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Effects of different ecological environments on phenological and cultural parameters of organically cultivated soybean (*Glycine max* (L.) Merril.)

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This paper summarizes research results on organic soya production conducted at three ÖMKi on-farm sites in 2014 in Hungary. Trial sites were located in West-Transdanubia (Tornyiszentmiklós) and the East-Hungarian Plain (Földes and Hajdúböszörmény). Objective of the research was to determine the specific varieties of soybean which favour these areas. Five varieties were tested (Prestopro from the early, Growpro, Hipro, Royalpro and Pannónia Kincse from the medium maturity group). Pannónia Kincse is a Hungarian breed that is dominantly used in East-Hungary. The other varieties have been bred in the USA. The test farms used their usual agronomical practices (tab. 1). During the trial period we recorded weather conditions (daily precipitation, max-min. temperature), and the phenological parameters of plants: average number the pods per plant, average number of seed per pod, average number of branches per plant, and average plant heights. Yield and oil protein content of seeds were measured after harvest. In August and September extreme weather conditions occurred in West-Transdanubia (tab. 2); plants were damaged by flooding on the test site. On the other areas typical droughty periods occurred in the beginning of summer. At Hajdúböszörmény there was no possibility of interrow-cultivation because of the narrow row spacing (35 cm). The weed-coverage at this site was above 50 % at harvest period. At Tornyiszentmiklós the node number was the lowest despite plant height, and yield was also less than at the other sites. Relying on these data (tab. 3) we can state that there were considerable differences between the average yields of the research areas and the yields of the tested varieties. The differences of protein content were less remarkable. The yield of Prestopro was lowest among tested varieties on East Hungarian sites. Most favourable variety in 2014 was Pannónia Kincse regarding both yield (0.7-1.6 t ha^{-1}) and protein content (average of variety: 35,6 %).

Keywords: soybean, varieties, organic production, yield, protein content

1 Introduction

In recent years different protein sources have gained importance. The exploitation of available genetic capacities – as a form of renewable resource – of protein plants is a fundamental method for increasing their yields. To do this we must harmonize the biological needs and ecological attributes of the given varieties with the circumstances of their cultivation.

Today, soybean is one of the most important plant sources of protein and vegetable fats (Bódis and Kralovánszky 1988). In the past decade the crop area in Hungary devoted to soybeans has increased to almost 40,000 hectares. In 2012 organic cultivation accounted for 491 hectares. Organic soy production for feedstock in organic animal husbandry is needed in Hungary as well as the rest of the EU. Current production in Hungary is just 10 % of the market demand, the 2.0-2.2 t ha^{-1} average yield appears to be static for the time being (Kurnik and Szabó, 1987). The main reason for this appears to be related to variable weather conditions, most Hungarian soy production occurs under irrigated conditions. Unpredictable weather in Hungary (regional variability – West part of land 800 mm, East 450 mm precipitation per year, annual variability (average precipitation per year 450-1000 mm, often long droughty period in flowering time of soybean) tests the genetic makeup of different varieties showing high amounts of variation under stressed conditions. Soy is an excellent

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preparatory crop. It improves soil structure and leaves considerable nitrogen in the soil from residues for the following crop (Walter and Samuel 1980; Marcus-Wyner and Rain1983; Németh 1995). Soy is also a reliable crop, tolerant of temporary water excess and slightly tolerant to cold post establishment, but the symbiotic bacterium (*Bradyrhizobium japonicum*) needs sufficient soil temperature to colonize root nodules (Zimmer et al, 2012). The grain of present-day varieties contains on average 40-43 % protein and 21 % oil by dry matter weight. For this research, we analysed the effects of different ecological environments on yield potential factors of soybeans cultivated in Hungary.

2 Material and Methods

Observations were carried out at three organic soybean farms. Two research sites were in the Eastern part of Hungary (Földes, Hajdúböszörmény) and one research site was located in West-Hungary (Tornyiszentmiklós). The soils of the research sites have different characteristics with relatively deep but poorly drained soils in the East, and shallow soils with less water retention capacity in the West.

Growing conditions also varied among the different research sites (sowing time, sowing distance, row cultivation) (Table 1). Our on-farm research is intended to sample results from regular farm operations, so farmers were allowed to practice their standard production methods, with only the varieties being changed for each test plot. The 5 soy varieties tested were of the early Prestopro and medium-ripening Growpro, Hipro, Pannónia Kincse, and Royalpro. Each test was conducted on 0.25-0.5 ha per variety in stripe design. Sowing date was to the middle of May with soil temperature between10-12 °C.

Table 1 Growing system parameters at the research sites (2014)

Research site	Földes	Tornyiszentmiklós	Hajdúböszörmény
Humus content of soil (%)	2.2	1.9	3.5
Previous crop	maize	maize	maize
Row spacing (cm)	76.2	50	35
Number of plants	500	600	500

3 Results

In 2014 in West-Hungary we had a long and unusually wet period between August and September (333 mm at Tornyiszentmiklós). This value is multiple of the average precipitation of the region (Table 2). Consequently, the trial area was periodically covered with water, and weeds caused a considerable problem. At the other areas typical summer drought period took place. In Hajdúböszörmény there was no possibility of interrow-cultivation because of the narrow row spacing (35 cm). The weed-coverage at this site was above 50 % in the harvest period. In Földes, located on the South-East Great Plain, in June it was possible to conduct mechanical cultivation three times (row cultivator and hoeing in row), and the weed-coverage remained below 15 %. The wild-damaged caused here an increased branching of stems. Here plants had the highest number of divergence (average 4/plant), number of pods (average 50 per plant), and average yield (1.4 t ha^{-1}).

Results confirm that ecological conditions can fundamentally influence the yield factors of soybean. The greatest difference was recorded in the number of divergence/plant (mean of 2 vs. 4) and the number of pods per plant (mean of 25 vs. 50 pods per plant). Little difference was observed between the average protein content of varieties (33.1-33.3). The highest protein content (36.4 % of Pannónia Kincse) was measured at Tornyiszentmiklós, however also this value is much below the average protein content of soybean varieties in recent years in Hungarian.

Table 2 Precipitation (mm) at the research areas (2014)

Research area	IV.	V.	VI.	VII.	VIII.	IX.	X.	IV-X.
Földes	53	65	17,5	115	50	78	60	439
Tornyiszentmiklós	22	63	88	76	*133*	*203*	85	670
Hajdúböszörmény	24	55	33	121	48	69	78	429

Data of plant growth, number of nodes/plant and pods/plant can be seen in Table 3.

Table 3 Phenological parameters of soybean *(Glycine max (L.) Merril)* varieties (2014)

Variety	Plant high (cm)	Divergence Nr.	Nodes/ plant Nr.	Pods/ plant Nr.	Seed/ pods Nr.	Thousand seed weight	Oil %	Protein %	Yield t/ha
Földes									
Growpro	102	2,5	16	59	2,8	232	19,8	32,6	1,3
Hípro	90	4	15	41	2,4	162	19,0	33,8	1,8
Pannónia K.	90	4	14	44	2,7	172	19,1	34,2	1,6
Prestopro	75	3	16	71	2,8	153	19,2	33,3	1,2
Royalpro	90	4	18	34	2,5	218	21,4	31,4	1,3
Mean	**89**	**4**	**16**	**50**	**2,6**	**187**	**19,7**	**33,1**	**1,4**
STDEV	*9,58*	*0,71*	*1,48*	*15,00*	*0,18*	*54,5*	*0,82*	*0,90*	*0,20*
Tornyiszentmiklós									
Growpro	90	1	9	25	2,4	190	20,2	32,2	0,5
Hípro	85	4	12	26	2,2	170	20	31,4	0,4
Pannónia K.	100	1	13	32	2,4	221	16	36,4	0,7
Prestopro	102	1	11	25	2,6	120	19,8	34,8	0,3
Royalpro	95	1	15	28	2,2	200	20,5	32,4	0,5
Mean	**94**	**2**	**12**	**25**	**2,4**	**180**	**19,3**	**33,4**	**0,5**
STDEV	*7,02*	*1,34*	*2,24*	*3,10*	*0,17*	*38,34*	*1,52*	*1,70*	*0,12*
Hajdúböszörmény									
Growpro	130	0	18	28	2,5	15	19,2	33,4	0,7
Hípro	110	4	14	33	2,3	163	19,2	34,2	0,5
Pannónia K.	125	1	17	29	2,5	164	20	36,1	0,7
Prestopro	105	4	13	38	2,3	124	19	34,5	0,6
Royalpro	125	3	13	16	2,2	242	19	32,5	0,5
Mean	**119,0**	**2,4**	**15,0**	**28,8**	**2,4**	**177,0**	**19,3**	**34,1**	**0,6**
STDEV	*8,85*	*1,48*	*1,91*	*6,67*	*0,11*	*35,65*	*0,34*	*1,10*	*0,08*
Mean of research areas									
Growpro	107	1	14	34	3	205	19,7	32,7	0,8
Hípro	95	4	14	33	2	165	19,4	33,1	0,9
Pannónia K.	105	2	15	35	3	186	18,4	35,6	1,0
Prestopro	94	3	13	45	3	132	19,3	34,2	0,7
Royalpro	103	3	15	26	2	220	20,3	32,1	0,8
Mean	**100,9**	**2,5**	**14,3**	**34,6**	**2,5**	**181,5**	**19,4**	**33,5**	**0,8**
STDEV	*4,94*	*0,85*	*0,65*	*5,44*	*0,11*	*28,07*	*0,58*	*1,11*	*0,10*

The yields under adverse conditions (Tornyiszentmiklós and Hajdúböszörmény) were significantly less than the local average, and the averages of Földes, experiencing normal precipitation. The highest yield (1.8 t ha^{-1} of Hipro) was also recorded here (Figure 1).

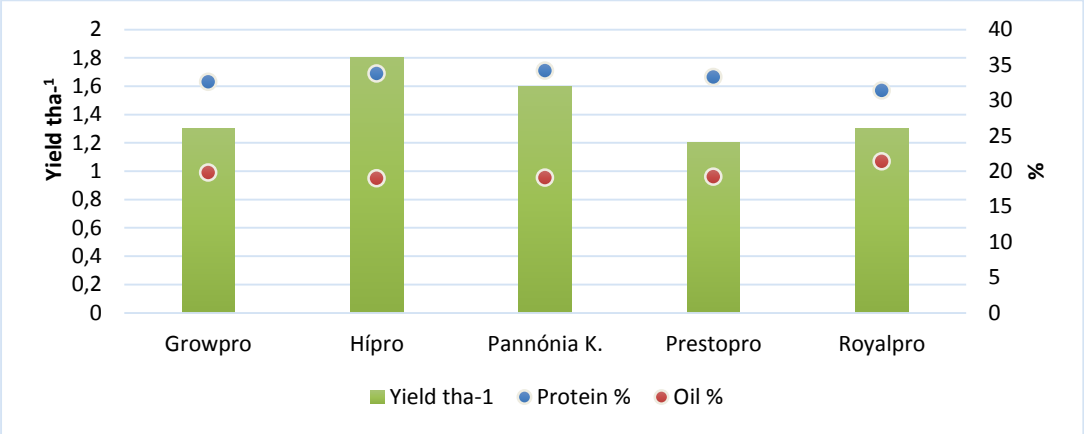

Figure 1 Yields and quality of soybean varieties (Földes, 2014)

4 Conclusions

In 2014 yield was highly variable (Földes: 1.2-1.8 t ha^{-1} STDEV 0.2 at the other two research sites 0.3-0.7 t ha^{-1}), but overall well below the regular average. The different conditions of the different geographical areas may have influenced yields decisively; however, they influenced specific varieties in a different manner.

In addition to ecological conditions, agricultural technology also determines the yields of soybean varieties. Narrow spacing (35 cm) is not sufficient to suppress weeds, and thus crop yield is reduced.

There were considerable differences between the average yields of the research areas and between the yields of the tested varieties (in the 1. area 0.6 t ha^{-1}, average of the varieties 1.4 t ha^{-1}), in the 2nd area 0.4 t ha^{-1} average of the varieties 0.6 t ha^{-1}), in the 3rd area 0.3 t ha^{-1}, average of the varieties 0.8 t ha^{-1}). The differences of protein content were lower (in Földes 2.8 %, average of varieties 33.1), Tornyiszentmiklós 5 %, average of varieties 33.4), in Hajdúböszörmény 3.5 %, average of varieties 33.5 %). The yield of Prestopro was lowest among the tested varieties in Földes and Hajdúböszörmény (mean 0.7 t ha^{-1}), the most favourable variety was Pannónia Kincse both regarding yield (0.7-1.6 t ha^{-1}) and protein content (average 35.6 %).

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