Determination of the profile available water capacity of maize and wheat at different growth stages

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Abstract

The profile available water capacity (PAWC) for maize and wheat was determined at different growth stages. In previous studies difficulty was experienced with pre-dawn leaf water potential (PLWP) as an indicator of first material stress (FMS) under conditions of high evaporative demand and other parameters had to be tested. It was decided to use the leaf expansion rate (LER) to indicate FMS in maize plants and the stem elongation rate (SER) in wheat plants during early growth stages. LER and SER proved to be reliable parameters during the early growth stages while PLWP could be used to indicate FMS in mature plants. It was also found that young maize and wheat plants were more sensitive than older plants with respect to water stress as indicated by PLWP. During early growth stages (i.e. until the 14-leaf stage in maize or until the appearance of the first node in wheat) FMS was clearly identified when PLWP decreased to approximately -800 kPa. In mature plants, FMS was clearly identified only when PLWP dropped well below -1 000 kPa. PAWC values found during this study showed that the maximum PAWC value is already reached at the 14-leaf stage for maize and at the appearance of the flag leaf for wheat, quite some time before flowering stage. This illustrates that mild water stress during the vegetative growth stage stimulates root growth.

Nomenclature

FMS	–	first material stress
LAP	–	leaf area parameter
LER	–	leaf expansion rate
LOL	–	lower limit
PAWC	–	profile available water capacity
PLEXW	–	potential extractable water
PLWP	–	pre-dawn leaf water potential
SER	–	stem elongation rate

Introduction

Vanassche and Laker (1991) give a comprehensive review of research on profile available water capacity (PAWC).

Hensley and De Jager (1982) defined PAWC for a specific crop and soil under a certain evaporative demand as "the amount of water which is held in the effective root zone between field capacity and first material stress". The lower limit of PAWC (i.e. FMS) is defined as "the quantity of water in the soil profile at the degree of crop water stress at which the next irrigation should be applied if optimum yield is to be obtained". This definition was later changed by Hensley (1984) to read: "First material stress can be defined as the soil water content at which plant physiological processes have been reduced by 25% of their normal rate". Hensley and De Jager (1982) defined field capacity (upper limit of PAWC) as the amount of water retained in a soil profile when free drainage has effectively ceased.

Prior to the research of Vanassche and Laker (1989) PAWC determinations and related studies were always conducted at the full canopy phase or flowering stage (Hensley and De Jager, 1982; Boedt and Laker, 1985). A need existed for studying PAWC at different earlier growth stages and its evolution as the plants mature. This was the first objective of this study. The second objective was to improve identification of FMS in view of the unsatisfactory results found by Laker et al. (1987) with PLWP and visual symptoms under conditions of high evaporative demand.

Materials and methods

This paper uses experimental data reported by Vanassche and Laker (1989). The research was conducted at the Cradock Research Station of the Department of Agriculture and Water Supply near Cradock in the Eastern Cape Province, Republic of South Africa. Cradock (32°08' S, 25° 37' E; situated 660 m above sea level) is situated about 250 km north of Port Elizabeth at the eastern border of the Great Karoo, a large semi-arid region in the central part of South Africa. The young soil of alluvial origin is classified according to the South African binomial soil classification system (MacVicar et al. 1977) as an Oakleaf (Limpopo series). According to Soil Taxonomy (USDA, 1975) the soil is classified as a Mollic Ustifluvent.

Five plots of 5 x 5 m were laid out for each experiment. Aluminium neutron hydroprobe access tubes were inserted in each plot to a depth of 1 500 mm. The plants were protected against animals by a fence of strong netting and rain was kept off the plots by movable rainsheds. Flood irrigation was practised and a centrifugal pump, which was calibrated at regular time intervals, was used to transfer water from the furrow to the plots. To prevent soil erosion in the plots the water was pumped into a small basin adjacent to the plot. In one experiment maize *(Zea mays* L.), cultivar Pioneer PNR 542, was planted on 20/10/1986 at a density of 40 000 plants/ha. In another experiment wheat *(Triticum aestivum* cv Zaragossa) was sown on 8/07/1985 at a density of 100 kg of seed per hectare. Fertiliser applications (based on chemical soil analysis), planting densities and pest and weed control treatments were applied according to the standard recommendations of the Cradock Research Station.

Soil water measurements were carried out on a daily basis by means of a Campbell Pacific Nuclear Neutron hydroprobe (model CPN 503). The instrument was calibrated against different soil water contents determined gravimetrically at depth intervals of 150 mm.

A pressure chamber similar to the one described by Scholander et al. (1964)was used to determine PLWP. The methods of

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