THE REACTION OF SOYBEAN TO STRESS FACTORS

REAKCIA SÓJE FAZUĽOVEJ NA STRESOVÉ FAKTORY

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Abstract: *Field experiment was established in University farming business in Oponice (48° 28´N, 18° 9´E) to evaluate the influence of abiotic and biotic factors on formation of the yield components and the yield of soybean in 2004 – 2006. The number of plants per m^2, number of pods per plant, number of seeds per pod, thousand of kernels weight and grain yield by variety Korada and OAC Vision were tested. Variants of fertilization: (1) unfertilized treatment, (2) LAV 27% (40 kg ha^{-1} nitrogen) in the growth stage of first pair of true leaves, (3) Humix komplet (rate 8 l ha $^{-1}$) applied twice in the stage of first pair of true leaves and before flowering. The yield of seeds was statistically significantly influenced with year and fertilization, but yield was not significantly influenced by studied varieties. Higher yield was reached by the variety Korada (4.24 t ha^{-1}) than by the variety OAC Vision (3.87 t ha^{-1}). The yield was positively influenced by application of Humix komplet fertilizer.*

Abstrakt: *V poľných podmienkach sme skúmali vplyv biotických a abiotických faktorov na tvorbu úrody a úrodotvorných prvkov sóje fazuľovej. Pokus prebiehal na hnedozemi v rokoch 2004-2006 na experimentálnej ploche SPU v Oponiciach (48° 28´s.š.,18° 9´ v.d.). Bol zisťovaný počet rastlín na m^2, počet strukov na jednej rastline, počet semien v struku, hmotnosť tisícich semien a úroda semien pre odrody Korada a OAC Vision. Varianty hnojenia: (1) nehnojený variant, (2) LAV 27% (40 kg ha^{-1} dusíka) v rastovom štádiu prvého páru pravých listov, Humix komplet (dávka 8 l ha^{-1}) aplikovaný dvakrát – a to v štádiu prvého páru pravých listov a pred kvitnutím. Úroda semien bola štatisticky preukazne ovplyvnená pestovateľským ročníkom, a hnojením. Skúmané odrody neovplyvnili úrodu preukazne. Vyššia úroda bola dosiahnutá odrodou Korada (4,24 t ha^{-1}) ako odrodou OAC Vision (3,87 t ha^{-1}). Aplikácia hnojiva Humix komplet priaznivo ovplyvnila výšku úrody.*

Key words: *soybean, fertilization, variety, yield, yield components*
Kľúčové slová: *sója fazuľová, hnojenie, odroda, úroda, úrodotvorné prvky*

INTRODUCTION

Soybeans are the most important grain legume in the world, with an average of 182 Mt of seeds produced annually between 2000 and 2004, mainly in the USA (about 43%), and in Central and South America (42%). The EU25 produces only 0.5% of the world soybeans production (www.grainlegumes.com). Two-thirds of the EU requirements in proteins for feed uses are imported, including large amounts of soybean meal. Grain legumes represent 20% of the European animal diet (including soybean meal), but only 4% of the European arable land (CRÉPON et al. 2004).

Sustainable agriculture is characterised by the introduction of more diversity in crops, and it should ensure fertility of soil and nitrogen balance (Macák 2006). Introduction of grain legumes in crop rotation may be beneficial for farmers. These crops have low input requirement and enhance diversification in crop rotation and productivity of crop rotation (PAHL, 2001; HRONEC et al. 2007; KOVÁČ and MACÁK 2007a, b).

Yield of soybean and peas is highly unstable because of frequent water stress and high temperature occurring during the period of grain formation. Several genotypes are generally less sensitive to these stresses because their grain formation period occurs earlier (JEUFFROY and MESSÉAN 2004; SMATANA et al. 2006). Most environmental stresses reduce soybean yield through reducing growth rate from emergence to start of seed filling and seed number per area

(Board et al. 1992). The stress factor of humidity balance of soil can be influenced by tillage (Kováč et al. 2005).

The objective of the study presented here was to ascertain the influence of biotic and abiotic factors on yield and yield components of selected soybean varieties.

MATERIALS AND METHOD

A field trial of soybean growing was conducted over the period 2004-2006 in University farming business in Oponice (E 18°9', N 48°28'), altitude 168 m above sea level. The location has a continental climate with an average annual temperature of 9.5°C and an average annual precipitation of 607 mm. The main soil type is a Haplic Luvisol on carbonate loess with loamy to clay-loamy texture. Soil was cultivated using conventional system. Winter wheat was used as forecrop for soybean growing.

The experiment was a split-plot designed with a three replicates, when the variety (Korada, and OAC Vision) was designed to be the main plot factor and the variants of fertilization was designed to be the subplot factor. The acreage of subplots was $14 m^2$. Just before the harvest, plant samples were collected for mechanical analyses. Canadian variety OAC Vision has for 10 days shorter vegetation than Korada. The sowing pattern was 0.6 million of fertile seeds/ha, into the depth of 0.05 m, row space was 0.125 m. Used seeds were inoculated by HiStick.

Sowing dates: 14 May 2004, 3 May 2005, 27 April 2006.

Dates of harvest: 8 October 2004, 10 October 2005, 20 October 2006.

Variants of treatment:

1) Control – without use of fertiliser

2) LAV 27% (40 kg ha^{-1} of nitrogen in the growth phase of first pair of true leaves formation and before the flowering, BBCH 101),

3) Humix komplet (8 l ha^{-1} applied twice in the growth phase of first pair of true leaves formation and before the flowering, BBCH 101, BBCH 501).

RESULTS AND DISCUSSION

Soybean was grown on soil with neutral reaction, and middle humus content. Soil characteristics are in table 1.

Table 1

The agrochemical analysis of soil before sowing to the depth of 0.3m

Year	pH	Humus	N_{an}	N- NH_4	N- NO_3	P	K	Mg
		(g kg^{-1})	(mg kg^{-1})					
2004	7.19	26.8	37.71	11.37	26.34	82.0	323.0	200.0
2005	7.06	25.5	51.88	14.05	37.83	89.0	320.6	230.0
2006	7.13	32.0	25.94	10.70	15.24	92.0	323.0	430.0

Nowadays are observed distinctive differences in the amount of rainfall and its distribution during growing season. This negatively influences the yield and growth of plants.

Studied soybean was under stress events of great variability of temperature and precipitation (Table 2).

Stress events influence whole plant organism. Water stress influences mainly prolongation of plant. The most critical role has the extent of water stress (Kostrej et al. 1998). Soybean plants are sensitive also to extensive moisture and waterlogging. Long lasting precipitation and higher values of average temperatures prolong the vegetation (Javor, Surovčík et al. 2001). In average, the values of transpiration coefficient for legumes are 600-

1000 g of water per production 1 g of dry matter (Lahola et al. 1990). Dryness and high temperatures, similarly as cold and extent precipitation can cause falling of flowers. Flowering dependently on soybean variety and growing conditions lasts three weeks (Fábry et al. 1990). The growth phases recorded during the vegetation are written in table 3. Too early pods formation after flowering was recorded in year 2006.

Table 2

Weather conditions in years 2004 – 2006

Year	Month												Sum
	1	2	3	4	5	6	7	8	9	10	11	12	
Precipitation (mm)													
2004	55.9	31.1	52.8	36.3	36.9	93.8	33.8	19.4	36.7	45.3	45.7	26.8	514.5
2005	36.4	58.3	3.4	78.7	60.9	31.5	59.0	94.5	47.1	12.1	43.2	113.2	638.3
2006	57.4	39.0	35.2	48.1	95.6	63.9	23.7	84.0	12.7	15.3	24.4	7.8	507.1
Temperature (°C)													Average
2004	-3.3	1.6	4.7	11.7	14.3	17.9	20.0	20.1	14.7	11.7	5.5	0.8	9.9
2005	-0.1	-2.7	2.7	11.0	15.2	18.0	20.7	19.1	16.3	10.5	4.1	0.4	9.6
2006	-1.7	0.5	4.7	10.1	14.8	18.3	19.7	19.2	15.4	10.1	4.9	0.5	9.7

Table 3

The course of soybean growth phases

Beginning of growth phase	Year/Date		
	2004	2005	2006
Emergence	31 May	12 May	10 May
Flowering	25 July	13 July	12 July
Pods formation	13 August	10 August	23 July
Full maturity	5 October	10 October	20 October

Yield components were strongly influenced with plant growth conditions. The number of plants during studied years at both soybean varieties was nearly equilibrate, but the number of pods per plant differed dependently on used variety, fertilizer and on year (Table 4).

Higher number of pods per plant was recorded for variety OAC Vision in years 2004 and 2005, and in year 2006 for variety Korada. Varieties responded differently on fertilization treatment. The number of pods for variety Korada distinctly increased after application of Humix komplet during years 2004 and 2005 and for OAC Vision after application of LAV. On the contrary, both varieties responded opposite on used fertiliser in year 2006 (Table 4).

Table 4

Yield forming components of soybean in 2004 – 2006

Variety	Treatments of fertilization	Number of plants per m^2			Number of pods per plant		
		Year					
		2004	2005	2006	2004	2005	2006
Korada	Control	58	58	56	17.97	24.62	14.50
	LAV	56	52	57	24.07	19.85	21.10
	Humix	50	59	56	31.12	29.69	20.80
	Average	**58**	**56**	**56**	**24.39**	**22.56**	**18.73**
OAC Vision	Control	40	58	57	24.75	24.28	16.00
	LAV	52	54	58	33.23	25.70	13.50
	Humix	58	55	58	29.66	23.85	19.50
	Average	**50**	**55**	**57**	**29.21**	**24.31**	**17.13**

The number of seeds per pod was influenced by variety, fertilization treatment and weather conditions during years (Table 5). Both varieties had the highest number of seeds per pod in LAV treatment. Beside year 2004, higher number of seeds per pod was ascertained in variety Korada. According to Egli (2005), the number of pods and seeds per area causes great fluctuation of seeds yield. The founding of Egli (2005) was confirmed also by results obtained in our experiment, where the yield of seeds of variety OAC Vision was lower than Korada (Table 4, 6).

Table 5

Yield forming components of soybean in 2004 – 2006

Variety	Treatments of fertilization	Number of seeds per pod			Thousand of kernels weight (g)		
		Year					
		2004	2005	2006	2004	2005	2006
Korada	Control	1.97	2.23	1.79	150.57	179.65	181.33
	LAV	2.22	2.37	2.32	165.40	180.40	194.86
	Humix	2.30	2.27	2.28	153.60	185.83	178.34
	Average	**2.16**	**2.29**	**2.13**	**156.52**	**181.96**	**184.84**
OAC Vision	Control	2.04	1.46	1.99	160.80	165.97	155.76
	LAV	2.67	2.07	2.15	168.77	176.87	169.43
	Humix	2.29	1.77	2.15	172.20	165.20	156.82
	Average	**2.33**	**1.77**	**2.09**	**167.26**	**169.35**	**160.67**

Thousand of kernels weight (TKW) is characteristic for each variety and it is changeable due to weather conditions. The highest values of TKW were reached for variety Korada in year 2006, and for variety OAC Vision in year 2005. Considering used fertiliser, TKW was positively influenced by applied LAV (Table 5).

The yield of seeds considerably depended on growing conditions. The highest yield was reached in year 2005, when the humidity and temperature were sufficient. Similar results were reached by Egli and Wardlaw (1980) who found that yield of soybean was significantly lower due to low temperature during initial stage of seeds filling. They concluded that seed filling of soybean was fastened due to increased day temperatures (from 18˚ – to 27˚ C) and night temperatures (from 13˚ – to 22˚ C). We suppose that decrease of yield in year 2006 was caused by moisture deficiency during pods and seeds formation. In our study, during three years, higher average yield was reached by variety Korada (Table 6). Variety OAC Vision responded more sensitively on unfavourable weather conditions. Both used fertilisers influenced yield of soybean.

Table 6

Yield of seeds (t ha^{-1}) in years 2004 – 2006

Variety	Variant of fertilization	Year			Average
		2004	2005	2006	
		Yield of seeds (t ha^{-1})			
Korada	Control	3.58	4.74	3.39	3.90
	LAV	4.41	4.36	4.18	4.32
	Humix	4.95	4.95	3.64	4.51
	Average	**4.31**	**4.68**	**3.74**	**4.24**
OAC Vision	Control	3.48	3.35	2.60	3.14
	LAV	4.61	4.45	3.24	4.10
	Humix	4.88	4.37	3.86	4.37
	Average	**4.32**	**4.06**	**3.23**	**3.87**

On the base of statistical evaluation we can conclude, that yield of soybean was statistically significantly influenced by fertilization treatment and weather conditions during growing years. The yield was not significantly influenced by studied varieties (Table 7).

Table 7

The influence of selected factors on soybean yield (multifactorial analysis of variance)

Source of variability	f	Seeds yield	P<0.05	P<0.01
Year	2		0.507	0.676
2004		4.31 b		
2005		4.37 b		
2006		3.48 a		
Variety	1		0.456	0.608
Korada		4.24 a		
OAC Vision		3.87 a		
Fertilization	2		0.513	0.781
Control		3.52 a		
LAV		4.21 b		
Humix komplet		4.41 b		

Means followed by the same letter are not significantly different at the P<0.05 probability level

CONCLUSIONS

Results obtained in this study showed that soybean yield components were strongly influenced by abiotic stress events during years 2004-2006. Equable temperature and rainfall are very important during whole vegetation.

The yield of seeds was statistically significantly influenced by weather conditions during years and by used fertiliser. Interactions year with fertilization and variety with fertilization were also significant. The interaction year with variety was not significant. According to the results obtained in our study we conclude, that variety Korada with longer vegetation stage was sufficient for growing in studied soil-climatic conditions, since its yield was higher than in variety OAC Vision. The application of Humix komplet (in two terms during vegetation) influenced yield of soybean more positively than application of LAV.

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