PLANTS AND SOIL MOISTURE

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Summary

As it follows from the report of the UN World Food Program, currently 850 million out of 6.5 billion people on the Earth are constantly undernourished. And this takes place in spite of the fact that the area of plains on the Earth (available for intensive agriculture) and solar radiation could provide with food more than 25 billion people. But in semi-desert and desert regions of the tropical zone (where a large part of developing countries are located) only 1% of potentially available soils is used. Totally, more than 50 million square kilometers of potentially available soils remain unused due to lack of water in soils. Vast barren deserts (Sahara, Gobi, Atacama, Kalahari, Central Australia) whose areas reaches 25 million square kilometers are located in central parts of continents where the amount of precipitation is very small. These soils are huge reserve for agriculture in the case of irrigation, and huge volumes of water are contained in lakes, rivers and underground reservoirs in humid zone. Part of this water can be transported into an arid one (of course, with consideration for ecological conditions). Perspectives of iceberg seaborne transportation from polar latitudes to the subtropical and tropical ones are interesting and seem to be realistic. But, these expensive measures will give desirable effect and its may be dangerous for Nature in the case of smattering of physiology of plants, physics and reclamation of soils, geography, climatology and other associated sciences. This article presents briefly and in a popular manner the ideas from the area of interaction between plants and soil moisture, necessary for efficient and ecologically competent solution of the problem of food provision for the Earth population.

1. Water in Soil and Plants is the Object of Inter-disciplinary Investigation

Plants and the soil moisture are necessary components of any land ecosystems. Finding out of laws of the soil moisture absorption by plants is a problem of scientific discipline

called “ecological hydrophysics of soils”. Owing to their great practical importance this problem has long been investigated by ecologists, physiologists of plants, pedologists, meteorologists, and hydrologists.

The physiologists paid the most attention to influence of the content and the state of water in plants on various physiological and biochemical processes. Numerous studies, partially generalized in the symposium «Environmental Control of Plant Growth» (1957) and monographs of A.M. Alekseev (1948), N.A. Maximov (1952), R.O.Slatyer (1970), proved that the active component of plants (i.e. the protoplasm) should normally contain, on average, more than 85% of water. Reducing of water content in plants results in deterioration of the physiological processes (especially the photosynthesis), and, as a consequence, plant biomass reduction, and at the moisture content less 33% proteins completely loose the vital activity. The water content in plants is determined by difference between intensity of water input from a soil and evaporation from leaves (i.e. transpiration), which is proportional to intensity of CO_2 input from the atmosphere. Since CO_2 is needed for the photosynthesis, absorption of water by plants from a soil is also necessary. To do this, plants develop deep and branched root system.

Since initial cause of the water movement in the system “soil-plants-the atmosphere” is the transpiration, it is studied very actively. Theoretical and experimental works of hydrometeorologists have demonstrated that, at the optimal soil moisture content, evaporation from plane surface of vegetation on large territory is nearly equal to evaporation from water surface, and it is determined mainly by intensity of the heat energy influx to the evaporating surface (under condition of free removal of the vapor from the surface). However, if a vegetation surface is not plane, it influences (sometimes very strongly) on the plant transpiration per unit of the soil surface. For instance, transpiration of sparse trees in the meadow may be very high (phenomenon of the “oasis effect”). But, laws, governing this process, are not a consequence of specific physiological characteristics of plants or soil physical properties. Its manifest themselves only when soil moisture content and its availability became low.

Several characteristic levels of the soil moisture content are used in the soil hydrology: 1. Field capacity is optimal soil moisture content for plants; 2. Soil moisture content at the slowing-down of the plant growth is usually associated with “lento-capillary point”; 3. Permanent wilting point is the soil moisture content at the moment when plants (usually barley or sunflower) show signs of permanent wilting; 4. Unavailable moisture for plants is usually associated with maximum hygroscopic water. However, in the intervals between these levels availability of the soil moisture for plants changes rather gradually. These phenomena are very complicated, but they can be understood using the thermodynamic method.

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Biographical Sketches

Ivan I. Sudnitsyn, Dr.Sc., professor was born in 1932 in Moscow (Russian Federation). In 1955, he graduated from Lomonosov Moscow State University as a soil scientist in the area of agrochemistry. A citizen of Russia, he is now one of the leading Russian scientists in the field of ecological soil hydrophysics. His PhD (1962) and Doctor (1979) theses (dissertations) were devoted to investigation of the soil moisture movement and consumption by plants. In 1955-1965, he worked in the Institute of Forest of the Russian Academy of Sciences, in 1965-1968 – in the Institute of Applied Physics, and since 1968 he is fellow scientist of the Soil Science Faculty of Lomonosov Moscow State University. He repeatedly participated in International Congresses of Soil Science. He is the author of over 200 scientific publications (including 12 monographs) and 10 inventions. He is the Honorary Scientist of Russian Federation (2006) and Academician of the Russian Academy of Natural Sciences. He is also Laureate of the Lomonosov Prize (1982) for works in the field of science, and Laureate of the President Prize (2005) for works in the field of education.

Evgeny V. Shein, Dr.Sc., professor was born in February 1950 in Moscow (Russia). In 1972, he graduated from Lomonosov Moscow State University as a soil scientist in the area of agrochemistry. A citizen of Russia, he is now one of the leading Russian scientists in the field of soil physics. His PhD (1975) and Doctor (1991) theses (dissertations) were devoted to investigation of the soil moisture movement and consumption by plants. Since 1975, he works at the Soil Science Faculty of Lomonosov Moscow State University, and since 1998 he is Head of the Chair of soil physics and melioration. He repeatedly participated in International Congresses of Soil Science. He is Chairman of the Soil Physics Commitee of the Dokuchaev Soil Science Society. He is the author of over 200 scientific articles, monographs, inventions and discovery. He is also the Williams Prize Laureate (2008).