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

FMG Vanassche[1*] and MC Laker[1]
Department of Soil Science, University of Fort Hare, Alice, Republic of Ciskei

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

*To whom all correspondence should be addressed.
1) Present address: Department of Soil Science and Plant Nutrition, University of Pretoria, Pretoria 0001, South Africa.
Received 18 June 1992; accepted in revised form 28 September 1992.

TABLE 1
GROWTH STAGES AT WHICH DRYING CYCLES FOR MAIZE AND WHEAT WERE STARTED

Maize		
Plot	**Phenological stage**	**Days after planting**
a	4-leaf	27
b	6-leaf	37
c	8-leaf	47
d	12-leaf	57
e	used as a well-watered control plot	
Wheat		
Plot	**Phenological stage (*)**	**Days after planting**
a	3	35
b	5	55
c	7	68
d	8	75
f	flowering	100

*Phenological stages according to Large (1954)
Stage 3: Thillering
Stage 5: Leaf sheaths strongly erected
Stage 7: First node of stem visible
Stage 8: Flag leaf just visible

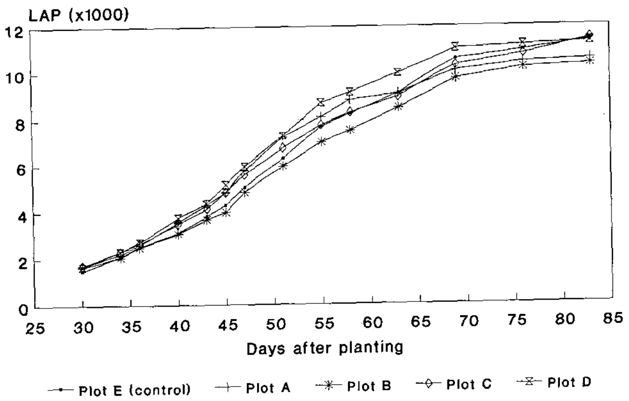

Figure 1
Cumulative leaf expansion as indicated by the LAP of maize on plots a, b, c, d and control

sampling, measuring and the sequence of measuring were done according to a standardised procedure in order to obtain representative and reproducible values (Vanassche and Laker, 1989). Measurements commenced at the beginning of the drying cycles and continued daily until stress had clearly set in.

Leaf expansion measurements on maize were done at regular time intervals (3 times per week) on 5 randomly selected plants in each plot. LAP was defined as follows:

$$LAP = sum_L \text{ of } [(L \times B) / 100] \ (cm^2)$$

with:
L = length of the leaf (mm)
B = width of the leaf in the centre, i.e. halfway between base and tip (mm).

A similar index was used by Denmead and Shaw (1960), while Mallet (1972) showed that LAP would have to be multiplied by 0,78 in order to approximate the true leaf area.

$$\text{Actual leaf area} = LAP \times 0{,}78 \ (cm^2)$$

Stem elongation measurements on wheat were carried out at regular time intervals (3 times per week) on 10 randomly selected plants in each plot. As the soil surface level was constantly changed by irrigations and by walking through the plots, a reference height had to be defined. The two most important conditions were that the reference level had to be stable and easily retrievable. Long steel nails were inserted in the soil as close as possible to the plants and their heads were used as a reference level, which was about 15 mm above the initial soil surface. The nails, labelled with numbers, could easily be traced afterwards.

The different growth stages of maize and wheat at which the different drying cycles commenced are listed in Table 1. All plots were well-watered (maximum extraction of 40 mm before refilling to field capacity) until the start of the respective drying cycles. During the drying cycles the well-watered control plots were irrigated as soon as 30% of PAWC was depleted.

Results and discussion

Maize

Leaf expansion and pre-dawn leaf water potential patterns

The leaf area of the plants on plot A exceeded that of the plants on the control plot E until day 35 of the drying cycle for plot A, i.e. 62 d after planting, at 12-leaf stage (Fig. 1). LER on plot A dropped below that on plot E on day 22 of the drying cycle, i.e. 49 d after planting at 8-leaf stage (Fig. 2). However, LER on plots B, C and to a lesser degree D, which were also well-watered at that time, were also lower relative to that of plot E from day 49 until day 57 after planting (Fig. 2). It was, therefore, not plot A that slowed down, but the plants on plot E that grew abnormally fast during those few days. Then on day 26 of the drying cycle LER on plot A slowed down sharply relative to that of plot E while the rate on plots B, C and D kept up with that of plot E. By day 33 of the drying cycle LER of the plants on plot A dropped to 50% of the rate measured on control plot E and remained that low. PLWP dropped to -800 kPa on day 30 of the drying cycle, but recovered partially thereafter. On day 40 of the drying cycle PLWP dropped sharply to -1 200 kPa, a value which would normally indicate FMS (Fig. 3a). This was far too late and plants were already experiencing severe water stress as was indicated by their physical appearance (leaves were folded along the main vein and standing up). It seems, therefore, that at this growth stage FMS is indicated by PLWP values of about -800 kPa.

LER on plot B was somewhat slower than the rate measured on control plot E throughout the whole season (Figs. 1 and 2). Between days 12 and 18 of the drying cycle for plot B, i.e. days

49 and 56 after planting, the growth rate on plot B was much smaller than on plot E, but thereafter the two rates became practically identical again. Comparison with LER patterns on plots A, C and D indicated that it was in fact the plants on Plot E that were growing abnormally fast during that period. Then, on day 29 of the drying cycle (i.e. day 68 after planting), LER on plot B was at 50% of LER measured on the control plot,

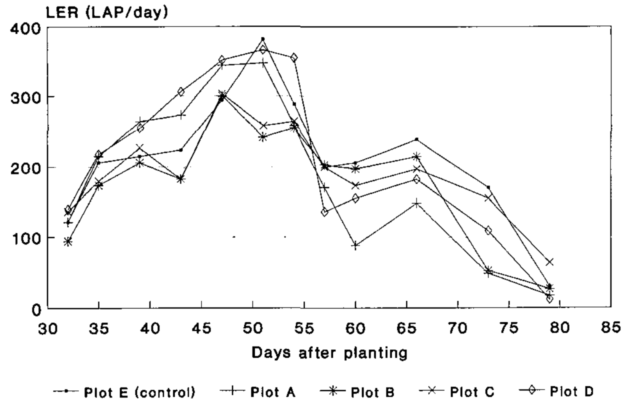

Figure 2
Leaf expansion rates (change in LAP per day) of maize on plots a, b, c, d and control

indicating FMS. Two drops in PLWP were observed during the drying cycle (Fig. 3b). The first drop was measured on day 29 of the drying cycle when the values decreased sharply to -850 kPa. The plants recovered during the following days but did not reach the high values as attained before day 29. This temporary recovery was followed by a second drop to -1 200 kPa on day 36 which was far too late as severe stress had set in. FMS was identified by the drop in PLWP to -850 kPa on day 29 of the drying cycle, i.e. at 14-leaf stage, which coincided with the sharp decrease in LER.

LER of plot C did not indicate FMS. The pattern was identical to that of the control plot E until maturity was reached (Figs. 1 and 2). FMS was indicated by the very sharp drop in PLWP to a value of -1 200 kPa on day 28 of the drying cycle for plot C, i.e. at 16-leaf stage (Fig. 3c).

The results of PLWP and LER measurements on plots A, B and C are summarised in Table 2. It is clear that the classical concept of FMS, which uses a critical PLWP value of less than -1 000 kPa to identify FMS, is not applicable during young growth stages (i.e. before the 14-leaf stage). The results suggest that during young growth stages a critical PLWP value of -800 kPa should be used to define FMS. From the 14-leaf stage onwards a drop in PLWP to less than -1 000 kPa is interpreted as an indication of the onset of FMS. This was also found during similar experiments with wheat and with maize at other sites (Vanassche and Laker, 1989).

Soil water stress did not have any effect on the leaf expansion

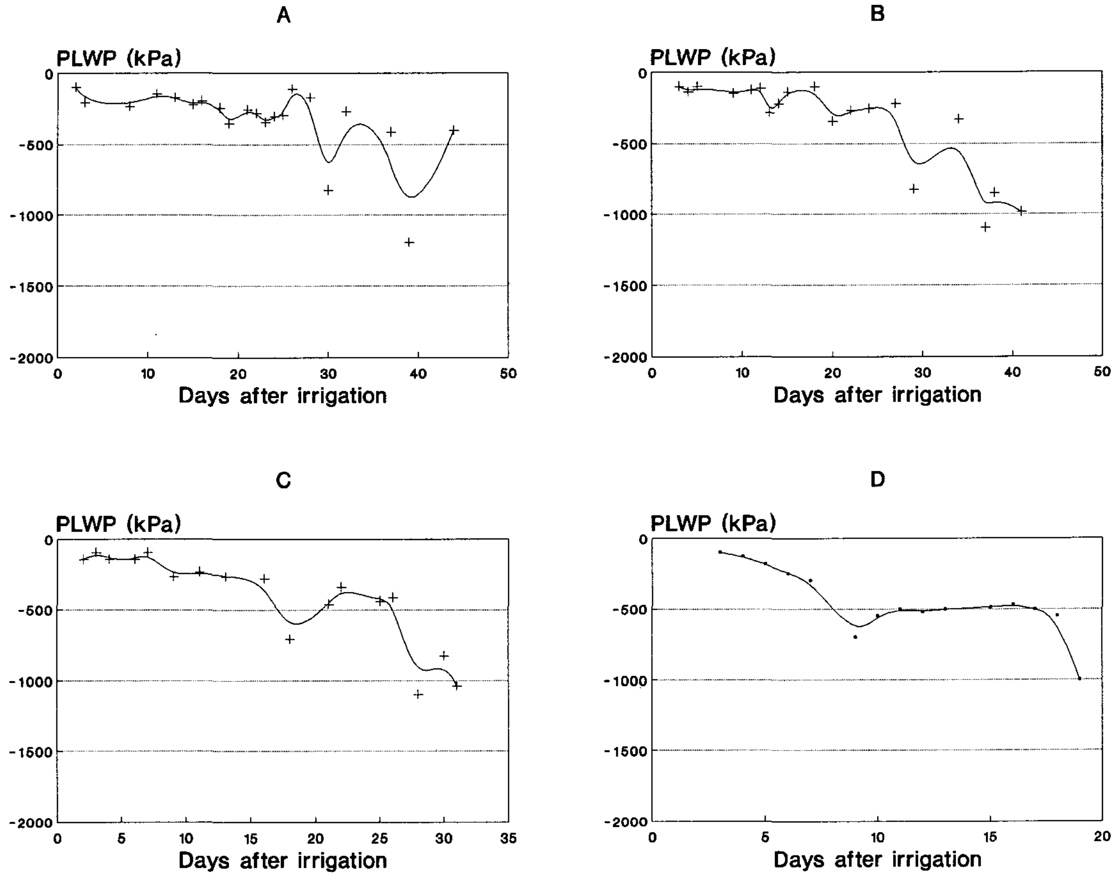

Figure 3
Pre-dawn leaf water potential patterns of maize on plots a (A), b (B), c(C) and d(D)

TABLE 2 DAYS ON WHICH THE DROP IN PLWP AND LER OF MAIZE WAS MEASURED ON PLOTS a, b and c				
Plot	PLWP day	PLWP value (kPa)	LER day	Growth stage
a	30	-800	33	12-leaf
b	29	-850	29	14-leaf
c	28	-1 200	n.a.	16-leaf

TABLE 3 PHENOLOGICAL GROWTH STAGES OF MAIZE AT THE START AND END OF THE DRYING CYCLES, NUMBER OF DAYS TO REACH FMS AND PARAMETERS USED TO IDENTIFY FMS IN MAIZE AT DIFFERENT GROWTH STAGES				
Plot	Phenological stage * start	Phenological stage * end	Days to FMS	Parameter **
a	4-leaf	12-leaf	30	PLWP* and LER
b	6-leaf	14-leaf	29	PLWP* and LER
c	8-leaf	16-leaf	28	PLWP
d	12-leaf	silking	20	PLWP

TABLE 4 QUANTITIES OF SOIL WATER EXTRACTED BY MAIZE AT DIFFERENT SOIL DEPTHS AND PAWC VALUES FOR EACH GROWTH STAGE				
	Water extracted (mm)			
Depth (mm)	a	b	c	d
0-100	18,0	17,0	16,8	16,3
100-200	19,8	19,3	18,3	17,3
200-300	22,5	23,3	22,0	19,3
300-400	18,5	24,8	24,3	22,5
400-500	18,5	27,0	27,0	26,0
500-600	21,3	28,8	28,5	29,5
600-700	5,0	12,5	12,0	12,5
700-800		3,0	4,3	4,5
800-900			5,5	8,8
900-1000			1,2	2,5
1000- 1100				
PAWC	123,6	155,7	159,9	159,2

of the plants on plot D since the plants reached the fully grown stage within about 15 d after the start of the drying cycle. LER could, therefore, not be used to indicate FMS. The drop of LER at the end of the measuring period was the result of the termination of the vegetative growth stage and was also found on the other plots (Figs. 1 and 2). The PLWP pattern was different to the patterns found on the other plots. Soon after the start of the drying cycle, the values decreased quickly to -500 kPa and fluctuated between -400 kPa and -500 kPa until FMS was observed (Fig. 3d). These were normal values for nearly fully grown maize plants and these tendencies were also observed during other experiments (Vanassche and Laker, 1989). Bennie (1986) also found that mature maize plants do not reach the high PLWP values found in younger plants, even under optimal conditions. Similar PLWP patterns in which the values of mature maize plants dropped quickly to -300 kPa were found by Boedt and Laker (1985). Lorens et al. (1987) also found a seasonal decrease in leaf water potential of maize. The PLWP plateau of unstressed wheat and durum wheat was also found to be higher earlier in the season (Vanassche and Laker, 1989). FMS was identified when PLWP dropped sharply from -500 kPa to below -1 100 kPa on day 20 of the drying cycle for plot D (shortly before silking stage).

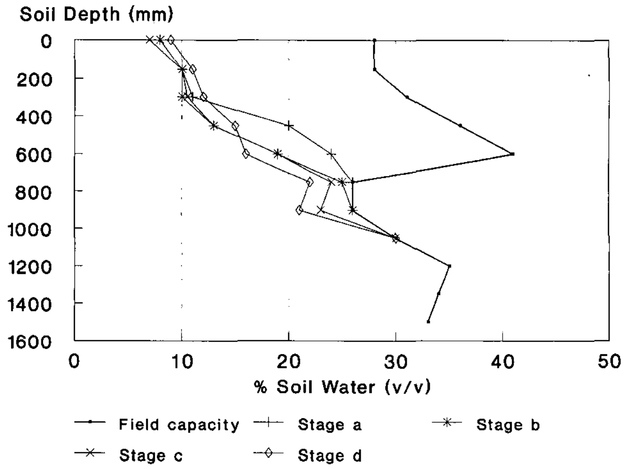

Figure 4
Soil water extraction patterns of maize at different growth stages

The phenological growth stages, the number of days to reach FMS and the parameters used to identify FMS are summarised in Table 3.

Soil water extraction patterns and PAWC values

The soil water extraction patterns for the different growth stages are shown in Fig. 4. The basic shape of the patterns was a fan shape. The convergence point, marking the lower boundary of the effective root zone, was at a depth of 750 mm at stage A. The compacted B-horizon impeded root penetration and development in soil layers deeper in the profile. This theory was confirmed by the soil water extraction patterns at other sites, with no compacted horizons, where the convergence point was already at a depth of 1 200 mm at that stage (Vanassche and Laker, 1989). The presence of the restricting layer is clearly illustrated in the soil water extraction patterns. A first indication is the high apparent field capacity value above the restricting layer due to partial waterlogging, the true field capacity for this part of the profile being much lower. However, this water was also available to the plants and must be taken into account when calculating PAWC. A second characteristic is an apparent high root density above this layer, inferred from the high rates of soil water extraction.

The evolution of the extraction patterns from stage A (12-leaf stage) to stage D (silking stage) consisted mainly in a downward movement of the convergence point from a depth of 750 mm to 1 050 mm. However, the largest increase in soil water extraction was found between 300 mm and 750 mm.

The quantities of soil water extracted at different soil depths and the PAWC values at each growth stage are listed in Table 4. It is clear that the extraction below a depth of 700 mm did not increase much as the plants grew older. The additional soil water extraction from layers deeper than 700 mm between growth stage A and growth stage D was about 16 mm which only accounts for 10% of the final PAWC. The PAWC value found at growth stage B (14-leaf) was very close to the value found at silking stage

(159 mm). At growth stage C, the PAWC value was identical to that found at silking stage.

Wheat

Stem elongation and pre-dawn leaf water potential patterns

On plot A the stem elongation rate (SER) dropped sharply to below that of the other plots on day 13 of the drying cycle for plot A, i.e. day 48 after planting (Figs. 5 and 6). It remained fairly constant for another 5 days, before it started decreasing further to reach zero on day 23 of the drying cycle, i.e. day 58 after planting (Fig. 6).

PLWP remained constant at -150 kPa for 12 d after the start of the drying cycle (Fig. 7a). On day 13 it dropped to -600 kPa, where it remained until day 23. On day 24, the day after growth stopped, it dropped sharply to -1 500 kPa. It can be concluded that on plot A an initial stress, which can be equated with FMS, set in on day 13 of the drying cycle. By day 23 severe stress, which agrees with the *in situ* measured LOL of the "potential extractable water (PLEXW)" concept of Ratliff et al. (1983), i.e. when plants become dormant, occurred.

The drying cycle on plot A was continued for another 5 days, inducing severe stress conditions. When irrigated (on day 29), the plants responded immediately: PLWP increased overnight to values of -150 kPa and SER rose very sharply and after some days became even higher than on the other plots. The plants ended up comparable in size to the plants on the other plots.

On plot B the cumulative stem elongation was equal to that of the plants on plots C and D, which were unstressed, during the first 19 d of the drying cycle, i.e. until day 74 after planting (Fig. 5). Their SER patterns were also identical (Fig. 6). After day 74 SER of plot B started decreasing relative to those on plots C and D. It again initially dropped to a plateau, after which it dropped to a very low value 9 days later on day 83, i.e. 28 d after the start of the drying cycle (Fig. 6). The plants did not become dormant, however, as in the case of plot A. A first definite drop in PLWP (to -1 150 kPa) occurred 19 d after the start of the drying cycle, i.e. on the day on which SER started decreasing relative to plots C and D (Fig. 7b). Although much higher values were measured again afterwards, this drop together with the drop in SER must be seen as a clear indication of the onset of FMS. From then on PLWP fluctuated very sharply, with decreasing minima to the oscillations. This type of pattern was also identified by Laker et al. (1987). On day 30 of the drying cycle (day 85) a PLWP value of -1 500 kPa was reached, coinciding with the onset of a period of very slow growth due to severe water stress.

The SER of the plants on plot C was similar to that of the plants on plot D for the first 6 d of the drying cycle, i.e. until day 74 after planting (Fig. 6), giving parallel cumulative elongation lines (Fig. 5). For the next few days SER on plot C dropped far below that of the well-watered plot D, after which the values for the 2 plots became similar again. This initial drop in SER was not due to soil-induced water stress but to extreme temperatures developing under the plastic covers on plot C on a few very hot days when rain was expected (plot D was not covered during this period). After day 16 of the drying cycle, i.e. day 84 after planting, SER dropped sharply to reach a low value on day 20, indicating FMS. The PLWP pattern of plot C seems very irregular because of the sharp fluctuations at the beginning of the drying cycle (Fig. 7c). Of particular importance is the sharp drop on day 6, the day on which SER decreased sharply. These drops were caused by the "greenhouse effect", induced by the plastic covers for protection against rain. Very high temperatures (above 30°C) during this period caused even higher temperatures under the plastic covers as the heat could not escape due to a lack of wind. The plastic covers could not be removed during this period because of the high possibility of thunderstorms in the afternoon. The fact that similar drops occurred on the same dates at other sites, where similar experiments were conducted, supports this theory. FMS, as indicated by the drop in SER on day 20 of the drying cycle, was confirmed by the drop in PLWP to nearly -1 500 kPa 23 d after the start of the drying cycle.

The drying cycle on plot D did not have any effect on the stem elongation and the plants were taller than on the other plots (Fig. 5). The drop in SER, 17 d after the start of the drying cycle, was a result of the termination of the vegetative growth stage and was not induced by stress conditions. This is supported by the drop in SER on all plots (Fig. 6). FMS was identified by the drop in PLWP on day 19 of the drying cycle (Fig. 7d).

The drying cycle on plot F (flowering) was started at flowering stage in order to determine the mature stage PAWC. The drop in PLWP occurred 31 d after the start of the drying cycle, indicating FMS (Fig. 7f). At the start of the drying cycle water demands

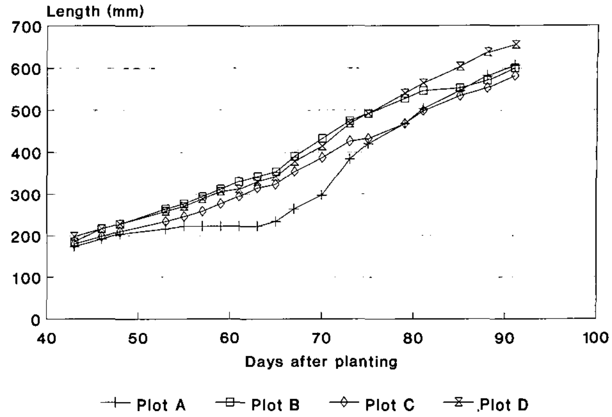

Figure 5
Cumulative stem elongation of wheat

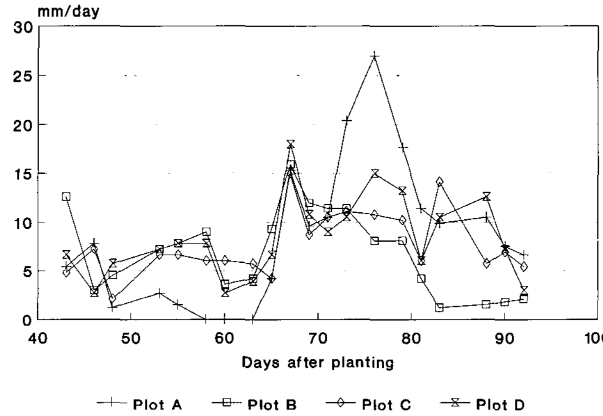

Figure 6
Stem elongation rate of wheat

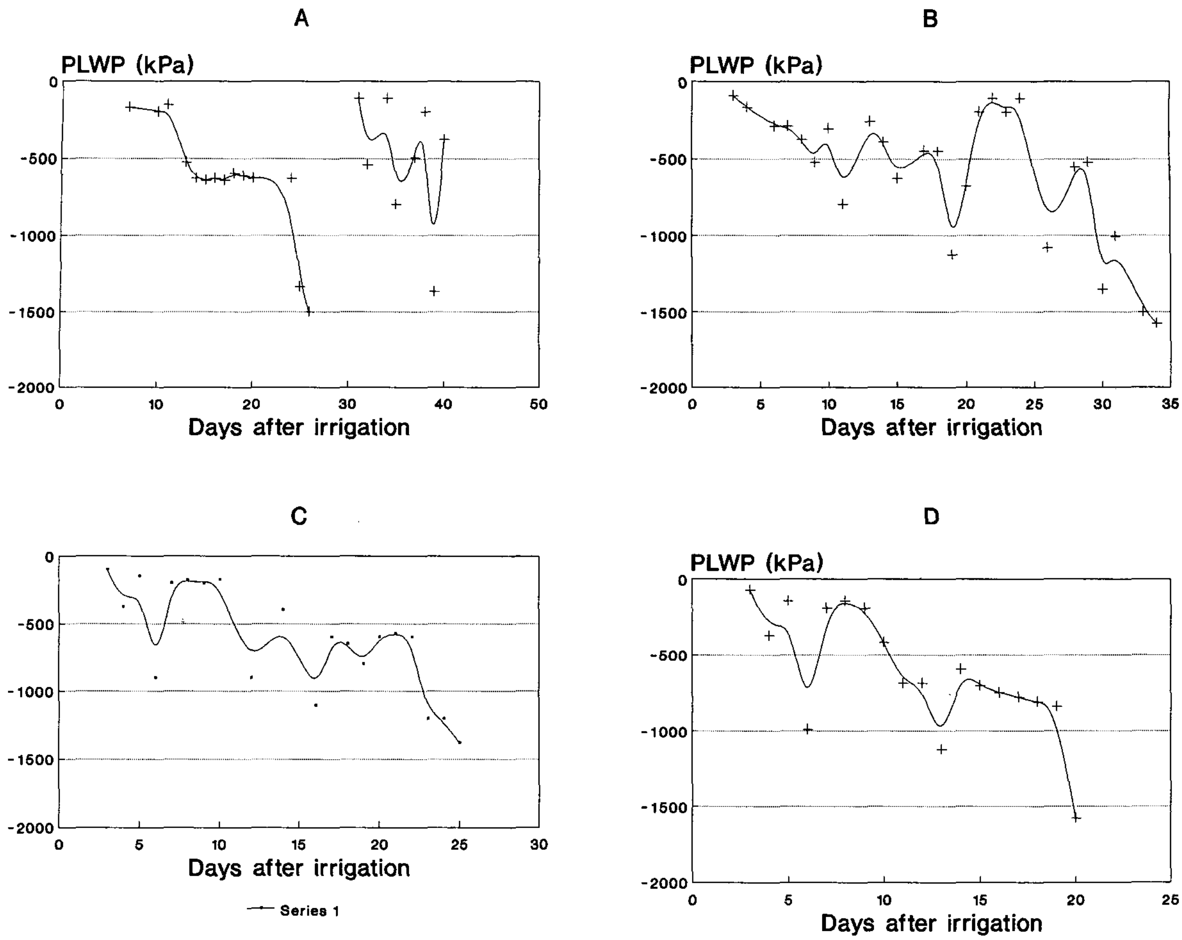

Figure 7
Pre-dawn leaf water potential patterns of wheat on plot a (A), plot b (B), plot c (C) and plot d (D) and over the flowering period (F)

were at peak level and started decreasing from that time onwards (see also Boedt and Laker, 1985). This explains the longer period to reach FMS.

The number of days to reach FMS, the phenological growth stage at which FMS was reached and the parameters which identified FMS are summarised in Table 5.

Soil water extraction patterns and PAWC values

The soil water extraction patterns for plots A, B, C, D and F are shown in Fig. 8. All patterns show the same basic fan shape with time. The evolution of the patterns as the plants developed consisted mainly in the downward movement of the convergence point from a depth of 700 mm on plot A at growth stage 5 according to Large (1954) to 1 200 mm on plot D (growth stage 10.1). Soil water extraction from layers below 700 mm at young growth stages was not markedly different from that at flowering stage. The low soil water extraction from layers below 700 mm is explained by the presence of a compacted layer with upper boundary at a depth of 600 mm to 700 mm, resulting in very poor root development below this depth at this site.

The quantities of soil water extracted at different soil depths and the PAWC values at each growth stage are listed in Table 6. It is clear that the extraction below 700 mm did not increase much as the plants grew older. The difference in soil water extraction from layers deeper than 700 mm between extraction period (a) and extraction period (d) was about 11 mm which was less than 10% of the final PAWC. The PAWC value found at flowering stage (140 mm) was already reached at extraction period (c) (growth stage 10). The slightly lower value found for extraction period (d) (growth stage 10.1) is probably due to spatial variation.

Conclusions

LER and PLWP patterns can both be used to indicate FMS in maize during the early vegetative stages. As in the case of wheat and durum wheat, PLWP values at FMS during early growth stages (until 14-leaf stage) were at about -800 kPa. Once the plants were past the 16-leaf stage, PLWP values below -1 000 kPa clearly indicated FMS. As expected, LER was not a reliable parameter for FMS from this growth stage onwards, due to entry into the reproductive phase.

The existence of a seasonal variation in PLWP as indicated by Lorens et al. (1987) was also found during these experiments. As the plants reach maturity, PLWP values tend to be lower than during the early vegetative stages, even under optimal conditions. This was also found with durum wheat (Vanassche and Laker, 1991). The same tendencies were found by Bennie (1986).

Ceulemans et al. (1988) found that PLWP was not as sensitive

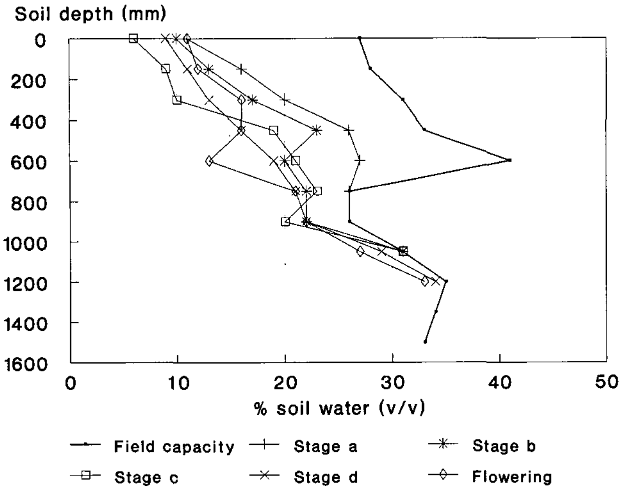

Figure 8
Soil water extraction patterns of wheat during different extraction periods

in indicating FMS as the net carbon-dioxide exchange rate, especially under climatic conditions characterised by a high evaporative demand which enhances insensitivity of PLWP (Dwyer and Stewart, 1986 and Boedt and Laker, 1985). However, Ceulemans et al. (1988) conducted a short-term study and based their conclusions on single, daily PLWP measurements. It is very important to realise that when using PLWP as an indicator for FMS, daily measurements, starting as soon as possible after irrigation, must be used over an extended period so that trends can be clearly observed. Single PLWP values cannot be used as indications of FMS since this parameter seems to be susceptible to climatic fluctuations and atmospherically induced water stress is unavoidable. The use of a well-watered control plot is, therefore, recommended.

The results obtained during this study showed that the maximum PAWC value for maize is already reached at the 14-leaf stage, quite some time before flowering stage. This illustrates that mild water stress during vegetative stages stimulates root growth as a result of the repartitioning of the photosynthetic assimilates to the roots, favouring root growth (Lang and Thorpe, 1976) and increasing PAWC.

Both SER and PLWP patterns clearly indicated the onset of FMS in wheat during early growth stages (until the flag leaf was completely developed, stage 9 according to Large, 1954). It became clear that during early growth stages (i.e. until stage 7 according to Large, 1954) wheat plants are more sensitive to soil water stress as indicated by PLWP than during later growth stages. This was also found during similar experiments at sites other than the one discussed in this paper (Vanassche and Laker, 1989). During the early growth stages FMS was clearly identified when PLWP decreased to about -800 kPa. During later growth stages FMS is indicated only by PLWP values of clearly less than -1 000 kPa, as was also found by Boedt and Laker (1985).

For both crops, the maximum PAWC value, i.e. the value at flowering stage, is already reached long before flowering and PAWC during early growth stages is relatively much higher than would be expected. This means that one can use the maximum value at a younger growth stage when applying the PAWC concept in irrigation scheduling.

TABLE 5
PHENOLOGICAL GROWTH STAGES OF WHEAT AT THE START AND END OF THE DRYING CYCLES, NUMBER OF DAYS TO REACH FIRST MATERIAL STRESS (FMS) AND PARAMETERS USED TO IDENTIFY FMS OF WHEAT AT DIFFERENT GROWTH STAGES

Plot	Phenological stage * start	end	Days to FMS	Parameter
a	3	5	13	PLWP** and SER
b	5	8	19	PLWP and SER
c	7	10	20	PLWP and SER
d	8	10.1	19	PLWP
f	flowering	grain filling	31	PLWP

*Phenological growth stages according to Large (1954):
Stage 3: Tillering
Stage 5: Leaf sheaths strongly erected
Stage 7: First node of stem visible
Stage 8: Flag leaf just visible
Stage 10: Ears in boot
Stage 10.1: Appearance of the ears

PLWP**: At values higher than -1 000 kPa

TABLE 6
QUANTITIES OF SOIL WATER EXTRACTED BY WHEAT AT DIFFERENT SOIL DEPTHS AND PAWC VALUES FOR EACH EXTRACTION PERIOD

Depth (mm)	water extracted (mm) a	b	c	d	flowering
0-100	13,3	15,5	18,7	16,5	17,0
100-200	10,6	14,5	19,8	16,8	15,8
200-300	10,3	14,3	20,7	17,5	15,0
300-400	9,1	13,7	18,3	18,3	17,8
400-500	10,6	16,2	18,0	19,5	22,3
500-600	12,7	22,0	20,8	22,0	28,3
600-700	6,1	10,0	8,3	10,0	12,5
700-800		4,5	4,2	4,3	4,5
800-900		4,8	6,7	4,5	3,0
900-1000		2,0	2,5	2,3	2,5
1000-1100					1,5
1100-1200					
PAWC	72,2	117,5	138,0	131,7	140,2

Acknowledgement

The research reported here was supported by a grant from the Water Research Commission.

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