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Agri-environmental impacts on yield formation of soybean crop

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Abstract: One of the most important leguminous crops that contributes to human alimentation and animal feed is soybean. The grain of the crop with its high nutritional value is an essential component for the food and feed industries worldwide. Grain yield of field crops highly depend on the agri-environmental conditions they are exposed to. The most influential factors are plant nutrition, plant protection and the influence of environmental, especially of biotic stresses. At the Department of Agronomy, Hungarian University of Agriculture and Life Sciences some agri-environmental impacts on grain yield of soybean crop have been studied in a replicated field trial. N application and various means of weed control was studied, and samples of grain yield were evaluated in accordance with the treatments. Apart from agronomic applications continuous observation and recording of game damages of the crop was implemented. The results obtained suggest, that N topdressing had positive, but no significant effect on the amount of grain yield, however the means of weed control resulted in an almost twofold yield improvement compared to the control. Rabbit bite damages were monitored during yield formation. The extent of game damage was consequent but not significant regarding crop yield.
Keywords: Soybean, grain yield, nitrogen, weed control, game damage

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Introduction

Soybean (*Glycine max* L. Merr) is one of the most valuable leguminous crops grown worldwide for food and feed production due to its high nutritional properties. Soybean is a major protein source but has a considerable lipid content as well. The role of the crop is essential in human alimentation and in the production of animal feedstuffs. Yield and nutritional composition of soybean rely on environmental conditions, type of variety used, and agronomic practices including nutrient and weed management. Inefficient nutrient and weed management may cause a reduction in crop yield and nutritional value (Rotundo and Westgate, 2009). From among environmental factors abiotic and biotic stresses may profoundly influence crop performance and so yield formation (Miransari, 2016).

One of the important nutrients for soybean is nitrogen. Nitrogen (N) is vital for many processes in plants like chlorophyll and protein synthesis. The two main sources of N for soybean are biologically fixed N_2 and mineral N fertilizer (Salvagiotti et al., 2008). N fertilization must be provided if a deficiency in fixed N_2 occurs (Miransari, 2016). Many previous studies have been conducted on the N requirement for different soybean varieties in various areas on yield and seed composition. Wood et al., (1993) recorded a positive effect on grain yields of soybean occurred for treatment that used N fertilizer in different locations. The results of this work suggest that N fertilizer application is the best in a rising proposition. Taylor et al. (2005) reported the same finding that N application increased seed yield regardless of planting date, cultivar, or crop site.

Weed control is a very important manage-

Table 1: Experimental treatments and their abbreviations

Treatments	
N1	0 N
N2	200 kg N/ha
W1	Weedy
W2	Hand weeded
W3	Mechanically weeded

ment practice in soybean cultivation. Soybean has been shown to be sensitive to weed interference, which is of great importance during the development of the crop. Weeds can compete for environmental resources and release allelopathic substances (Ariuanaa et al. 2016). Weed monitoring and weed control management are influential factors in field crop production, especially in relation with yield formation (Kassai et al. 2007; Kende et al. 2020).

Soybean crop is frequently exposed to game damages. Some authors have stated however, that from among game damages rabbit bite causes minor losses only (De Calesta and Schwendeman,1978). MacGowan et al (2007) found rabbits very effective in causing yield depression especially at the edges of crop fields. The magnitude of crop yield losses could be highly correlated with the rabbit population in a Hungarian experiment.

Materials and Methods

Open-field experiment

A field experiment was carried out at the experimental site of the MATE Department of Agronomy in Gödöllő, Hungary (47°46′N,19°21′E, 242 m above sea level), on a sandy loam, brown forest soil (Chromic Luvisol) during the 2020 growing season. The experimental site is located in a hilly area with a close to average climatic zone of the country. The 2020 year was exposed to slightly higher precipitation. The annual average precipitation of Hungary was 615 mm in 2020, while the respective value of Gödöllő was 694 mm. 12.8% higher than that. The actual crop years temperature means did not differ from the average.

A soybean variety used in the trial was ES Gladiator. It was planted with a scheduled plant density of 540 000 viable germs on a hectare. The experimental design was a 2×3 factorial arranged in a split plot design with four replications. In this experimental design, nitrogen fertilizer was assigned to the main plot and weed canopy to the sub-plot (Table 1.)

The experimental plot was cleared, ploughed, rotor-tilled and seedbed was prepared before planting. The basic fertilizer treatments were applied to the experimental field in accordance with the usual practices (Birkás et al 2004) following soil analysis data. A preemergent weed control was used to eliminate weeds by Targa Super EC. Soybean seeds were planted at a depth of 3 cm. After eleven weeks of planting, the plants were supplied with nutrition according to the treatments which were no nutrient supply (control) and supplied with 200 kg N/ha. Weeds were controlled every two weeks according to the weed canopy treatments which were weedy, hand weeded and mechanically weeded. Plant development, plant density, rabbit bite damages were monitored a recorded with phenological observations. The plants were then harvested manually. Planting and harvest dates were respectively

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Table 2: The decline in plant density during the vegetation period, % by observation date

TRT	22.07.20	12.08.20	24.08.20	04.09.20	10.09.20	17.09.20	07.10.20
N1W1	100	100	100	96	96	93	91
N1W2	100	100	100	100	100	100	93
N1W3	100	100	100	95	95	95	79*
N2W1	100	100	100	100	100	100	100
N2W2	100	100	100	96	93	93	93
N2W3	100	100	100	95	95	95	87*
Mean	100	100	100	97	96	96	91

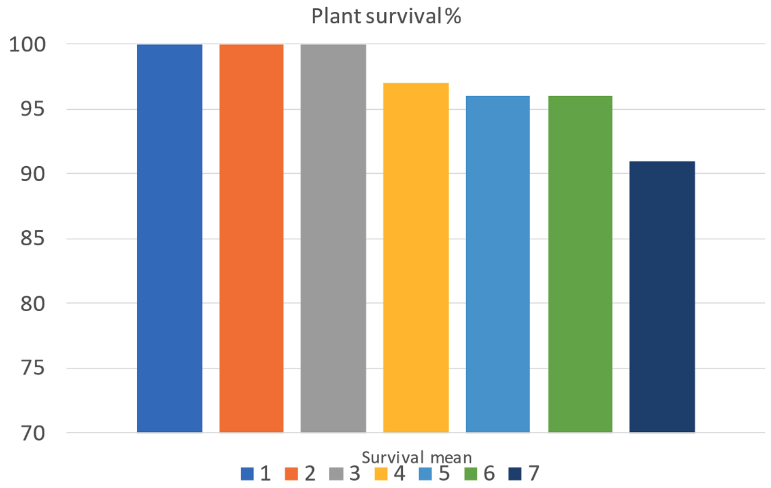

Figure 1: Plant survival average of the trial, %

on the 25th May and 7th October.

At harvest, all the plants in a sampling area of 1 row meter in each plot were harvested to calculate grain yield. Pods from harvested plants were oven-dried immediately at temperature of 50 °C for two days for grain yield determination. The dried pods then were hand-threshed and the grains were weighed to calculate grain yield per plot. All seed samples were analysed at the laboratory of the MATE Institute of Agronomy.

Statistically, a one-way between treatments ANOVA was conducted to compare the effect of the different nutrition supply and weed canopy. ANOVA was performed at $p = 0.05$ level of significance to determine whether the treatments were different. Post hoc comparisons using the least significant difference (LSD) test was made at $p < 0.05$. For the statistical evaluation of our results, we used the Explore and ANOVA modules of the IBM SPSS V.23 software.

Results and discussion

The experimental plots were planted with a scheduled average of 7 viable seeds/row m. The first plant number count has recorded 6.375 plants/plot in average. This plant density was gradually reduced to 5.801 plants/plot, mainly due to rabbit bite damages. Altogether the plant survival was 91%

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Table 3: Pod number count by time and by experimental treatments

TRT	24.08.20	04.09.20	10.09.20	17.09.20	07.10.20
N1W1	33	36	36	39	39
N1W2	47	49	51	57	57
N1W3	31	31	28	30	30
N2W1	39	40	41	40	40
N2W2	51	56	58	59	59
N2W3	32	36	40	43	47

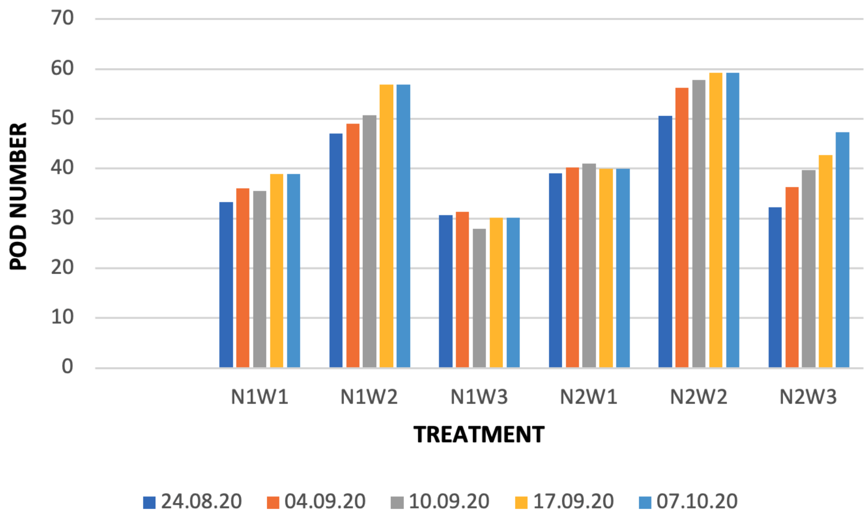

Figure 2: The increment of pod numbers by treatments

Table 4: 1000 grain weight, g

	1000 grain weight (g)	
TRT	Fresh	Dry
N1W1	144	112
N1W2	135	103
N1W3	128	98
N2W1	156	120
N2W2	160	123
N2W3	153	106

in average (Table 2).

The survival of plants was the best in the cases of control and hand weeded plots for both nutritional treatments. The decline started by the end of August and the first rabbit damages have been recorded from September. From that date the survival gradually decreased until harvest. Significant differences were found only in the case of mechanically weeded applications and by the

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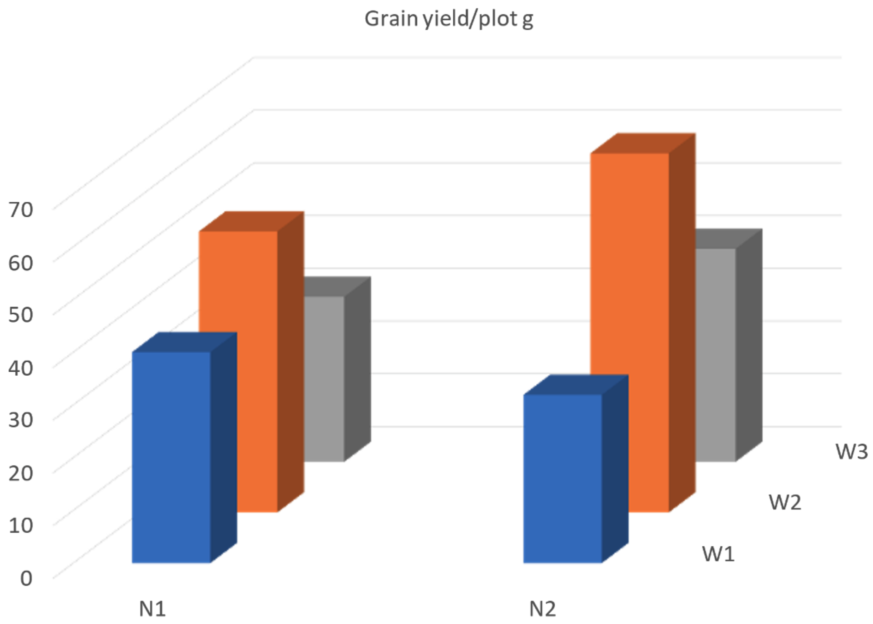

Figure 3: Total grain yields, g

last observation date (Fig 1).

Pod number performance of plots were rather diverse in accordance with the vegetation period and the treatments applied (Table 3). In general, it can be stated that the highest pod numbers were developed by plants of hand weeded plots. Nitrogen applications did not have a direct effect on pod number. Number of pods increased with time in most applications, however this consequent increment within treatment was not significant as it is demonstrated by Fig 2.

The harvested grain yield has shown detectable differences between applications. There were no significant differences between the yields harvested from N application plots, however significant differences were recorded due to weed control applications. Grain was less influenced by the 1000 grain weight of the yield samples (Table 4).

The total grain yields are presented in Fig 3. There was no statistically significant difference between nutrition groups according to one-way ANOVA at the $p<0.05$ level. However, there was a statistically significant difference between weed canopy groups for grain yield. Hand weeded versions had an almost twofold yield improving effect in the case of high N applications, and some 1.5 improvement in the case of no N treatments.

Conclusion

Agri-environmental impacts on grain yield of ES Gladiator soybean variety have been studied in a replicated field trial at the Gödöllő experimental field, Hungary. N application and various means of weed control was studied, and samples of grain yield were evaluated in accordance with the treatments. The results obtained suggest, that N topdressing had positive, but no significant effect on grain yield, while the means of weed control resulted in an almost twofold yield improvement compared to the control. Rabbit bite damages were recorded during yield formation phenophases. The extent of game damage was consequent but not significant regarding crop yield.

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