THE DYNAMICS OF SOIL MOISTURE AND THE CAPITALIZATION OF RAINFALL WATER BY MAIN FIELD CROPS ON A CLAYEY SOIL

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Abstract

The intensity of water uptake by plants depends, besides differences caused by species, crop kind, growing phases, the development of root and soil type, by agricultural practice. The present paper presents the dynamics of soil moisture in 2013-2014 agricultural years in relation with the technology that was applied with the following crops: wheat, corn, sunflower and pasture. After analyzing the evolution of soil moisture with the four crops, respectively 7 variants of soil moisture determination during 2014 year there could be observed soil moisture differences between applied technologies and between crops. For the analyzed area, respectively, on a levigated chernozem that was formed on clays, the capitalization of rainfall water is better by preparing the seedbed through plowing.

Key words: moisture, tillage, rainfall

During the last years the evolution of rainfall is changing such way the summers become drier and the meteorological extremes determine high yield losses. In order to diminish such phenomena the scientists research new technologies as well as their applying by farmers.

There are studies and researches on the ensuring of the water requirement for field crops and most of them show that the most important factor is the rainfall. This way, researches performed by Popescu C.V. (2001) in 1996-1998 period, by Pandrea R.C. (2012) in 2008-2010 with wheat, corn and sunflower crops in irrigated regime have shown that rainfall water is the major source of soil water and plant supplying, ranging between 50% to over 90%. There is clear that in order to use rainfall water efficiently there must be applied proper technologies that conduct to a better water keeping by soil, plant supplying by water and minimal evaporation from the soil.

Despite the fact that during previous years the plants suffered because of lack of water in the soil, the 2014 year was very rainy, the rainfall reaching 1,074 mm.

At the first sight these rainfall could be sufficient for the crops, especially wheat.

The main soil feature that influences the water regime is water permeability. in soils with good water permeability the water infiltrates and can be preserved by the soil on a thick depth (loamy soils) while the soils with low water permeability (clayey soils) the soil becomes waterlogged creating anaerobic conditions (Grumeza N., Klepş C., 2005).

MATERIAL AND METHOD

The researching method consisted in the following the dynamics of soil moisture in 2014 for the main field crops in Braneasa zone, Serbanesti locality, District Olt, Romania.

There was determined the soil moisture on 0-20 cm for the following crops, as follows:

a) Wheat: Gr1 – four tillage by heavy disk harrow, heavy soil, loamy-clayey; the cropped surface was of 87 ha. The previous crop was corn. The seedbed preparation consisted of four tillage by disk harrow during the autumn, on 25th of September. Before last disk harrow tillage there was made the basis fertilization. The drilling was performed between 13-17 October 2013 at a 4-5 cm depth. The harvesting was made at a 14% moisture of the grains, between 8-13 July 2014 obtaining an average yield for all three crop kinds of 6 t/ha.

Gr2 – plowing at 22-25 cm depth plus two tillage by heavy disk harrow, heavy soil, loamy-clayey. The cropped surface was 75 ha. The previous crop was wheat. Between 29 July and 5 august 2013 the entire surface was plowed at a 22-25 depth. At 10-14 September there was made tillage by disk harrow. At 15 October 2013 there was performed the basis fertilization. Three days before drilling there was made one tillage by combinatory and the drilling was made between 29 October and 2 November 2013. The harvesting

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was made at a 14% moisture of grains, between 1-3 august 2014 with an yield of 6.5 t/ha.

b) Corn: Pb1 – plowed at 30 cm depth plus three tillage by combinator, heavy soil, loamy-clayey; cropped surface was of 80 ha. The plowing was made at 30 cm depth between 20-25 november 2013. The previous crop was corn. In the spring the soil was leveled and loosened. The seedbed preparation consisted of two tillage by combinator between 1-3 april 2014. The drilling started at 5 april 2014 with a density of 58,000 grains per hectare, at 70 cm between rows and at 7-8 cm depth. There was performed the preemergent herbicide applying. Because of waterlogging the entire surface was drilled again. The seedbed preparation was made by one tillage by combinator, at 23 april 2014. The drilling was made between 24-26 april 2014 with a plant density of 60,000 grains per hectare. At 20 may there was applied on row fertilization by 220 kg/ha urea and then the mechanical hoeing was made. The harvesting was made at 14 october 2014 obtaining an yield of 6.9 t/ha corn grains with 15% moisture.

Pb2 – plowing at 20-28 cm plus disk harrow and combinator, heavy soil, loamy-clayey. The cropped surface was of 40 ha. The previous crop was wheat. The plowing was performed at 25-28 cm between 28-31 july 2013. In the spring the soil was leveled, loosened yet with remnant wheat plants from fall. The seedbed preparation consisted of one tillage by disk harrow at 24 april 2014 and then a combinator tillage at 28 april 2014. The drilling was performed at between 3-5 may 2014 with a density of 58,000 grains/ha, at 70 cm between rows and 7-8 cm depth. Along with the drilling there was fertilized by 250 kg/ha nitrocalcar (lime mixed with ammonium nitrate). At 5 june 2014 there was performed the mechanical hoeing. Postemergently (3-4 leaves) there was applied the herbicide. The harvesting was performed mechanically at 20 november 2014 with an yield of 5 t/ha at 15.5 % moisture.

c) Sunflower: Fls 1 – plowing at 24-27 cm plus disk harrow and combinator, heavy soil, loamy-clayey. The cropped surface was of 25 ha. The previous crop was wheat. The plowing was performed at 24-27 cm between 5-10 august 2013. In the spring the soil was leveled and loosened yet with remnant wheat plants from fall. On the plowed soil there was applied basis fertilization by 150 kg NPK 18:46:0. The seedbed preparation was performed by disk harrow tillage at 15th of March 2014 and then, at 20th of March there was made tillage by combinator. The drilling was performed at 26-28 march 2014 with a density of 58,000 grains/ha, at 70 cm between rows and 4-5 cm depth. The herbicide was applied preemergently. Between 10-15 may 2014 there was performed the mechanical hoeing and there was fertilized by 250 kg/ha nitrocalcar.

Postemergently (6-7 leaves) there was applied herbicide Pulsar 1.2 l/ha. The harvesting started at 5 september 2014, at 9% moisture of sunflower kernels with an yield of 3.6 t/ha.

Fls 2 – plowing at 24-27 cm plus disk harrow and combinator. The cropped surface was of 20 ha. The previous crop was wheat. The plowing was performed at 24-27 cm between 5-10 august 2013. In the spring the soil was leveled and loosened yet with remnant wheat plants from fall. On the plowed soil there was applied basis fertilization by 150 kg NPK 18:46:0. The seedbed preparation was performed by disk harrow tillage at 10 april 2014 and then, at 15 april 2014 there was made a tillage by combinator. The drilling was performed at 26-28 april 2014 with a density of 58,000 grains/ha, at 70 cm between rows and 4-5 cm depth. The herbicide was applied preemergently. Between 10-15 june 2014 there was performed the mechanical hoeing and there was fertilised by 250 kg/ha nitrocalcar.

Postemergently (6-7 leaves) there was applied herbicide Pulsar 1.2 l/ha. The harvesting started at 12 october 2014, at 10.5 % moisture of sunflower kernels with an yield of 2.8 t/ha.

d) natural pasture – Paj.

The evolution of soil moisture was made by determining the actual soil moisture.

In order to analyze the soil moisture data there is need the knowing of climatic data from meteorological stations Caracal, District Olt and Stolnici, District Arges.

There were analyzed the meteorological data from the two stations because the researched area is between these two stations. There was observed that there no high differences as regard rainfall and temperatures between the two stations. In additions there were taken from Serbanesti hall the rainfall data of 2013-2014 year.

RESULTS AND DISCUSSIONS

From meteorological data of Braneasa zone, District Olt (*table 1*) there can be noticed that the annual average temperature is 10.5ºC and for the vegetation period it is of 17.4ºC. The lowest average temperatures are recorded in January (-3.1ºC) and February (-0.8ºC) and the highest are recorded in July (22.8ºC) and August (22ºC). From the determinations of average multiannual values there can be noticed that there were recorded extreme values as well, both negative and positive.

The rainfall data during 2013 and 2014 there were taken from Serbanesti hall, District Olt, the multiannual average rainfall was taken from Caracal station, Distrct Olt.

As it can be seen, on the basis of data from 1.a. table, in 2014 the rainfall in Serbanesti – Tufeni area is almost double as compared with the multiannual average, being of 968 mm in 2014, as compared with 512.5 mm the multiannual average.

As regard the rainfall, the multiannual average sum 512.5 mm per year, respectively

326.6 mm within the vegetation period, the monthly repartition of them is being very different. During the vegetation period the rainfall are between 31.3 mm in Septembrie and 69.9 mm in June.

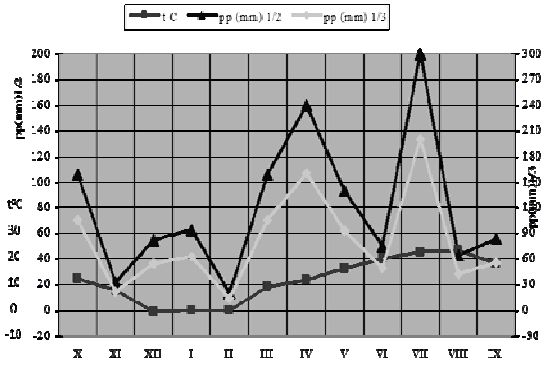

Figure 1 **Climogram for 2013-2014 agricultural year**

The 2013-2014 agricultural years can be characterized as excessively humid (*figure 1*). The average annual temperature was of 11.8ºC and during the vegetation period it was of 17.8ºC (*table 1*). Such way, there was recorded an accentuated warming as compared with the multiannual average. The spring, summer and autumn months of 2013-2014 year had almost equal temperatures with the multiannual ones yet for the winter months these were higher than the multiannual averages.

The rainfall recorded during 2013-2014 agricultural years were much over multiannual average, of 968 mm compared with 512.5 mm, even during the vegetation period (+316.6 mm). The distribution of rainfall during the vegetation period has been much higher compared with the multiannual average (*table 1*).

Table 1

The average temperatures and rainfall during 2013-2014 agricultural year

Months														
Brăneasa	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	Annual average	Vegetation period
Temperature (ºC)														
2013 - 2014	12.2	7.8	-0.5	0.1	0.2	9.2	11.8	16.4	20	22.8	23.5	18.3	11.8	17.8
Multiannual	11.3	4.9	-0.3	-3.1	-0.8	3.5	11.1	16.6	20.5	22.8	22	17.5	10.5	17.4
Deviation	0.9	2.9	-0.2	-3	1	5.7	0.7	-0.2	-0.5	0	1.5	0.8	1.3	0.4
Rainfall (mm)														
2013 - 2014	106	22	55	63	14	106	160	93	50	200	43	56	968	708
Multiannual	41.2	47.3	38.3	37.8	31.5	31	40.9	63.6	69.9	43.1	36.6	31.3	512.5	326.6
Deviation	64.8	-25.3	16.7	25.2	-17.5	75	119.1	29.4	-19.9	156.9	6.4	24.7	455.5	381.4

The soils from the studied area are typical for the zone – the levigated chernozem which was formed on clays and are less productive than the chernozem formed on loess material. This soil is acid and this was the reason for applying lime amendments. During rainfall this kind of soil does retain most of the water. Waterlogging condition determine anaerobic reaction within the soil and plants suffer after heavy rains during the summer while in drought conditions this soil cracks and plants, also, suffer.

In *figure 2* there can be observed that the soil moisture was lower around 29 may 2014 and this was the critical phase for winter wheat (blooming, fecundation and grain formation). After harvesting, there can be observed an increase of soil moisture with the winter wheat that was drilled in plowed soil in comparison with the one drilled in disk harrow basis tillage, proving a better water retention in these conditions.

The dynamics of soil moisture with corn crop (*figure 3*) there can be observed an increase of water uptake around 20th of August 2014, when there was recorded the final of the critical phase of corn grains formation yet the hottest period during the corn vegetation.

With the last soil sampling for moisture determination there was observed that with the Pb2 at 20th of November 2014 the amount of water consumption was higher than Pb1 which was taken at 14th of October 2014.

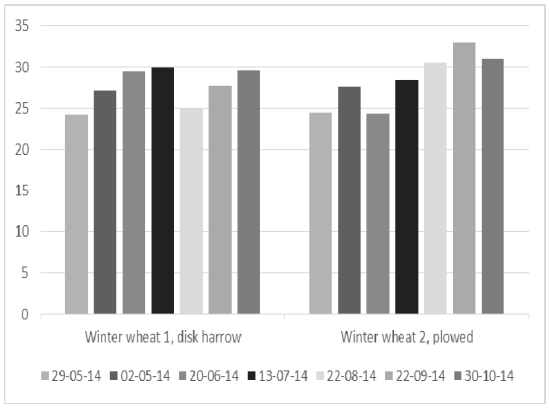

Figure 2 **Dynamics of soil moisture with winter wheat crop**

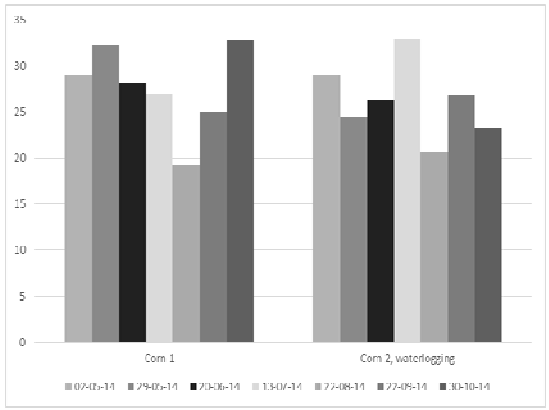

Figure 3 **Dynamics of soil moisture with corn crop**

With sunflower crop (*figure 4*) there can be observed that during the entire vegetation period the plants did not suffer yet around 29th of may 2014 in Fls1 and at 13th July in Fls 2 the soil moisture has increased a lot due to excessive rainfall.

With sunflower crop Fls 1 the soil moisture has decreased during the critical phase of grain formation and this period overlap on the hottest month of the vegetation period.

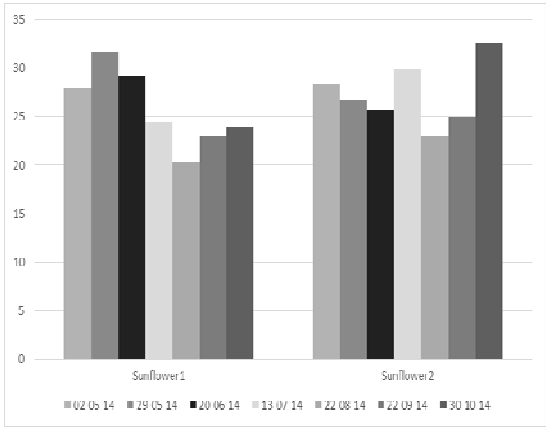

Figure 4 **Dynamics of soil moisture with sunflower**

As regard the dynamics of soil moisture on pasture there can be observed that it complies with the rainfall as well as with the air temperatures.

It is interesting that the lowest values of the soil moisture has been recorded at 22 august and 22 September 2014 on pasture, respectively, 19.77 % and 20.03% as compared with the soil moistures in the other field crops. This fact is due to high air temperatures during august and, especially, September 2014 (*figure 5*).

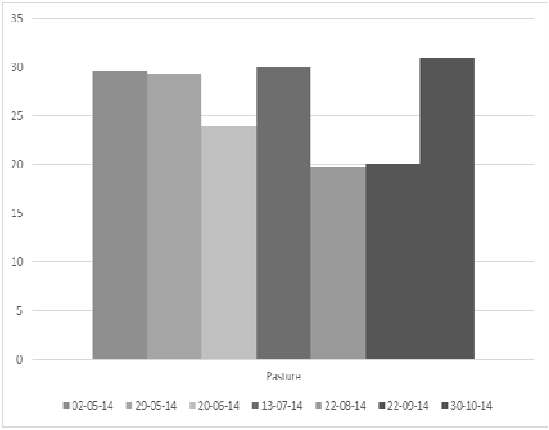

Figure 5 **Dynamics of soil moisture with pasture**

The analysis of the dynamics of soil moisture with four researched crops (table 2 and figure 6) and 7 variants of soil moisture determination, during 2014 reveals the following aspects:

- at the beginning of the vegetation period, when first determination was made, at 2.05.2014, there can be observed that the soil water reserve is close for all 7 soil samples being sufficient and normal for this period;

- with the second determination, at 29.05.2014 there appear differences with crops. With winter wheat crop that was, at this date, at the highest water consumption phase, the lowest soil moisture (24.19% and 24.41%) as compared with the other crops: 32.21% - Pb 1; 31.68% - Fls 1; 29.34% - Paj. The Pb 2 (24.46%) and Fls 2 (26.67%) variants have lower moisture due to the fact that these crops have been drilled much earlier in comparison with Pb1 and Fls 1 and they were much developed and their water consumption was higher;

- with the determination from 20.06 it has to be emphasized the fact that there was recorded a difference between the two winter wheat variants Gr1 (disk harrow) = 29.43% and Gr 2 (plowed) = 24.32% and, in the same time, the yield difference: Gr 1 = 6000 kg/ha, Gr 2 = 6500 kg/ha. This difference is the result of better water supplying.

- at 13.07, after rains, almost all variants recorded high moisture content except Pb1 and Fls

1 which recorded lower values of soil moisture till harvesting as compared with the other variants which proves a better water use and higher yields in comparison with Pb2 and Fls 2.

- the determinations after wheat harvesting indicate that the winter wheat plowed plot (Gr2) has stored more water in comparison with the winter wheat plot that was worked with the disk harrow as basis tillage. This fact proves better results with the plowing rather than disk harrowing as basis tillage for the winter wheat in this region.

Table 2

The comparative analysis of soil moisture (%) for researched crops

Date	Winter wheat 1, disk harrow	Winter wheat 2, plowed	Corn 1	Corn 2, waterlogging	Sunflower 1	Sunflower 2	Pasture	Rainfall Şerbăneşti (mm)
2.05.2014	27.15	27.61	29.02	28.94	27.98	28.37	29.57	160
29.05.2014	24.19	24.41	32.21	24.46	31.68	26.67	29.24	93
20.06.2014	29.43	24.32	28.14	26.38	29.22	25.71	24.01	50
13.07.2014	29.98	28.41	26.97	32.87	24.42	29.89	30.04	200
22.08.2014	24.89	30.56	19.25	20.64	20.33	23.05	19.77	43
22.09.2014	27.73	32.91	25.07	26.82	22.94	24.96	20.03	56
30.10.2014	29.58	31.03	32.78	23.34	23.87	32.58	31.01	54

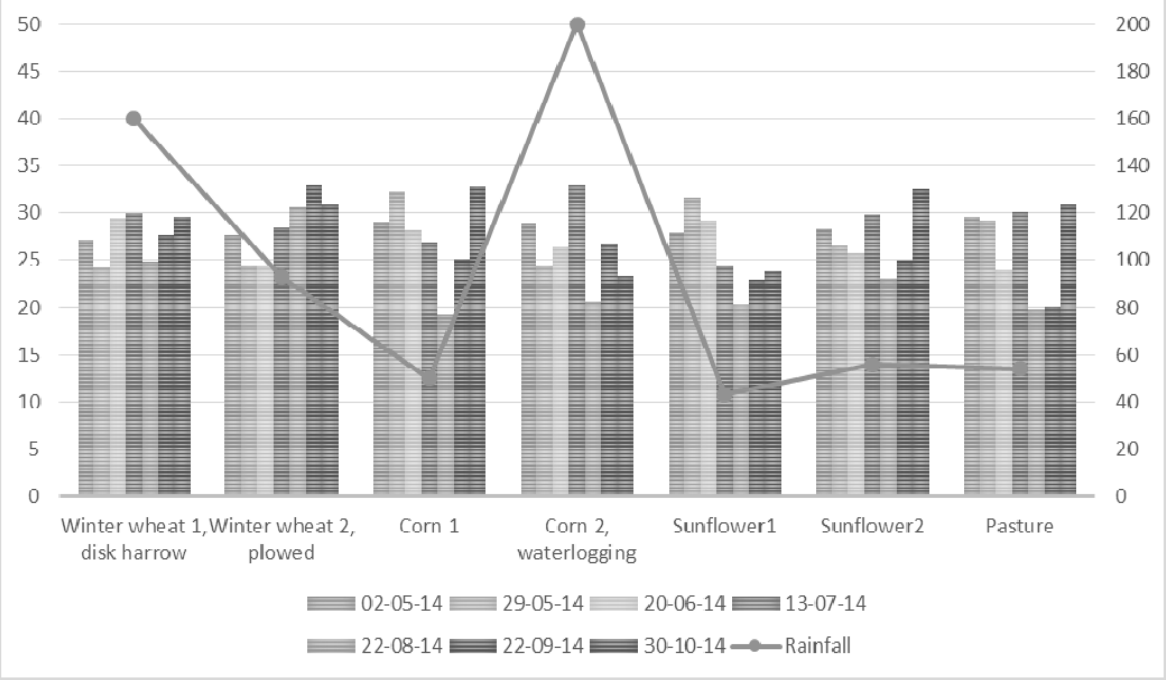

Figure 6 **Dynamics of soil moisture in function of rainfall**

CONCLUSIONS

The 2014 researching year can be characterized as an excessively humid and hot, recording rainfall of 1,074 mm and, during the vegetation period, approximately 708 mm.

The annual average temperature was of 11.8ºC and, during the vegetation period, of 17.8ºC.

Both rainfall and temperatures that were recorded within the researched area have overpassed the average multiannual values. There was recorded a plus of 455.5 mm rainfall and plus 1.3ºC temperature.

For the analyzed zone, on a clayey soil, the abundant rainfall determines difficulties in doing tillage and hoeing.

High rainfall yet uneven during the vegetation period determine a bad utilization of water by field crops. In order to avoid such situations there has to be identified the most appropriate tillage that determine the best water retention by soil.

For the winter wheat crop within the ear unfolding period till the end of grain formation there were recorded lots of rainfall (1 may-1 june), about 160 liter/m^2 which satisfied entirely the crop requirements for water and recording very good yields for this zone.

From the soil moisture data as well as from yield results we can conclude that the best option is to drill winter wheat in plowed land.

Considering the highest water consumption for the sunflower crop in 20^{th} of June – 10^{th} of August period and analyzing the rainfall within this period, we can conclude that this crop did not suffer being recorded best condition for plant development.

With the case of corn crop, during the critical phase of ear appearing till the end of grain formation (20 July – 25 August) the rainfall have been of approximately 100-150 liters/m^2 but the previous rainfall and the even terrain form determined soil waterlogging conditions with Pb2 variant and this fact determined high yield losses.

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