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# CRITICAL SOIL MOISTURE IN RAINFED SOYBEAN FIELD

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**Summary.** The content of soil moisture in different soil horizons of soybean fields in the 0-150 cm layer was studied in years with different meteorological conditions. The current forecast of the degree of aridity of the growing season is carried out according to soil moisture data in the soil layer 0-150 cm. In the sawing the critical level of soil moisture in rainfed soybean fields was 300 mm. In the pod filling stage the critical level of soil moisture in rainfed soybean fields was 200 mm.

**Keywords**: *field soybean, soil moisture, deep soil horizons, drought.*

**Introduction**. Any decrease in non-beneficial water consumption must result in increased production per unit of consumed water [9]. The absorption of water by the roots of soybean plants is an important factor in the water consumption of the cenosis. At least half of the root biomass could be found in the upper 20 cm of soil for all crops [3]. For annual crops, soybean showed deeper rooting depth than other crops, with 95% of roots occurring in the top 138 cm and with a maximum rooting depth of 180 cm [5]. Plant height correlated with rooting depth about twice the plant height until the six-node stage [8]. Under rainfed conditions during a drought period, the matrix potential of the soil in the surface horizons can decrease more (less than -0.8 MPa in a layer of 0-30 cm) than in deep horizons (-0.4 MPa at a depth of 122 cm), as a result soil matric potential data indicated significant water extraction at the 153-cm depth in the rainfed field near the end of the drought [10]. The aim of the work was to assess the soil moisture content particularities in different soil horizons of soybean agrocenoses in the 0-150 cm layer.

**Materials and methods**. The studies were carried out in 2018-2023 at the fields of the Institute of Genetics, Physiology and Plant Protection (IGFPPP)

with different soybean varieties (Amelina, Aura, Laduţa). To assess meteorological conditions was used the relative precipitation index (RPI) - the ratio of precipitation sum for the given period P and the long term average for the same period P expressed in percent, RPI = P/P*100%; for long period (quarter, year) are such criteria of RPI value: 0-49,9% (extremely dry), 50,0-74,9% (very dry), 75,0-89,9% (dry) and 90,0-110,0% (average) [7]. Gravimetric soil moisture samples were taken by hand drill AM-26 at 10 cm depth increments to 150 cm deep. For each horizon, soil samples were taken in triplicate. To determine soil moisture, the samples were dried in an oven at 105 °C to constant weight [1]. To reduce the effect of random scatter, a one-time smoothing procedure using the “moving average” method was applied to the gravimetric soil moisture results before presentation in a graphical form: in this case, each point of the curve is consistently the average result of the experimental tabular data for this point and two adjacent (upper and lower 10cm layers). To determine the volumetric soil moisture content, the gravimetric data were multiplied by the soil density values, obtained experimentally [6]. Water use efficiency (WUE) is defined here as seed yield divided by the sum of seasonal rainfall together with a seasonal decrease in soil water amount in the 0-150 cm layer.

**Results and discussions**. The season of 2018 was the most moisture-provided (both in the «winter» period of accumulation and during the growing season). The six years consist of two triples (normal, dry and extremely dry): 2018, 2019 and 2020; 2021, 2022 and-2023. Of the extremely dry seasons, the contrasting ones are 2020 (after two "winter" droughts, which was the first time for the entire period of observations since 1900) and 2023 (after two "summer" droughts). Two years (2019 and 2022) meteorological conditions were almost the same.

Fig. 1 shows distribution of water in different soil layers of a soybean field and bare soil (2023).

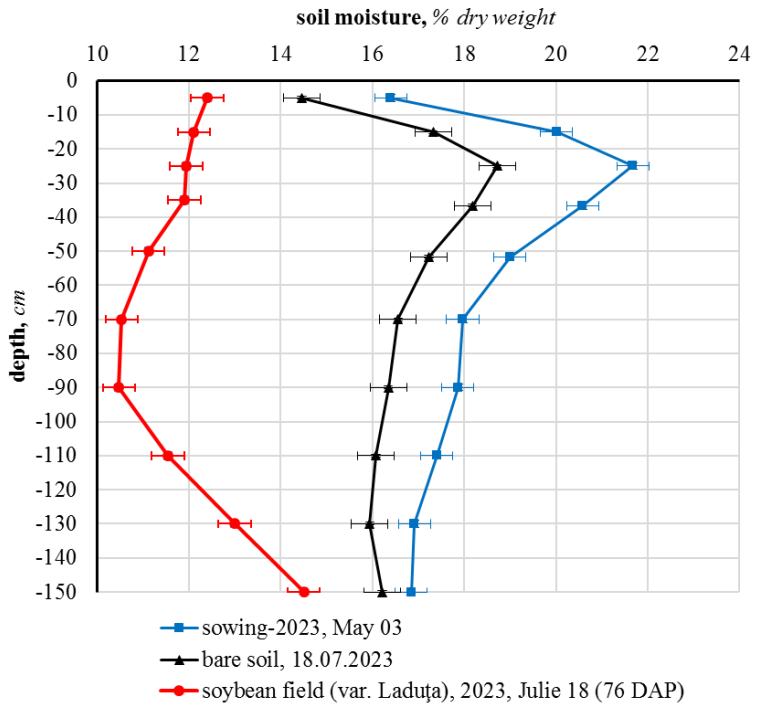



Fig. 1. Distribution of water in different soil layers of a soybean field and bare soil (2023).

During the growing season, soil moisture decreases not only under plants, but also on soil without plants. For soil without plants (bare soil), a significant decrease in moisture by the date of July 18 relative to the sowing date was noted for a layer of 20-30 cm. In reality, the absorption of moisture by plants from the surface horizons is greater than that only from soil moisture, since the upper horizons contain the bulk of soybean roots: more than 50% in the 0-11 cm layer [3], and 77% in the 0-40 cm layer [4] The decrease in soil moisture reserves in the 0-40 cm layer by 38 mm (to 76 DAP) does not reflect the real water consumption in the soybean field, which by this time is 188 mm (taking into account 129 mm from the decrease in soil moisture reserves in the layer 0-150 cm and 59 mm of precipitation). The decrease in soil moisture reserves by 63 mm in the 40–100 cm layer not only reflected the activity of roots in this layer, but also explained the active role of roots in more deep horizons (soil moisture significantly decreases to 120 cm).

Fig. 2 shows distribution of water in different soil layers of a soybean field at sowing and harvesting (2018, variety Amelina).

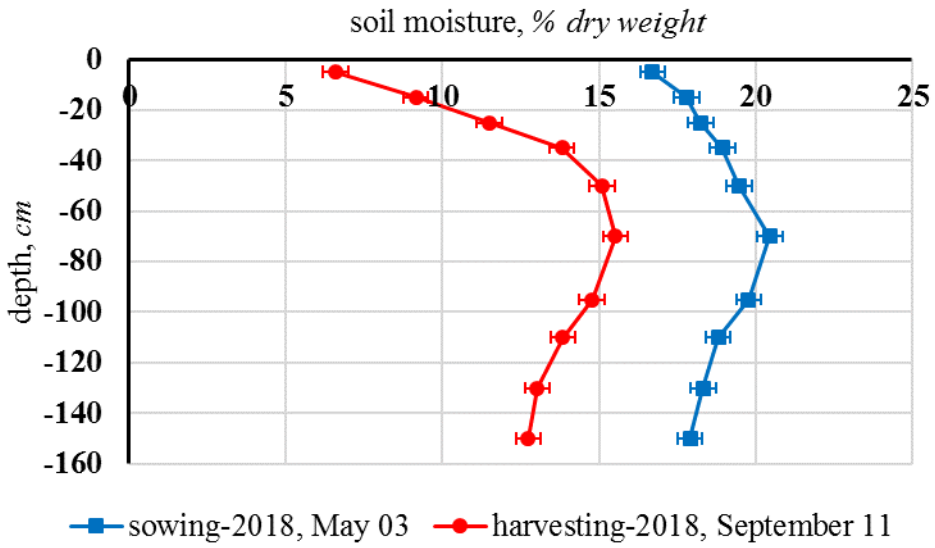



Fig. 2. Distribution of water in different soil layers of a soybean field at sowing and harvesting (2018, variety Amelina).

At sowing-2018 soil moisture was significantly high (17-20%) in all layers from 0 to 150 cm. During the season-2018 under soybean plants soil moisture significantly decreased in all layers from 0 to 150 cm. High soil moisture at sowing promotes plant growth. In the presence of available, with Ψ ~ -0.3 MPa, moisture in deep horizons, young plants easily run away from surface drought. The water potential was -0,35 MPa in the elongating root region [2]. Under favorable conditions, the primary root and several major laterals grow rapidly and may reach a depth of 2.5 to 3.25 feet by V6 [11]. Deepening the roots increases the amount of water used.

The seasonal decrease in soil moisture reserves in the 0-40 cm layer (by 44 mm) does not reflect the real seasonal water consumption in the soybean field, which is 438 mm (taking into account 104 mm from the decrease in soil moisture reserves in the layer 0-150 cm and 318 mm of precipitation, including 162 mm in June, 231% of the long-term average). With the yield 365±36 г·м$^{-2}$ WUE was 0,87±0,08 g/kg $H_2O$.

At sowing-2020 soil moisture in the field of Amelina variety was significantly low (11-14%) in all layers from 0 to 150 cm. Pre-sowing soil moisture reserves in the 0-150 cm layer were small, 251 ± 1 mm, which is 120 mm less than in 2018. Water consumption occurred primarily from surface soil horizons, which was also facilitated by precipitation (June -86 mm; July - 111

mm). Residual (when harvesting in 2020) soil moisture reserves in 0-150 cm layer amounted to 179.0 mm. The seasonal decrease in soil water reserves from the 0-150 cm layer was 72±1 mm. The seasonal decrease in soil moisture reserves in the 0-40 cm layer (by 41 mm) does not reflect the real seasonal water consumption in the soybean field, which is 288±20 mm. WUE was low, ~0,2 g/kg $H_2O$ (combine harvesting).

Fig. 3 shows distribution of water in different soil layers of a soybean field at sowing and harvesting (2019 and 2022, variety Aura, linia A2).

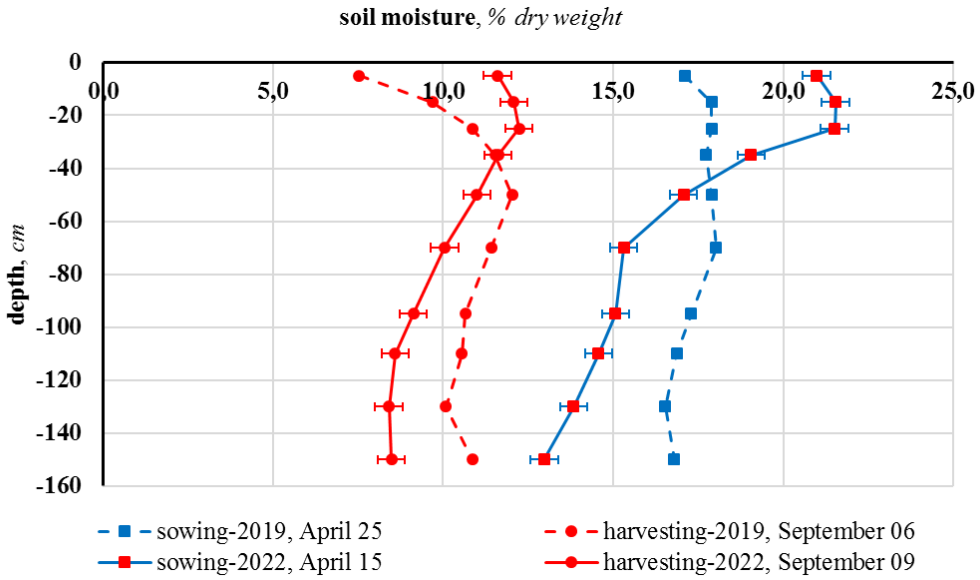



Fig. 3. Distribution of water in different soil layers of a soybean field at sowing and harvesting (2019 and 2022, variety Aura, linia A2).

In 2019 and 2022, in the soil layer of 0-150 cm, the moisture reserves during sowing averaged 340 ± 6 mm (346 and 334). During harvesting, soil moisture reserves in the 0-150 cm layer were 211±1 mm. Decrease in soil moisture reserves for the seasons of 2019 and 2022 averaged 121±13 mm (134 and 108 mm). Seasonal precipitation in 2019 and 2022 averaged 219±16 mm (203 and 235 mm). Total water consumption for the seasons 2019 and 2022 averaged 341±2 mm (339 and 343 mm).

In 2022, the greatest soil drying was not at the time of harvesting, but 1.5 months earlier. On 07/26/2022 (102 DAP), only 179,4 mm remained in the 0-150 cm layer, while on 07/25/2019 (91 DAP), 219,8 mm remained in the 0-150 cm layer.

WUE on average for 2019 and 2022 was 0,54±0,06 g/kg $H_2O$ (0,60 and 0,48). Ceteris paribus, the reason for the higher WUE in 2019 compared to 2022 seems to be June precipitation: 83 mm versus 7 mm. The same reason may explain and the Aura soybean crop in 2011 (750 g $m^{-2}$), when upon normal moisture during the accumulation of soil moisture (from September 2010 to April 2011, 314 mm fell at a norm of 306 mm), in June precipitation fell 150 mm (288% of the norm in 66 mm).

**Conclusions**. A preliminary forecast of the possibility of drought is made before sowing according to weather data on precipitation: relative precipitation index value (*RPI*) for the previous period of accumulation of moisture in the soil (from September of last year to April of this year). The current forecast of the degree of aridity of the growing season is carried out according to soil moisture data in the soil layer 0-150 cm.

In the sawing the critical level of soil moisture in rainfed soybean fields was 300 mm. In the pod filling stage the critical level of soil moisture in rainfed soybean fields was 200 mm. An additional significant (with good pre-sowing moisture reserves) factor in the moisture supply of soybean plants is an increased amount of precipitation in June.

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