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ELEMENTS OF SOIL MOISTURE REGIME AT MAIZE CROP, WITHIN A FARM LOCATED IN MITOC - BOTOŞANI COUNTY, UNDER DROUGHT CONDITIONS CORRESPONDING TO 2012 AGRICULTURAL YEAR

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Abstract

Agricultural year 2012 was characterized, in terms of climate, by high temperatures in all cultivated areas of the country and small amounts of precipitation. According to official data it was estimated that, among the spring crops, the most affected by prolonged drought at national level was maize crop, on more than its half cultivation area. Climatic drought was completed by pedological drought, which led to installation of severe drought respectively, a soil moisture whose values were more below the values appreciated as optimum for field crops, according to specialized institutions. In this context, drought effects have also been strongly manifested in Moldavian Tableland and Plain region, especially in certain counties where, in the absence of irrigation systems, caused severe disturbances in spring crops development. Based on these considerations, the present work-paper highlights a few aspects regarding the soil moisture regime, during the vegetation period of maize crop, within a non-irrigated agricultural farm, specialized on plant production and located in north of Moldova (respectively Mitoc, Botosani county).
In order to get information on soil humidity and water reserve, determinations were made on soil momentary moisture in the field, at intervals corresponding to different development stages of maize. For establishing the range of soil water availability for maize plants, soil moisture was estimated in correlation with active humidity interval, using soil active moisture index (Iua). Active moisture index showed that, in the first stage of vegetation, soil water was very easily accessible to plants. Thus, maize plants benefit of a proper start in vegetation, covering the emergence - 8 leaves stage under very favourable conditions. At the end of June - early July, the active moisture index showed the tendency of soil moisture to decrease significantly, approaching - in terms of value - the wilting coefficient. Decreased soil moisture coincided with the beginning of maize critical period for water. In the period between panicle emergence - maturity, due to lack of rainfall, associated with pronounced increased temperatures, a drastic decrease of soil moisture could be registered; in this case, active moisture index showed a very low water accessibility for plant, the values being almost equal to the wilting coefficient. It can be state that, in year 2012, maize production in the investigated farm began to be influenced, in the sense of its diminution, since panicle emergence stage, drought manifesting until the end of the vegetation period. Thus, maize had not properly covered all its vegetation stages, reaching maturity much earlier. The 3.5t/ha average yield obtained was estimated as significant under the productive potential of the used hybrid, soil fertility and inputs applied.

Key words: *drought, maize, north of Moldova, active moisture index, soil water reserve.*

INTRODUCTION

In terms of climate, agricultural year 2012 was characterized by high temperatures in all agricultural areas of the country and small amounts of precipitation. Thus, July of 2012 was ranked as the second driest July in100 years, with precipitation that had not exceed the average 30 l/m, according to the official data provided by Romanian National Meteorology Administration (www.anm.meteoromania.ro). At country level, the total area affected by drought was estimated at approximately 3.7 million hectares, representing 40% of the arable land. Among the spring crops, maize has been one of the most affected by drought, on approximately 81.2% of its sown area, followed by sunflower, with 45.8% of the cultivated surface (www.madr.ro). Drought recorded to soil level (pedological drought) was added to the meteorological one, resulting a severe drought, respectively a soil moisture between 300-600 m3/ha, considerably low, taking into account that optimal value is usually considered between 1250-1600 m^3/ha (www.anm.meteoromania.ro).

Under these conditions, Moldavian region made no exception, in terms of lack of rainfalls effect; here, the drought was accentuated manifested, especially in certain counties where, in the absence of irrigation systems, has caused severe disturbances in the development of spring crops (especially to the species where weeding is applied), disturbances which limited drastically the possibility of obtaining adequate agricultural yields. In this context, it appears right that "the high degree of climate variability is one of the biggest risk factors for production and producers have to continuously consider this aspect in modern agriculture" (Nagy, 2010) especially when the droughty years are significantly more frequent in the last decades. More, the capacity of soils to maintain plants life essentially depends on their state of moisture, as Chiriță specified (1974) and larger yields are only achieved with higher precipitation, as it was also demonstrated in a long-term experiment carried out in Debrecen, Hungary (Nagy, 2010).

Based on these considerations, the work-paper highlights a few aspects regarding the soil moisture regime, during the vegetation period of maize crop, within an agricultural farm, specialized on crop production, located in north of Moldova, respectively Mitoc-Botosani county. Like in many other cases, the entire farm area does not benefit of irrigation facilities, so it is clear that water becomes a restrictive factor in the very droughty years.

In 2012, the agricultural unit has had the next crop structure: winter wheat (200 ha), maize (250 ha), sunflower (150 ha) and soybeans (100 ha). The dominant soil type is represented by phaeozem, with the following features: loamy texture (with 29.8% clay content in the first horizon and 30.5% in the second one), medium humus content (4.8-4.32%), neutral soil reaction (pH 7.1-7.5), good supply in potassium, moderate supply in nitrogen and low phosphorus content (Ştefan C. and Ştefan G., 2012). In the paper, the soil water regime is regarded in correlation with the symptoms that maize plants manifested, as a natural physiologic response to drought, the way it could be found by observation during plant vegetation.

MATERIALS AND METHODS

In order to monitor soil moisture and soil water reserve, observations and measurements were made in the field, at intervals corresponding to different developmental stages of maize, in this way emphasizing the critical periods for water. Thus, at the crop setting up and throughout the maize vegetation, soil moisture was monitored using a portable MLMO750 soil moisture meter, by sampling from 0-20 cm and 21-60 cm. In total, 9 determinations on momentary moisture (W%) were done, as follows: 1 in April, 2 in May, June and July, and 1 determination in August and September.

The value of soil clay content allowed the calculation of field water capacity-CC(%) and wilting coefficient-CO(%) indicators, based on formula: $CO=0.05+0.35A$, $CC=21.2+0.0626A$ (A-clay content% corresponding to the analysed horizon) (Udrescu et al., 2002). Estimation of CO and CC indicators was made in accordance with the limits set by the specific methodology (Udrescu et al., 2002; R.M.S.S.E., 1987).

To highlight the amount of soil water that can be used by maize plants in various stages of their vegetation, it appeared the necessity to estimate the soil moisture in correlation with active humidity interval (IUA), by calculation of active humidity index: Iua or W(%IUA). Iua points out how much soil moisture, determined at a given time, represents (in percentage) of active humidity interval, based on the formula: $W(\%IUA)$ or $IUA = W\text{-}CO/CC\text{-}CO \times 100$ (Chiriţă, 1974) taking into account that the difference between CC and CO is the active humidity interval (or soil usable water capacity). The determination of active humidity indices presents a great practical importance because they express the degree of water accessibility for plants (Chiriţă, 1974).

The obtained values were framed based on the intervals: W(%IUA)/Iua < 0 inaccessible humidity; W(% IUA)/Iua = 0-20 - very difficult to access humidity; W(%IUA)/Iua = 20-50 – medium accessible humidity; W(% IUA)/Iua = 50-90 - easily accessible humidity; W(% IUA)/ Iua = 90-100-very easily accessible humidity; Iua = 100, when W = CC; Iua > 100, when W > CC and Iua = 0, when W=CO (Chiriţă, 1974; Petcu, 2012).

The momentary moisture and bulk density (BD-g/cm^3) values allowed the calculation of moisture as a percent of soil volume (Wv%): Wv% = W x BD. Based on the value of Wv%, soil water reserve (m3/ha) on 0-60 cm interval could be estimated later on: W(m^3/ha) = Wv x H, where H - soil depth (cm) (Udrescu et al., 2002). The results on momentary moisture and active moisture index were periodically recorded and correlated with the changes that occurred on maize plants, as a result of drought.

As for the investigated maize crop, the applied technology consisted of: winter wheat as previous crop; ploughing in autumn at 35 cm depth with advanced machinery equipment; seedbed preparation conducted with combiner; sowing in April 2012, between 12-17th,with an aggregate consisting of tractor and Amazon precision drill, at 70 cm distance rows and 5-6 cm depth. Seed material was represented by 4490 DKC semi-early maize hybrid, pre-treated with plant protection products (insecticides and fungicides), assessed as high efficient and currently existing on the market. 63,000 seeds/ha was the assured density in the field, a value recommended for the used hybrid in non-irrigation conditions. Fertilization was performed with NPK complex fertilizer 15:15:15 (250 kg/ha). For weed control during vegetation, two herbicides mixture was applied; the maize crop also benefit by application of a zinc and manganese foliar fertilizer.

RESULTS AND DISCUSSIONS

First determination on soil momentary moisture was performed after sowing. It was then also when bulk density values were registered: 1.21 g/cm^3 in 0-20 cm interval and 1.23 g/cm^3 for 20-60 depth (Table 3). The calculated values for field water capacity and wilting coefficient are: 23-23.1%, in case of field water capacity (rated as medium-limits between 21-25%) and 10.1-10.7%, in case of wilting coefficient (rated also as medium-limits between 9-12%).

As a result of first determination on moisture, it has been noted that maize crop shall benefit of a good start at the beginning of its vegetation; moisture values ranged from 20.1% at 0-20 cm depth to 22.1% at 21-60 cm, reflecting a soil water content assessed as easy and very easily accessible for plants, according to the calculated values of active humidity index: Iua=77.2% on 0-20cm, respectively 92.6% on 20-60cm (Table 3, Figure 1).

As a consequence of that, soil water supply favoured an uniform germination and emergence of plants, as it could be observed while monitoring the field; the very good start in vegetation ensured a 63,000 plants/ha density, overall.

In the first decade of May, due to the recorded precipitation corresponding to late April that provided a favourable moisture level, the momentary moisture values indicated that humidity was very close to field water capacity level, respectively 23.1% on 0-20cm depth and 23.7% on 21-60 cm (Table 1, Table 2). Active moisture index showed, in case of both measurements from May, that soil water was very easily accessible to plants: 100.5%-105.6% at the beginning of month and 118.3%-122.7% at the middle of month (Figure 1). In this way, maize plants started well in their vegetation, covering the emergence - 8 leaves stage under very favourable conditions.

At first determination on soil moisture in early June, active moisture index showed that water was still easily accessible to plants, becoming medium accessible in the second half of the month (Figure 1). At the end of June-beginning of July, water availability for plants continued to decline, as the index showed the tendency of soil moisture to approach the wilting coefficient, recorded values being noted as: between 42.4 to 30.7% on 0-20 cm interval, respectively from 43.8 to 30.8% on 21-60cm interval (Figure 1). The drought installation effects began to become observable to plants level, consisting of front leaves twisting (noticeable especially during 12-16 hour interval).

Soil moisture decreasing coincided with the beginning of maize critical period for water, respectively 8 leaves – panicle emergence stage (Table 3).

In stage 3 of plant vegetation (panicle emergence-maturity), due to lack of rainfall, correlated with the sharp increase of temperatures value (consecutive days with temperatures above 38ºC), it could be registered a drastically decrease of soil moisture. Thus, it was observed that, on both depth considered, soil moisture values decreased to near wilting coefficient and active moisture index is between 0 and 20%, which indicates a very difficult accessibility of water for plants (Figure 1).

The soil water reserve (m^3/ha), which values were cumulated for the two depth considered (Table 3) reflects the evident variation of water quantity during maize vegetation: 1573 m^3/ha at the beginning (in accordance with optimal limits) and continuous diminution up to 776 m3/ha, in early September.

Table 1. Average amount of precipitation (l/m^2) in 2012 registered at Avrameni-Boto? ani meteorological station

Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.
19.4	80.8	39.0	32.9	30.2	29.7	2.4	31.1	21.8

Table 2. Field water capacity (FWC/CC) and wilting coefficient (CO), estimated by indirect method (calculation)

Depth (cm)	Clay content (%)	CC (%)	CO (%)
0-20	28.8	23	10.13
20-60	30.5	23.1	10.7

Table 3. Elements concerning soil moisture regime, in correlation with maize vegetation stage

Maize vegetation stage	Determination date	Soil depth	Soil moisture (W%)	BD (g/cm^3)	Soil moisture (Wv%)	Soil water reserve/depth (m^3/ha)	Soil water reserve (m^3/ha) (0-60 cm)
Stage 0: sowing, germination-emergence	20.04.2012	0 - 20	20.1	1.21	24.3	486	1573
		20-60	22.1	1.23	27.1	1087	
Stage 1: emergence-8 leaves	2.05.2012	0 - 20	23.1	1.21	27.9	559	1725
		20-60	23.7	1.23	29.1	1166	
	12.05.2012	0 - 20	25.4	1.21	30.7	614	1883
		20-60	25.8	1.23	31.7	1269	
Stage 2: 8 leaves - panicle emergence	3.06.2012	0 - 20	17.8	1.21	21.5	430	1330
		20-60	18.3	1.23	22.5	900	
	15.06.2012	0 - 20	15.6	1.21	18.8	377	1169
		20-60	16.1	1.23	19.8	792	
	5.07.2012	0 - 20	14.1	1.21	17	340	1053
		20-60	14.5	1.23	17.8	713	
Stage 3: panicle emergence –maturity	26.07.2012	0 - 20	12.7	1.21	15.3	307	951
		20-60	13.1	1.23	16.1	644	
	14.08.2012	0 - 20	11.2	1.21	13.5	271	846
		20-60	11.7	1.23	14.3	575	
	10.09.2012	0 - 20	10.15	1.21	12.2	245	776
		20-60	10.8	1.23	13.2	531	

Wv (%) = Wg x BD; W(m^3/ha) = Wv x H

In the field, it could be directly observed the emphasized effects of symptoms caused by lack of water: phenomena of irreversible wilting leaves that were associated with an obvious diminution of plant growth rhythm. Soil level drought associated with atmospheric drought caused the shortening of silking period, a low development of male and female inflorescences, which then generated the shortening of the pollination period; as a consequence of that, a large number of low developed cobs resulted. As a whole, the acceleration of the metabolic processes caused by installation of drought led to the evident shortening of the vegetation period (Figure 2). More, dry time that has followed, corresponding to August-September period, has caused poor grain filling, characterized by a high percentage of shrivelled grains.

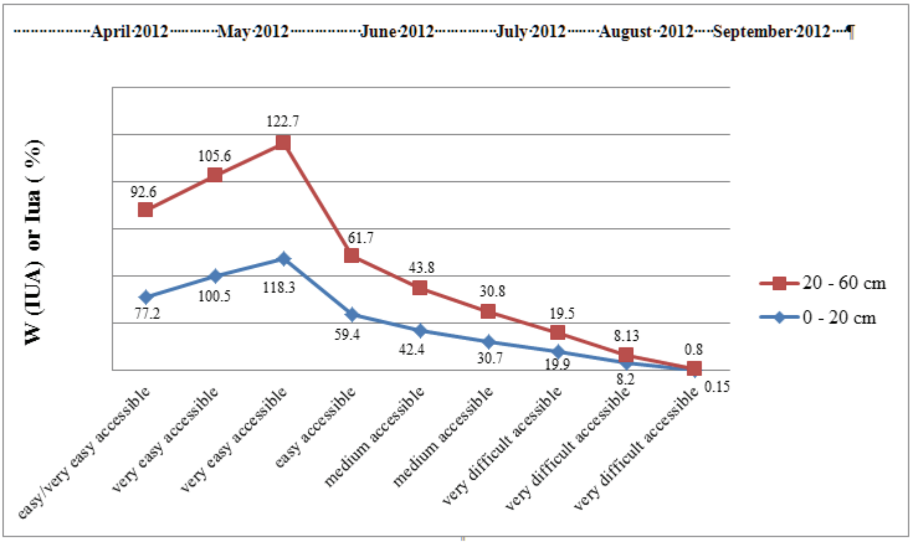

Figure 1. The availability of soil water to maize crop in 2012 agricultural year, within the analyzed farm, illustrated by the variation of active humidity index IUA (%), determined based on soil moisture, wilting coefficient (CO) and field capacity (CC) indicators-Mitoc, Botosani

Also, it was observed a decrease of the cobs size, a decrease of cob rows and grains per row, which conducted to the thousand kennels weight (TKW) diminution. All these symptoms have been observed in the field, in the mentioned period.

As a result of severe drought, the maize crop in the investigated farm has reached maturity much earlier, compared to its natural vegetation period. In this context, it appeared the necessity to initialize harvesting, which began in September, the 15th.

In the end, the effects of drought have been reflected by the medium yield registered: 3.5 t/ha, estimated as significant under the productive potential of the used hybrid, soil fertility and inputs applied.

Figure 2. Crackers at the soil layer as an effect of drought (left) and general aspect of maize crop in mid August (right) (original)

CONCLUSIONS

Severe drought that affected Botoşani agricultural region in 2012 has generated accentuated disturbances in agricultural cycle. An eloquent example in this respect was recorded at a field crop agricultural unit located in Mitoc where, despite the proper technology application and inputs applied, it conducted to the increased diminution of maize yield level.

In soil, the installation of drought was reflected by the momentary moisture values, active moisture index and soil water reserve, which indicated that water has become a limitative factor for plants since the middle of June and continued to decrease drastically in the following period.

Due to the small level of precipitations in July and August, correlated with high level of temperatures, drought effects were manifested at maize until the end of vegetation period, an aspect which accelerated the metabolic processes and led to necessity of harvesting before time.

As a result of that, maize crop did not properly covered all its vegetation stages and yield has shown the tendency to decrease since the panicle emergence stage.

It can be state that, in the next years, the amount of rainfalls and most of all, its repartition during field crops vegetation shall continue to represent the most influential factor for agricultural production, in the absence of irrigation.

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