TECHNOLOGY FOR ORGANIC PRODUCTION OF SOYBEAN IN MACEDONIA

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ABSTRACT

Organic production within the EU is defined the Regulation, which recently replaced the old 2092/91.Although Macedonia is not yet a member of the European Union, technology for organic production of soybeans is harmonized according to the requirements of the EEC. This paper detailed how the techniques and principles of organic production of soybeans, as it can be implemented in production conditions in different agroecosystems conditions in Macedonia. The yields from the soybean grain which can be obtained in Macedonia through organic production, depending on conditions and methods of production from 1000 to 2500 kg/ha. This technology of agricultural production is based on the results of scientific research, knowledge and practical realization within the scientific and practical experiences. The data referred to in this paper, except from existing research and experience in the field of soybean breeding conducted with us, and are supported by data from foreign literature and results from this area.

Keywords: organic, soybean, production, yields, principles, technology

INTRODUCTION

According to the old Chinese literature, the first written information about soybean can be found in the book Materia medica from the tsar Sheng Nung from 2838 B.C. [11]. According to the written data of [1], soybean as agricultural crops is growing in China since 6-7 thousands years ago [3] [10]. The soybean together with the rice, wheat, barley and millet, was one of the five most important crops for the Chinese civilization. Development of the marine traffic in the 18th century, soybean has been spread to Europe and America. In Europe, for the first time, a German botanic Engelbert Kaempfer has spoken about it. After his trip to Japan, he wrote the book „*Amoenitatum exoticarum*". The book is published in 1712 and contains detailed description of the plants and recipes for preparation of different drinks and food [3] [5]. Charles Linne in 1737, in the book „*Hortus Califfortianus*" is mentioning soybean as *Phaseolus max*, and in 1753 in his famoust masterpiece „*Species Plantarum*" is describing soybean under the name Dolichos soja. Konrad Moench is naming it as, while Maksimovič in 1873 is giving the name *Glycine hispida*. Today worldwide the name *Glycine max* (L.) Merrill is accepted, recognized by Ricker and Morse in 1948 [citation in 6].

According to USDA [15], the world production of soybean is continuously increasing. Today the biggest soybean producer is USA with 38% and 86.8 millions tones from the total world production (228.4 millions tones) in 2006. The soybean as crop for oil production is leading as compared to the other oilseed crops with participation of 57% from the total plant oil production. Also, the soybean is culture with number 1 world consumption of protein food with participation of 68%.

The soybean is extremely important in human nutrition because of the special chemical composition of the grain as it contains approximately 30-50% proteins and 18-24% oil, depending of the variety and cultivation conditions. The commercial varieties averagely contain up to 40% proteins and 20-22% oils, 34% carbohydrates and about 5% mineral elements: potassium (K), phosphorus (P), sulfur (S), calcium (Ca), iron (F), magnesium (Mg) и sodium (Na). Also, the grain is rich with vitamins: A, B-complex, D, E and K. The proteins are rich in essential aminoacids, especially with lysine and methionine. These aminoacids are the most similar with the animal proteins, thus they have high biological value [8].

The soybean is commonly used as fodder, but in the last two decades more and more different products for human nutrition are spreading, as: cheese tofu, soybean milk, burgers, sausages, bread, different types of sweets and other products [16].

The possibility for acquiring medical and diet products from soybean for human consumption made soybean to be very attractive for organic production. Soybean is very important in the crop rotation because the plants are naturally enriching the soil with nitrogen that is stays available for the next crop. The particularity of soybean regarding nitrogen as compared to other cultures is in the ability through symbiosis with noodle bacteria to secure major part of this element. Because of this characteristic, the soybean is

very favourable culture for organic production, where the application of chemical fertilizers is unacceptable. The soybean is utilizing soil nitrogen only in the period of phase VE (emerging) to the period of noodle formation at the root hairs, which is according to many authors the period of the first two to three weeks after the emerging. After it the greatest part of the needs is utilised from the atmospheric nitrogen. In conclusion the needs of nitrogen fertilization are very small and necessary only in the first month of vegetation when the plants are small and the utilization is low, if symbiotic nitrogen fixation is provided. The soybean with symbiotic nitrogen fixation can fixate important quantity of nitrogen as up to 40-50 kg/ha [12]. Increasing the number of organic farms and debating for increase of energy prices, these "free of charge" natural ways of fertilization are coming back to the research centre of many scientists and organic farmers.

The aim of soybean yield utilization (green grain, mature grain, raw material for human nutrition, raw material for fodder, green manure etc) is of main importance for making the decision for soybean organic production. The previous conditionally depends on agriecological characteristics of the area where soybean cultivation is planned, irrigation possibilities, location and size of agricultural plots, agricultural mechanization etc [9].

MATERIAL AND METHODS

Climatic conditions

The mean monthly temperatures for the location Ovche Pole differ for 2006 and 2007 (Figure 1 and 2). For all months in 2007 the temperature was higher or equal with those in 2006. Mean annual temperature was also differing, for 2007 is 13.02°C, while for 2006 is 11.54°C. During the vegetation period (May – September) the values of mean monthly temperatures were higher in 2007 as compared to 2006. The analyses of precipitations show that great differences exist in the two research years for the location Ovche Pole (Figure 1 and 2). In the second year, 2007, the precipitations were two times higher (457 mm) as compared to 2006 (185.9 mm). However, in the critical vegetation period for soybean (flowering, pod formation) in July 2007 there is no rainfall. From the clime diagram (Figure 1) it is clear that the period from July to November is arid for the location Ovche Pole.

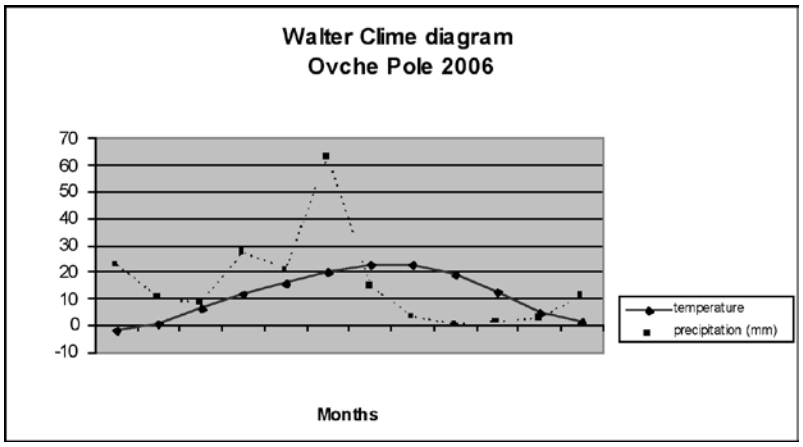

Figure 1. Walter clime diagram for Ovche Pole, 2006.

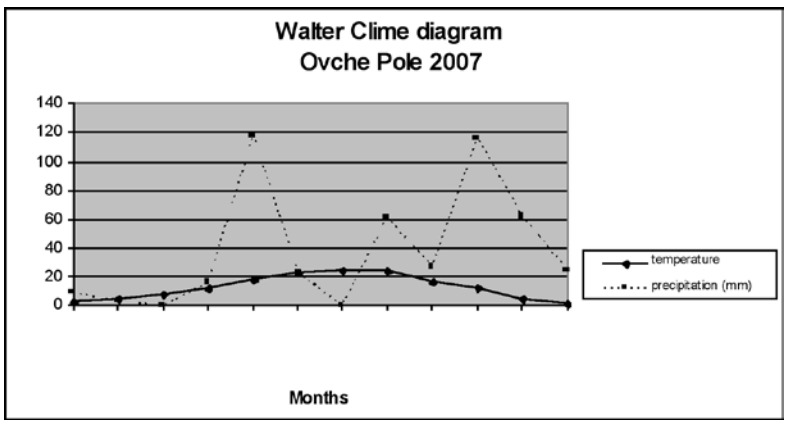

Figure 2. Walter clime diagram for Ovche Pole, 2007.

The mean monthly temperatures for the location Strumica differ in 2006 and 2007 similar as at the first location (Figure 3 and Figure 4). The values of mean monthly temperatures in 2007 are higher almost for all months, as in the vegetation periods. Mean annual temperature values are also different. In 2007 it is 12.8°C, while in 2006 was 14.1°C. In July 2007, maximum mean monthly temperature of 28°C is noted. At the location Strumica, the analysis of monthly precipitation shows higher values (623.9 mm) as compared to 2007 (537.4 mm). Nevertheless, these differences are not as extreme as it is for location Ovche Pole. As at the first location, the most critical month regarding the rainfall in 2007 is July (0.3 mm).

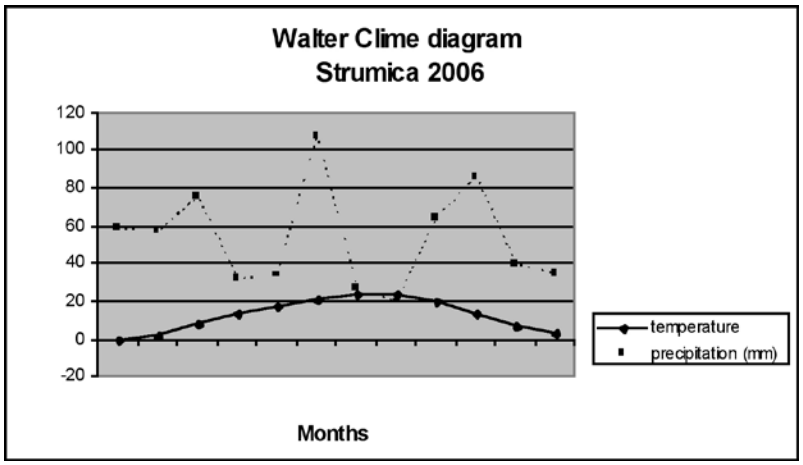

Figure 3. Walter clime diagram for Strumica, 2006.

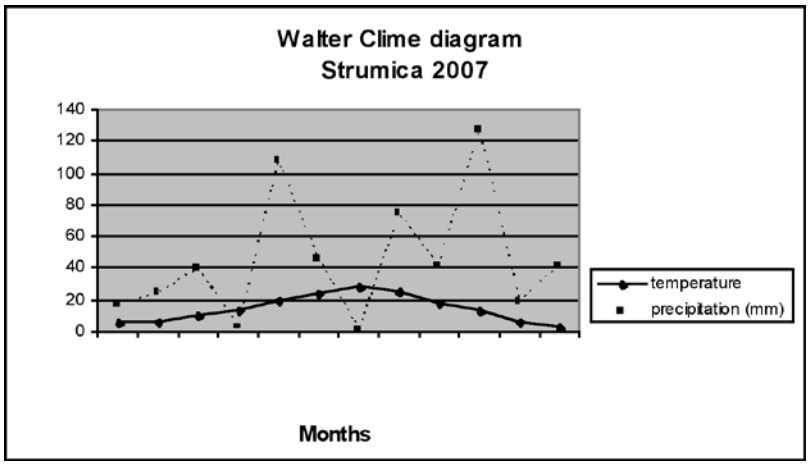

Figure 4. Walter clime diagram for Strumica, 2007.

If an experiment is conducted for one year and at one location the results will not be reliable and significant. Conducting experiments for more years and location is of highly importance for evaluation and breeding of varieties with wide adaptability [7]. Grain yield is the most important quantitative characteristic in soybean production (*Glycine max* (L.) Merrill) which depends of the genetic potential and the environmental conditions of growing [14]. Each environment is specific because there is specific action of predictable and unpredictable factors [citation in 13]. The field experiments are conducted on the trial fields that have been passed the organic conversion period at Faculty of Agriculture in Strumica and Poledelstvo, Erdzelija (Ovche Pole). The trial fields at both of the locations were under irrigation system. The sowing was performed in the beginning of May 2006 and 2007, at the both locations. The experiment design is randomized block system with basic trial field of 12.5 m^2. The 6 tested varieties are in 00/0, I and II maturation group in two agriecological different regions in Republic of Macedonia (Ovche Pole and Strumica). In Ovche Pole the trial field was at 230 m altitude, soil type smolnica and two years wheat as pre-cropping culture. In Strumica the soil is mild carbonate with low acid pH reaction.

Two basic factors are analysed, the first one is different soybean varieties and the second is different agriecological regions for growing (Ovche Pole and Strumica). The basic and before sowing plowing were standard, on time and in the same manner during the two experimental years, at the both regions.

The sowing was performed manually, where the distance between rows was 50 cm and 5 cm within the row, i.e. 400.000 plants per

hectare. Before sowing, the seeds of all used varieties were inoculated with biological concoction prepared from nitrogen fixation bacteria (*Bradyrhizobium japonicum* spp.). The following soybean varieties were examined:

(1) Ilindenka – is the first Macedonian soybean variety, recognized by the State Committee for varieties in 2004, II maturation group, 135 to 140 days vegetation length

(2) Pela – is the second Macedonian soybean variety, recognized by the State Committee for varieties in 2004, 00/0 maturation group, 90 to 100 days vegetation length

(3) Daniela 97 – Bulgarian variety, I maturation group, 125 to 135 days vegetation length

(4) Pavlicheni 121 – Bulgarian variety, 125 to 135 days vegetation length

(5) ZPS015 – Serbian variety, 0/I maturation group, 115 to 125 days vegetation length

(6) Delta – Canadian variety, maturation group 0/I, 120 to 125 days vegetation length

During the vegetation, 2 manual cultivations between rows were performed, the first one in phase (V_1- V_2), developed simple leaves, and one to two pairs triple leaves, and the second one in the phase (R_1) beginning of flowering. The first furrow irrigation (50 l/m^2) was conducted in the phase (R_3), beginning of pod formation, (different calendar schedule for varieties from different maturation group), and the second irrigation with the same irrigation norm at the phase (R_5- R_6), beginning of seed formation and their development. In the period between two irrigations the plants are foliar fertilized with biological liquid fertilizer based on dissolved humus from Californian Red Worms (*Lumbricus rubellus*), – Bioflor [18]. There were no any pathogens and pests during the vegetation period of soybean crop during the two years of cultivation. The harvest was conducted manually in the phase (R_8), full maturation which is different for different varieties that belong in different maturation groups. After the harvest, the yield (kg/ha) and grain quality characteristics were analysed. Grain quality was determined on average grain sample in laboratory. Protein content in the grains was determined according to Kjeldhal method, while the oil content according to method of extracted oils with Sokslet apparatus. All data were statistically analysed according to the method of variance analysis (ANOVA) and LSD test for evaluation of significant differences. As indicators of variability of tested characteristics for repetitions, locations and years, the following parameters were calculated: average value ($\bar{x}$), average value error ($S_{\bar{x}}$), standard deviation (s).

RESULTS AND DISCUSSION

Grain yield is the most important characteristic in soybean breeding (*Glycine max* (L.) Merrill), which depends on the genetic potential and the environmental conditions of soybean growing [14]. The organic cultivation is often followed with stresses; the difference in yield from different genotypes is depending not only on genetic components but also on different abilities for their replenishment [2].

Table 1. Soybean grain yield in kg/ha from 6 tasted varieties at two locations for two years according to organic production criteria.

Region		Variety						Average
		Ilindenka	Pela	Daniela 97	Pavlicheni 121	ZPS 015	Delta	
Ovche pole	2006	2840	1260	2500	1690	1540	1710	1890
	2007	1752	580	1510	610	935	1070	1076
Strumica	2006	3100	1490	2830	2570	2430	2760	2530
	2007	2270	670	1690	1980	1650	1540	1633
Average		2490	1000	2132	1712	1639	1770	1782

The results presented in Table 1 show that average yield for all the varieties grown in conditions of organic cultivation for two years is 1782 kg/ha. The yield for all genotypes is showing higher values for 2006, location Strumica as compared to 2007 for the location Ovche Pole. The highest yield is obtained from the variety Ilindenka (3100 kg/ha) in the first year in Strumica, and the lowest yield is for the variety Pela (580 kg/ha) in the second year in Ovche Pole.

Genotype	Year	Location	$\overline{x}$	Sx	s	CV(%)
Ilindenka	2006	Ovche Pole	138.35	1.56	15.80	11.42
		Strumica	164.65	1.96	19.75	11.99
	2007	Ovche Pole	133.59	1.70	17.21	12.88
		Strumica	143.91	1.67	16.84	11.70
Pela	2006	Ovche Pole	149.35	2.04	20.63	13.81
		Strumica	151.99	1.95	19.72	12.98
	2007	Ovche Pole	115.70	1.63	16.43	14.20
		Strumica	158.17	2.45	24.72	15.63
Daniela 97	2006	Ovche Pole	170.35	2.01	20.28	11.91
		Strumica	166.55	2.04	20.62	12.38
	2007	Ovche Pole	126.87	1.59	16.02	12.62
		Strumica	180.58	1.63	16.47	9.12
Pavlicheni 121	2006	Ovche Pole	110.68	1.48	14.92	13.48
		Strumica	114.04	1.10	11.07	9.71
	2007	Ovche Pole	82.32	0.84	8.53	10.36
		Strumica	114.17	1.62	16.32	14.29
ZPS015	2006	Ovche Pole	148.71	1.78	17.98	12.09
		Strumica	172.34	2.63	26.55	15.40
	2007	Ovche Pole	113.29	2.48	25.03	22.09
Delta	2006	Ovche Pole	168.40	2.57	25.96	15.42
		Strumica	166.46	1.86	18.78	11.28
	2007	Ovche Pole	131.20	1.93	19.47	14.84
		Strumica	148.21	1.89	19.11	12.89

Table 2. Average values and indicators for genotypes variability for 1000 grains weight for two years and two locations.

Although 1000 grains weight is depending mostly on genetic characteristics of the variety, it is also dependent on environmental conditions, mostly climatic. Absolute grains weight is determined by the speed and the duration of irrigation. The smaller grains are placed at the terminal pat of the plant because the period for irrigation is relatively short [2]. The highest value for 1000 grains weight is for the variety Daniela 97 (180.58 g) in 2007, location Strumica, and the lowest value is for variety Pavlicheni 121 (82.32 g) in 2007, location Ovche Pole (Table 2). The variability coefficient is in the range of 9.12% for variety Daniela 97 which in the same time showed the highest 1000 grains weight in 2007 in Strumica, to 5.63% for variety Pela in Strumica in 2007. It is well known that the strong interaction genotype – environment has strong influence on expression on qualitative characteristics. The temperature during soybean growing is strong factor influencing the protein and oil content in soybean grains [citation in 18]. Usually, protein and oil content are inverse variation to temperature changes, e.g. temperature raise increase oil content in grains and decrease protein content [17]. The protein content is very variable characteristic (Table 3).

Genotype	Year	Location	Protein	Oil
Ilindenka	2006	Ovche Pole	29.71	22.86
		Strumica	34.51	21.79
	2007	Ovche Pole	27.04	23.16
		Strumica	28.6	20.49
	Average		29.97	22.07
Pela	2006	Ovche Pole	35.67	22.27
		Strumica	32.1	24.15
	2007	Ovche Pole	36.31	25.74
		Strumica	36.5	20.62
	Average		35.15	23.19
Daniela 97	2006	Ovche Pole	31.09	22.67
		Strumica	32.05	22.05
	2007	Ovche Pole	21.97	26.84
		Strumica	29.01	23.00
	Average		28.53	23.64
Pavlicheni 121	2006	Ovche Pole	33.63	20.97
		Strumica	32.46	22.68
	2007	Ovche Pole	25.3	24.95
		Strumica	32.46	22.05
	Average		30.96	22.66
ZPS015	2006	Ovche Pole	32.9	21.80
		Strumica	34.99	21.56
	2007	Ovche Pole	24.99	25.24
		Strumica	31.91	21.80
	Average		31.20	22.60
Delta	2006	Ovche Pole	35.88	20.33
		Strumica	33.19	22.50
	2007	Ovche Pole	28.69	23.86
		Strumica	35.67	19.47
	Average		32.46	21.54
		$LSD_{0,05}$	2.25	1.10
		$LSD_{0,01}$	3.05	1.49

Table 3. Average values of protein and oil content in grains of different genotypes at two locations and two years.

The lowest and minimal protein content showed variety Pela (36.5%) in the first year 2006 in Strumica, and the lowest percent of proteins showed variety Daniela 97 (21.97%) in the second year 2007 in Ovche Pole. The highest average value of protein content, on average basis for all variants has variety Pela (35.15%), followed by the varieties Delta (32,46%), ZPS015 (31.20%), Pavlicheni 121 (30.96%), Ilindenka (29.97%) and Daniela 97 (28.53%).

CONCLUSIONS

From the conducted experiment on organic production of soybean in two different agriecological locations and during two experimental years, the following conclusions can be drawn:

- The average yield of soybean from the cultivated varieties during two years and at two locations is 1782 kg/h. Taking in account that the price of soybean grain as row material for organic products is higher, the gained yield indicates economic justification of organic production of soybean.
- The highest average yield is gained from the variety with the longest vegetation period (Ilindenka, 140 days), while the lowest yield is gained from the variety with the shortest vegetation period (Pela, 90 days).
- The highest average protein and oils content is observed in the variety with the shortest vegetation period (Pela). The low grain yield of this variety is compensated with very high quality of grains from nutrition aspect.
- Because of extreme low precipitations in July 2007 at the both locations, the grain yield is 40% lower as compared to 2006 for all the varieties under the experiment.
- According to the results of the experiment, the location Strumica showed higher average yield from all the varieties than the location Ovche Pole and it is more suitable for organic production of soybeans.

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