THE INFLUENCE OF THE PEDOLOGICAL DROUGHT AND IRRIGATION ON SOYBEAN YIELD IN THE CRISURILOR PLAIN CONDITIONS

Jude Eugen*, Bei Mariana

*University of Oradea, Faculty of Environmental Protection, 26 Gen. Magheru St., 410048 Oradea, Romania, e-mail: jdeugen@yahoo.com

Abstract

The paper is based on researches performed in the period 2014-2016 on the crop of soya. The crop of soybean occupies limited areas in the Crisurilor Plain, on of the causes being also the pedological drought that can even compromise the crop. The researches were performed at the Station of Reserach and Agricultural Development Oradea on a preluvosol, and the conclusions drawn are the following:

The water reserve from the soil on the depth of 0-75 cm has decreased under the level of the minimum limit 116 days in 2014, 94 days in 2015 and 48 days in 2016. The water reserve from the soil on the depth of 0-75 cm has decreased under the level of the coeficient of fading and namely; 17 days in 2014, 14 days in 2015 and 3 days in 2016. As a consequence for the maintaining of the water reserve between the minimum limit and the capacity offield on the depth of 0-75 cm was irigatd with 3350 m^3/ha in 2014, with 2800 m^3/ha îin 2015 and with 1900 m^3/ha in 2016.

The irrigation determined the increase of the total consumption of water of soybean with 71 % in 2014, with 56 % in 2015 and with 44 % in 2016. As a consequence were obtained greater productions, the differences from the non irrigated, 1470 kg/ha in 2014, 1550 kg/ha in 2015 and 1510 being very significant satistically. The results obtained argue the necessity of irrigation on the culture of soybean from the Crisurilor Plain.

Key words: soybean, pedological drought, water consumption, production

INTRODUCTION

Soybean (*Glycine hispida,* soybean – eng.) is one of the most important agricultural plants, for the alimentation of the people, animals and industry, being mentioned by the peoples from Eastern Asia 7000 years ago. In China is presented among the 5 holy plants: rice, wheat, millet and ciumiza.

The seeds of soybean have a very high nutritive value; 100 kg of soybean can replace the proteic content of 4 kg of meat, 75 eggs or 7.5 l of milk, soybean doesn't contain cholesterol. The proteins have a high digestibility 90%, the main components is glicinine, rich in S then legumelina. The aminoacids existent are: proline, phenylalanine, aspartic acid, glutamic acid, tyrosine, leveina, arginine, lysine, tryptophan, histidine. Soybean contains proteins 39.9%; fats 20.78%; hydrates of carbon 34.43%; mineral salts 4.89%.

Soybean flour 10-15%, in mixture with the wheat flour, give a nutritional, tasty bread. The soybean can be used in difference culinary

recipies, milk, cheese, basic raw material in the industry of the oil. Having multiple utilizations for the solving of the content of proteins is considered the plant of the future, the golden plant of the human kind, miracle plant.

The soybean is a plant with relatively high demands towards the humidity. Enciu V. (quoted by Bâlteanu Gh., 1979) considers that, comparing to the years when the precipitations regimen is optimum, in conditions of pedological drought the production decreases with 31-61%. Berbecel O. and Valuţă Gh. (1960), considers that the pedological drought in the period of blooming determined the decrease of production with 14-52%, while the pedological drought from the period of filling the bean determined the decrease of production with 41-87%.

Muntean L.S. and collab. (2008) appreciate that the Western part of the Plain of Rivers is situated in the very favorable area for the culture of soybean because it has fertile soils, and in the period May-August are registered 250-340 mm precipitations, the number of tropical days (20) is decreased and the temperature from the period of blooming and fructification (19-20^{o}C) is favorable.

MATERIAL AND METHOD

In the period of vegetation of the soybean (IV-IX) were registered 267.8 mm precipitations, 348 mm precipitations in 2015 and 386.3 mm precipitations in 2016 (table 1).

The research field is placed to the Station of Reserach and Agricultural Development Oradea on a preluvosoil with the following profile: Ap=0-24; El=24-34 cm; Bt_1=34-54 cm; Bt_2=54-78 cm; Bt/c=78-95 cm; C=95-145 cm.

The research field soil is characterized by a very large hydrostability of the aggregates of soil greater than 0.25 mm, 47.5% on the layer of 0-20 cm (table 2). The soil has an average total porosity on the depth 0-20 cm, 20-40 cm, 40-60 cm and small on the depths 6-80 cm, 80-100 cm and 100-150 cm. The values of the total porosity decrease on the profile of the soil from the surface to the depth. The hydraulic conductibility (K) is larger on the depth of 0-20 cm, average on the depths of 20-40 cm and 40-60 cm, small and very small on the following depths.

The field capacity (CC) has an average value on the entire profile of soil, and the coefficient of fading (CO) has, also, average value up to the depth of 80 cm and grater under this depth.

The interval of active humidity (IUA) or the capacity of useful water (CU) has great value on the depth 0-80 cm and average on the depth 80-150 cm. On the depths of irrigation used in the research field the interval of active humidity has a great value. Depending on the texture of the soil the minimum limit was established at 2/3 of IUA.

Table 1

Elements of the climate in Oradea in the period 2014-2016
(from the Meteorological station Oradea)

Year	Lunile												Annual average
	X	**XI**	**XII**	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	
Air Temperature ºC													
2014	1.,6	8.7	1.1	1.4	5.4	9.2	12.8	16.8	21.0	22.5	21.1	18.0	12.55
2015	12.2	7.7	3.7	1.9	2.1	6.7	10.5	16.5	20.7	24.6	24.5	18.8	12.49
2016	9.8			-0.6	6.8	6.9	13.4	16.4	21.3	22.5	21.1	18.0	
Multiannual average	10.6	6.7	3.2	-2.2	0.3	5.0	10.5	15.8	19.1	20.8	21.6	16.2	10.63
Rainfall – mm													
2014	52.2	46.4	8.3	46.6	18.3	14.2	35.0	52.4	44.1	38.7	65.0	32.6	453.8
2015	58	33.1	61.9	58.9	17.3	17.5	25.2	73.4	38.8	49.1	95.3	66.2	594.7
2016	104.2			49.7	76.3	45.9	26.4	46.4	168.1	85.3	27.1	33.0	
Multiannual average	41.1	48.6	50.7	34.4	38.8	35.1	46.2	61.9	84.9	71.6	57.5	45.5	616.3
Air humidity (%)													
2014	76	84	86	88	85	66	73	71	55	70	72	74	75.00
2015	77	85	83	86	87	67	72	70	54	67	70	72	74.16
2016	86			88	84	79	69	67	74	67	66	71	
Multiannual average	79	84	89	85	86	77	72	72	73	72	82	75	78.8

Table 2

Physical and hydrophysical characteristics of the preluvosoil from the research field, Oradea (from Domuţa C., 2012)

Depth - cm -	Total aggregate %	Clay 0,002%	DA g/cm3	K mm/ h	PT %	C.C.		CO		Minimum threshold		IUA	
						%	m^3/ha	%	m^3/ha	%	m^3/ha	%	m^3/ha
0-20	47,5	31,5	1,41	21,0	21	24,2	682	9,2	259	19,2	542	15,0	423
20-40	-	34,1	1,52	10,5	49	23,6	717	9,4	286	18,9	575	14,2	431
40-60	-	39,8	1,58	4,4	48	25,1	768	11,1	351	19,9	630	13,2	417
60-80	-	39,3	1,65	1,0	43	24,4	828	10,8	356	20,4	672	14,3	472
80-100	-	38,8	1,57	0,5	40	23,8	766	12,2	383	20,4	640	12,2	383
100-150	-	37,6	1,54	0,1	39	24,0	1833	14,2	1093	20,6	1586	9,6	740
0-50	-	-	1,49	-	-	24,0	1787	9,7	720	19,2	1431	14,3	1067
0-75	-	-	1,53	-	-	24,2	2782	10,1	1158	19,5	2240	14,1	1623
0-100	-	-	1,55	-	-	24,3	3769	10,5	1627	19,7	3055	13,8	2142
0-150	-	-	1,55	-	-	24,1	5611	11,7	2720	20,0	4646	13,4	2890

The soild form the research field has a reaction weakly acid on the entire depth studied, with increasing values from the surface to the depth.

The supply with humus is weak, and that with total nitrogen, weak-average, on the entire depth researched.

The yearly fertilization with shots of Phosphorus specific to the agrothechnique of the irrigated soils, determined the increasing of the Phosphate level of the soil from the research field so that after 35 years of stationary researches the quantity of mobile Phosphorus from the soil has incrased on the ploughed layer from 22.0 ppm (soil average supplied) to 149.9 ppm (soil very well supplied).

The content of soil in mobile Potasium is small – average, with values that increase from the ploughed layer (120.6 ppm on 0-2 cm) to the depth. The content of the soil in changeable Magnesium on the profile of the soil has an evolution similar to that of the Potasium, the soil being average supplied with this element on the entire profile. The active manganese characterizes the soild from the research field as soil with an average content on the depths 0-20 cm and 20-40 cm and small on the following depths. The soil is moderate submesobasic on the entire depth studied.

The source of water used for the irrigation of the culture is a deep bore of 15 m.

The laboratory analyses performed in the years 2007, 2008 and 2009 underlined a pH (7.3) which, from this point of view places the water in the category of those corresponding for irrigation. From the content of anions the irrigation water is a sulphate bicarbonate type, and from that in cations is of the calcium magnesium type. The content in natrium is decreased 12.9%. The fixed mineral residue (0.5 g/l) is under the admissible limit of 0.8-1 g/l.

From the irrigation coefficient ,,Priklonski-Laptev" (57.6) the water is good for irrigation. From the CSR index (-1.7) the irrigation water has a potential of alkalinization reduced (class C) being able to be used without restrictions. The potential of alkalinization (0.52) is also reduced (class S.1), the water being able to be used without restrictions for the irrigation of the soils. The classification of the waters, by N. Florea, depending on the absolute content of salts and the relative one of Na, shows that the irrigation water used in the research field is placed in group II, very good waters for irrigation.

The studied versions were:

- Non irrigated
- irrigated, with the maintaining of the water reserve between the minimum limit and the field capacity of 0-75 cm.

The technology of the soybean culture was wanted to be an optimum one. Was cultivated the breed Granat Agat at the density of 55 germinable

beans/m^2. The distance between the layers used was of 45 cm, and the system of fertilization included 60 kg N/ha and 120 P_2O_5/ha.

In the calculation of the minimum limit was considered the texture and the degree of battering of the field:

PM = CO + f(CC + CO) = CO + f x CU

In which:

PM = minimum limit (% g/g);

f = fraction from the interval of accessible humidity for which are used the following values:

- 2/3 for the sandy soils, the sandy-clay soils strongly battered, for the clay-argil soils moderated and strongly battered and for the argil soils;

The calculation of the water reserve from the soil (M. Botzan, 1966, 1972) was made by the formula:

Ra = Ug x DA x H

In which:

Ra = water reserve (m^3/ha)

Ug = gravimetric humidity (%)

DA = apparent density (%)

H = thickness of the soil layer (cm)

The total water consumption was calculated using the review equation of the water in the soil with closed circuit (without phreatic infusion) (N. Grumeza, 1975, N. Grumeza and collab., 1986, Apietroaiei St., 1997, Ionescu Șișești, Fl. Popescu, 1992).

Ri + Pv + Σm = Rf + Σ(e+t),

in which:

Ri = initial reserve (for seeding, planting, retaking the vegetation), m^3/ha

Pv = the precipitations from the vegetation period

Σm = norm of irrigation (m^3/ha)

Rf = final reserve from the soil (on harvest), m^3/ha

Σ(e+t) = total consumption of water, m^3/ha.

The irrigation involves an ensemble of technical organizational measures, in order to harsly establish a rational regimen of irrigation, regarding the evaluation of the water needed, the size and succession of applying the irrigations acoording to the higher knowledge of the soil-water-plant relations.

The harvest of the experiments and the calculation of the results was performed respecting the instructions provided by the experimental technique (N.A. Săulescu, N.N. Săulescu, 1967).

The interpretation of the results was accomplished with the help of the analysis of the variation.

RESULTS AND DISCUSSION

Is considered that there is a pedological drought at the crop of soybean if the water reserve on the depth of irrigation (0-75 cm) falls under the minimum limit, and if this falls also under the level of the coefficient of fading is considered that is registered a period of accentuated pedological drought (Domuța C., 2009). The pedological drought from 2014 has totalized a number of 116 days. In 2015, the total number of days with pedological drought from the season of irrigation of soybean has totalized 94 days. (table 3).

The water reserve on the depth of 0-75 cm fell also under the level of the fading coefficient, 17 days in 2014 and 14 days in 2015 (table 4).

Table 3

The analysis of the number of days with water reserve (Ra) under the minimum limit (PM) on the depth of 0-75 cm, for soybean in conditions of non irrigation, Oradea 2014-2016

Year	Days cu Ra<PM in					
	IV	V	VI	VII	VIII	Total
2014	0	26	30	29	31	116
2015	0	16	20	28	20	86
2016	0	15	20	3	10	48

Table 4

The analysis of the number of days with water reserve (Ra) under the fading coefficient (CO) on the depth of 0-75 cm, for soybean in conditions of non irrigation, Oradea 2014-2016

Year	Days cu Ra<CO in					
	IV	V	VI	VII	VIII	Total
2014	0	0	0	7	10	17
2015	0	0	0	6	8	14
2016	0	0	3	0	0	3

The twice a month determination of the humidity of the soil on the depth of 0-75 cm has impoed that for the maintaining of the water reserve between the minimum limit and the field capacity to be irrigated with 3350 m^3/ha in 2014 (8 irrigations) and with 2800 m^3/ha in 2015 (7 irrigations), (table 5).

The irrigation determined the increase of the values of the total consumption of water with 71 % in 2014, with 56 % in 2015 and with 44 % in 2016. At the crop of soybean irrigated was consumed a smaller quantity of water from the soil reserve (table 6)

Table 5

The regimen of irrigation necessary for the maintaining of the water reserve between the minimum limit and the fild capacity, on the depth of irrigation of the soybean crop (0-75 cm) in the conditions from Oradea, 2014-2016

Year	V		VI		VII		VIII		V-VIII	
	Σm	n	Σm	n	Σm	n	Σm	n	Σm	n
2014	**500**	**1**	**850**	**1**	**1000**	**2**	**1000**	**2**	**3350**	**8**
2015	**400**	**1**	**500**	**1**	**1200**	**3**	**700**	**2**	**2800**	**7**
2016	**400**	**1**	**300**	**1**	**300**	**1**	**900**	**2**	**1900**	**5**

Table 6

The total consumption of water of the soybean crop in conditions of unirrigation or irrigation and the sources of covering in the conditions from Oradea 2014-2016

Variant	The total consumption of water		Sources of covering a total consumption of water, m^3/ha		
	m^3/ha	%	Ri-Rf	Rainfall during the growing season	Irrigations
2014					
Unirrigation	4157	100	1020	3137	-
Irrigation	7095	171	608	3137	3350
2015					
Unirrigation	3907	100	1240	2667	-
Irrigation	6097	156	630	2667	2800
2016					
Unirrigation	4430	100	570	3860	-
Irrigation	6380	144	620	3860	1900

In 2014, in conditions of non irrigation was registered a production of 1700 kg/ha. The utilization of the irrigation in the moment of decreasing of the water reserve on the irrigation depth under the minimum level has determined an increase of production of 1470 kg/ha (87%), very significant statistically (table 7).

Table 7

The influence of the irrigation on the soybean production, Oradea 2014

Variant	Production		Difference		Significance statistical
	Kg/ha	%	Kg/ha	%	
Unirrigation	1700	-	-	-	**Mt**
Irrigation	3170	187	1470	87	***

$LSD_{5\%}$ 280;
$LSD_{1\%}$ 512;
$LSD_{0,1\%}$ 760

In conditions of unirrigation in 2015 was registered a production of 1960 kg/ha. The utilization of the irrigation in the moment of decreasing of the water reserve on the irrigation depth under the minimum level has determined an increase of production of 1550 kg/ha (78%), very significant statistically (table 8).

Table 8

The influence of the irrigation on the soybean production, Oradea 2015

Variant	Production		Difference		Significance statistical
	Kg/ha	%	Kg/ha	%	
Unirrigation	1960	-	-	-	**Mt**
Irrigation	3510	179	1550	78	***

$LSD_{5\%}$ 240;
$LSD_{1\%}$ 370;
$LSD_{0,1\%}$ 630

In conditions of unirrigation in 2016 was registered a production of 2300 kg/ha. The utilization of the irrigation in the moment of decreasing of the water reserve on the irrigation depth under the minimum level has determined an increase of production of kg/ha (78%), very significant statistically (table 9).

Table 9

The influence of the irrigation on the soybean production, Oradea 2016

Variant	Production		Difference		Significance statistical
	Kg/ha	%	Kg/ha	%	
Unirrigation	1960	-	-	-	**Mt**
Irrigation	3510	179	1550	78	***

$LSD_{5\%}$ 310;
$LSD_{1\%}$ 540;
$LSD_{0,1\%}$ 760

CONCLUSIONS

The researches performed in the period 2014–2016 on the influence of the pedological drought and of the irrigation on the level of soybean production, performed in the research field of the review of water in the soil from the Station of Reserach and Agricultural Development Oradea lead us to the following conclusions:

The decade determinations of the soil humidity showed that in conditions of unirrigation, on the depth of 0-75 cm (the depth of soybean irrigation), the water reserve fell under the level of the minimum limit each year of the studied period, being situated in a smaller number of days and under the coefficient of fading. Also in the versions with interruption of irrigations the phenomenon of pedological drought was registered in the months in which was needed the irrigation and was not irrigated.

The optimum irrigation has determined increases of production very significant statistically each year, and by the suspending of the irrigations were obtained smaller productions, the differences compared to the version without interruption of the irrigations were assured statistically.

By applying the irrigation was observed the increase of the content of protein in the soybeans compared to the unirrigated version. The interruption of the irrigations in different monhts has determined the decrease of the content of protein, the differences being assured statistically.

Because the pedological drought was present in 2014 and in 2015 and 2016, is imposed the optimum utilization of irrigation on the soybean crop, because the increases of production compared to non irrigated are assured statistically, and the quality of production is improved.

REFERENCES

1. Bîlteanu Gh., Salontai Al., Vasilică C., Bîrnaure V., Borcean I., 1991, Fitotehnie. E.D.P., Bucureşti.
2. Bîlteanu Gh., 2003, Fitotehnie vol I. Ed. Ceres, Bucureşti
3. Bîrnaure V., 1976, Fitotehnie. Institutul Agronomic Nicolae Bălcescu, Bucureşti
4. Borcean I., David Gh., Borcean A., 2006, Tehnici de cultură şi protecţie a plantelor tehnice Ed. De Vest
5. Borza I. M., Stanciu A. Ş., 2010, Fitotehnie, Editura Universităţii Oradea
6. Canarache A., 1990, Fizica solurilor agricole, Editura Ceres, Bucureşti.
7. Ciobanu Gh., Domuţa C., 2003, Cercetări agricole în Crişana. Ed. Universităţii din Oradea.
8. Conea A, Vintilă I., Canarache A., 1977, Dicționar de știința solului. Ed. Științifică și Enciclopedică, București
9. Domuţa C., 2003, Oportunitatea irigaţiilor în Câmpia Crişurilor. Ed. Universităţii din Oradea.
10. Domuţa C., 2005, Practicum de irigarea culturilor şi agrotehnică. Ed. Universităţii din Oradea.
11. Domuţa C., 2006, Tehnică experimentală. Ed. Universităţii din Oradea.
12. Domuţa C., coord., 2009, Irigaţiile în Câmpia Crişurilor. Ed. Universităţii din Oradea.
13. Domuţa C., 2009, Irigarea culturilor. Ed. Universităţii din Oradea.
14. Domuţa C. şi colab., 2012, Irigarea culturilor în Câmpia Crişurilor, Ed. Universităţii din Oradea.
15. Domuţa C. coord., 2012, 50 de ani de cercetări agricole în Oradea, Ed. Universităţii din Oradea.
16. Domuța C., Domuța Cr. (coord), 2014, Cercetări privind irigațiile în Câmpia Crișurilor (1976-2014) Ed. Universității din Oradea.
17. Domuţa Cr., 2010, Cercetări privind influenţa irigaţiei asupra culturilor de porumb, soia şi sfeclă de zahăr în condiţiile Câmpiei Crişurilor. Teză de doctorat, USAMV Cluj – Napoca, 2010
18. Grumeza N. şi colab., 1989, Prognoza şi programarea aplicării udărilor în sistemele de irigaţii. Editura Ceres, Bucureşti.
19. Muntean L.S. şi colab., 2011, Fitotehnie. Ed. Risoprint Cluj-Napoca
20. Săulescu N.A., Săulescu I.D., 1967, Câmpul de experienţă. Ed Agro-silvică, Bucureşti
21. Vârban Dan Ioan, 2008, Culturi de câmp, Ed. Risoprint Cluj-Napoca