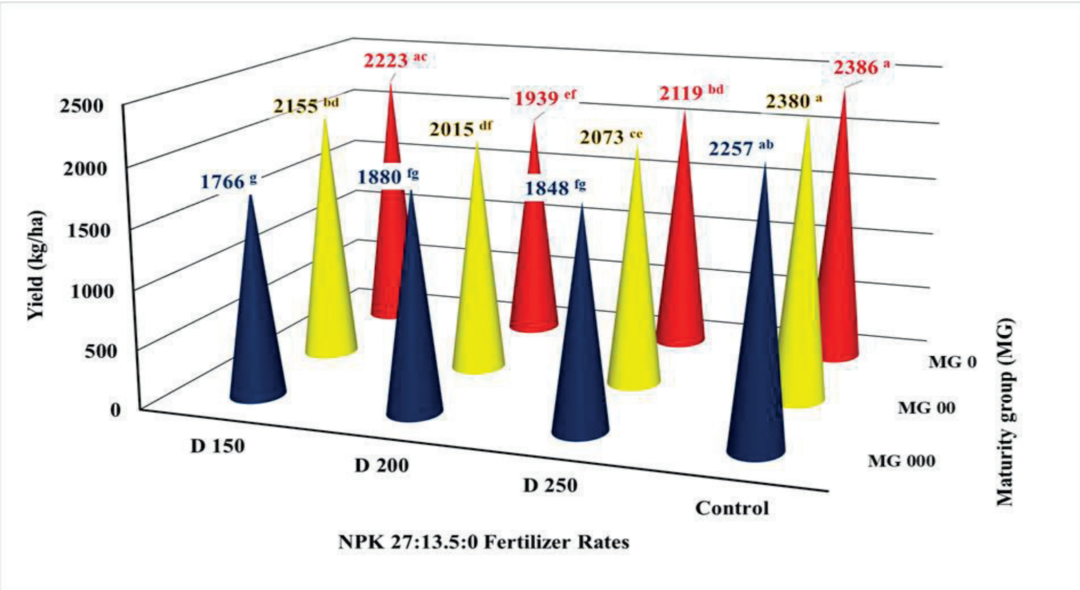
Cause of variability	SP	GL	s^2	F
D (dose)	549532.40	3	183177.50	2.88
G (maturity group)	266140.60	2	133070.30	27.75***
D x G	100376.40	6	16729.40	3.49*
R	9.37	2	9.37	
DxR	190842.80	6	63614.25	
GxR	2535.25	4	1267.62	
DxGxR	35815.08	12	5969.18	
Error D	190842.80	3	63614.25	
Error G	38350.33	8	4793.79	

Several reports worldwide show inconsistent responses to fertilization application in soybean grain yield. According to Duncan's test, the experiment conducted at SCDA Turda in 2019, reveals that soybean grain yield from each maturity group was differently affected by the applied levels of fertilizer. In general, the control (without fertilization) produced higher grain yields: 2386 kg/ha (MG 0), 2380 kg/ha (MG 00) and 2257 kg/ha (MG 000). While increased yield due to 150 kg/ha level of mineral fertilization was observed at 00 maturity group and 0 maturity group, yield decreases due to same dose was observed at very early soybean maturity group (MG 000) (Figure 3).

The fertilization dose influenced the yield level differently.

The best results being recorded by semi-early maturity group at the 150 kg/ha and 250 kg/ha NPK 27:13.5:0 complex fertilizer with an increase of production of 175 kg/ha respectively 106 kg/ha compared to the mean of the experimental variants (Table 4).

A model proposed by Eberhart and Russell (1966) was used to analyse the grain yield obtained in soybean genotypes with different growing season under four levels of mineral fertilization. This regression method reveals the magnitude of maturity groups and fertilization level interactions in yield obtained by different maturity groups of soybean crop (Figure 4).



Figue 3. Showing Duncan Multiple Range Test (DMRT) of four different levels of fertilization using three soybean maturity groups

Environmental indices indicated that most favourable for the yield was the environment without fertilization (control). Whereas environment with 200 kg/ha level of fertilization was unfavourable for production obtained in early and semi-early soybean genotypes.

The application of NPK fertilizer was also associated with small increases in yield in other studies (Cafaro et al., 2017; Farid, 2013).

Table 4. The influence of maturity group x fertilizer doses on soybean grain yield (Turda, 2019)

Doses	Maturity group	Yield (kg/ha)	%	Difference	Significance
D1 150 kg/ha	Average group	2048	100	0	Mt.
	GM 000	1766	86	-282	00
	GM 00	2155	105	107	-
	GM 0	2235	109	175	*
D2 200 kg/ha	Average group	1945	100	0	Mt.
	GM 000	1881	97	-64	-
	GM 00	2015	104	70	-
	GM 0	1939	100	-6	-
D3 250/ha	Average group	2014	100	0	Mt.
	GM 000	1849	92	-165	0
	GM 00	2073	103	59	-
	GM 0	2120	105	106	-
D4 Control	Average group	2341	100	0	Mt.
	GM 000	2257	96	-83	-
	GM 00	2380	102	39	-
	GM 0	2386	102	45	-

Figure 5 shows the genotypes that responded the best to fertilization. Raluca TD variety and the T-166 line, at doses of 200 kg/ha NPK 27: 13.5:0 complex fertilizer, registered superior productions compared to the control variant.

In summary, our results showed that it is possible to obtain high soybean yields without supplying fertilizer. Similar results were obtained by Aratani et al. (2008), Kaschuk et al. (2016) and Korber et al. (2017).

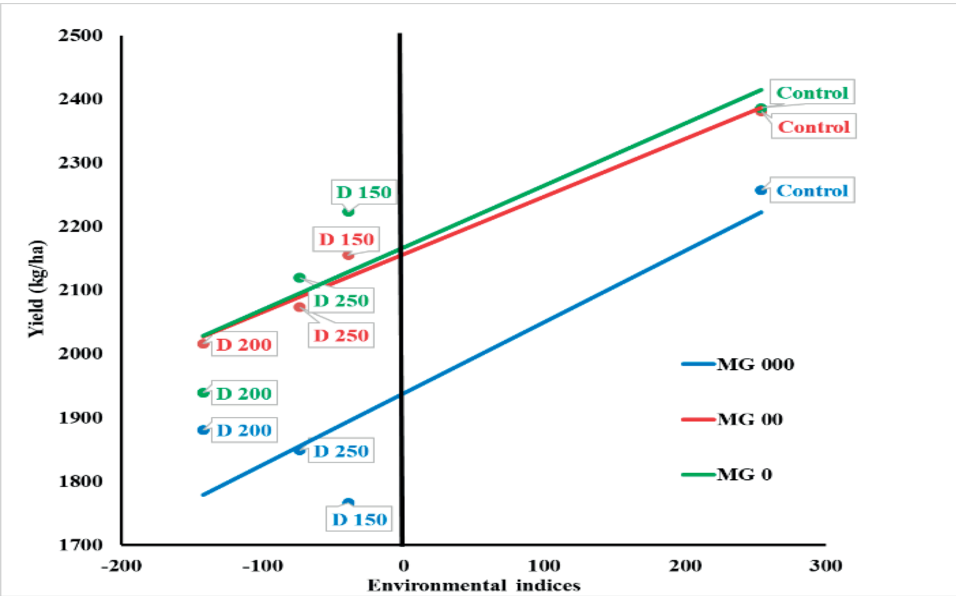


Figure 4. The influence of maturity groups and fertilization level interactions in soybean yield using the method purposed by Eberhart and Russell (1966)

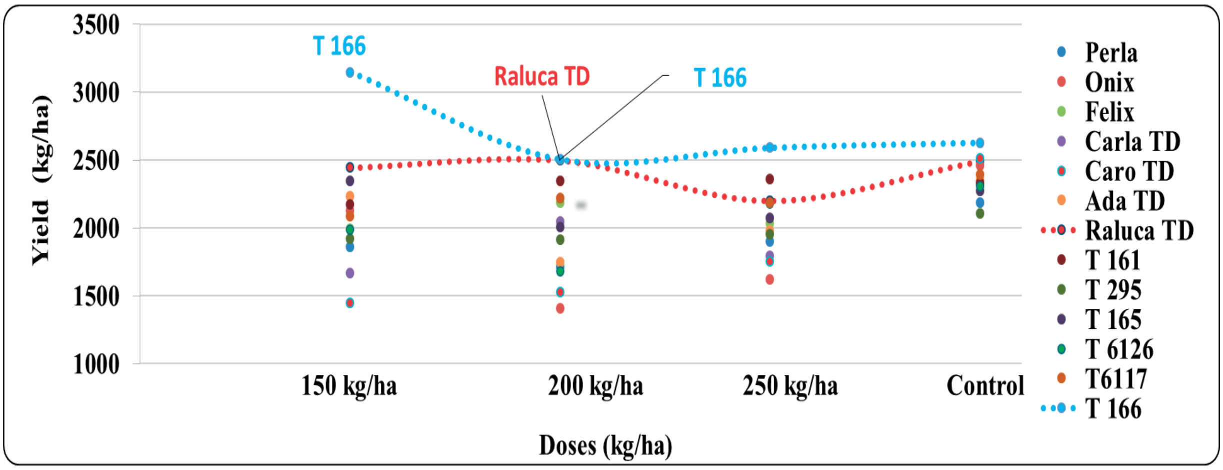


Figure 5. Genotype response to fertilization

CONCLUSIONS

Crop yield response to fertilization differed from each maturity group to another. The three different levels of complex mineral fertilization compared with a control (0) reveals that, in the climatic condition of 2019, in the experiment conducted at ARDS Turda, yield decreased when nutritional support was offered. Yield and yield components varied differently depending on MG and genotype, highlighting commercial varieties and perspective lines with good behaviour regarding mineral fertilization.
A positive yield response to fertilization was observed in semi-early soybean genotypes at the 150 kg/ha rate of fertilization with an increase of production of 175 kg/ha compared to the mean of the experimental variants.
Raluca TD variety and T-166 line fertilized with 150 kg/ha of NPK 27:13.5:0 recorded on average, positive grain yields compared to control.
The inconsistent responses of soybean to fertilization application has created the need for more information concerning how yield of this crop can be improved. Responses obtained in this experiment suggest that soybean producers could increase their profits by not applying fertilizers on soils with good nutrient content.

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