THE RESPONSE OF MIDDAY LEAF WATER POTENTIAL TO SOIL DRYING, AN INDICATOR OF SITE-SPECIFIC WATER AVAILABILITY DURING GROWING SEASON

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ABSTRACT

Water availability predominantly influences site-specific yield within one field. Site-specific water availability could be characterised by the response of midday leaf water potential to a 100-hPa decline in soil matric potential at 40 cm depth. The site-specific 'response' correlated significantly (p=0.05) with the biomass at plant maturity (R^2=0.77 for silage maize and R^2=0.48 for winter wheat). The values for the site-specific response was different between the two crops. However, site-specific evaluation of water availability was consistent.

INTRODUCTION

At Scheyern, in southern Germany, yield variability based on data from 3 years gave a relatively stable pattern for wheat and maize, thus dividing the fields into low- and high-yielding zones. It could be shown that spatial yield variation was related to water availability during growing season, which is determined by the available water capacity, on the one hand, and by the relief as well as the extent of upward fluxes, on the other hand.

For considering water availability in site-specific management a parameter is still needed integrating the combined effect of all factors determining site-specific water availability. Estimating the amount of available water may still not be sufficient, since Tardieu and Katerij (1991) showed that plant growth was predominantly influenced by the plant water status during the day with the latter being more closely linked to the soil water status in the main rooting zone.

This study aimed at characterising site-specific water availability through plant water status. Therefore plant and soil water status as well as plant performance were investigated at six different sites in one field for two years in silage maize and winter wheat. In this paper emphasis will be made on the results obtained in winter wheat during growing season 2000.

MATERIALS AND METHODS

The field trials were realised in the tertiary hills of southern Bavaria, Germany, with annual rainfall of 800 mm. Plant water status was determined through the midday leaf water potential, measured with the pressure chamber technique. Soil water status was assessed by the matric potential with tensiometers and gravimetric water contents at five depths in the roting zone. Leaf water potential and soil matric potential were determined at approximately weekly intervals, gravimetric water contents every two weeks. At plant maturity above-ground biomass was determined.

In the chosen field soil conditions (soil texture, soil bulk density) were slightly heterogeneous and the relief was undulating. Five sites were selected: The site ‚North‘ was located in a depression (467 m above sea level) in the northern part of the field. The soil was a fine-loamy, mixed, mesic, dystric fluventic Eutrochrept. Further south the ground level rose. In the western part of the field the site 'West Hill' was located near the hilltop (473 m above sea level) with similar soil as at the site 'North'. In the eastern part of the field the site 'East Hill' was located at (469 m above sea level). The soil was a fine-silty, mixed, mesic, dystric fluventic Eutrochrept. South of the site ‚West Hill' below the hilltop at 472 m above sea level the site 'West' was assessed. The soil was a coarse-loamy, mixed, mesic, dystric Eutrochrept. At the southern end of the field the site 'Valley (South)' was located close to a depression at 467 m above sea level.

RESULTS AND DISCUSSION

Midday leaf water potential decreased during growing season of winter wheat (Fig. 1) Site-specific differences occurred from 226 DAS but were not consistent.

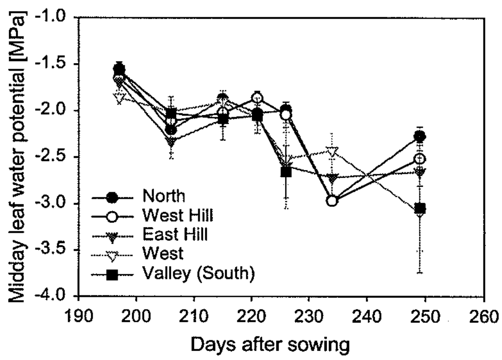

FIGURE. 1: Midday leaf water potential in winter wheat during growing season at various sites within one field. Data was obtained from three replicates. Vertical bars represent the standard deviation.

When midday leaf water potential was correlated with the soil matric potential at 40 cm depth, site-specific differences in water availability became apparent, as shown in Fig. 2 for three sites.

At the site 'North' the midday leaf water potential hardly changed with the soil matric potential decreasing at 40 cm depth, while it decreased distinctly at the site 'West'.

The site specific response, derived from the slope of the regression line, is defined as the decrease in midday leaf water potential to a 100-hPa decline in soil matric potential at 40 cm depth.

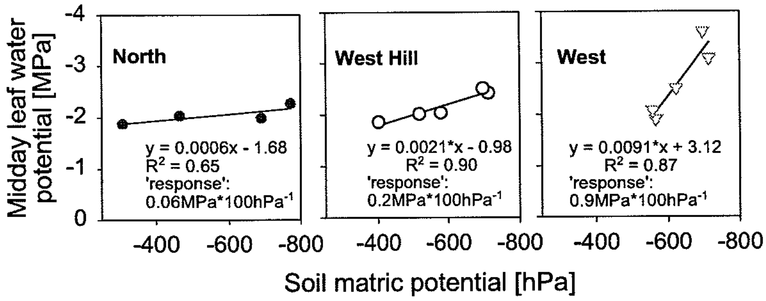

FIGURE 2: Relationship between the soil matric potential at 40 cm depth and the midday leaf water potential of winter wheat (growing season 2000) at three sites within one field. The equation and the coefficient of determination for each regression as well as the site-specific 'response' [MPa*100hPa^{-1}] are given.

The variation in the site-specific response indicated different extents of water availability at the various sites during growing season. At the site 'North' the lower response, hence the higher water availability, was related to its relief position. The site is located in a depression within the field where lateral fluxes may increase the amount of available water. Lateral fluxes may have been important for water availability at this site, since gravimetric water contents were slightly higher by 2-3 % compared to the other sites (data not shown here). This slight variation in water contents of the silt loamy soil might induce tremendous differences in hydraulic conductivity as shown by Jones and Tardieu (1998). At the site 'West', however, the slightly higher sand contents of the soil might have led to a greater decrease in hydraulic conductivity, apparently aggravating water limitation compared to the other sites.

The lower water availability at the site 'West' resulted in significantly lower biomass at plant maturity compared to the site 'North'. The 'response' was significantly (P=0.05) negatively correlated with the site-specific above-ground biomass of wheat with R^2=0.48 (Fig. 3, right graph). Similar results were found in maize at the same sites during growing season 1999 (Fig. 3, left graph).

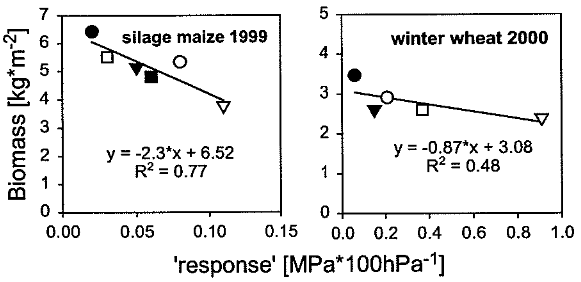

FIGURE 3: Relationship between the site-specific 'response' and the above-ground biomass of maize (1999) (left graph) and wheat (2000) (right graph). The equation and the coefficient of determination of the regression lines are given.

The values of 'response' obtained for wheat (2000) varied in a wider range than those found for maize (1999). Nevertheless, site-specific differences can be similarly illustrated through the 'response' (Fig. 4). According to the site-specific response from both years the sites may be divided into three groups of water availability during growing season. Water was most available at the site 'North', while it was least available at the site 'West'. The other sites may be classified as intermediate.

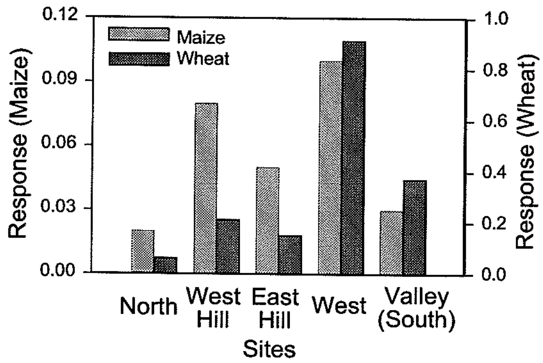

FIGURE 4: Site-specific 'responses' in one field are shown for maize (left column) from growing season 1999 and wheat (right column) from growing season 2000.

CONCLUSION

The response can be a useful tool to assess water availability at a site during growing season for different crops. It integrates the combined effect of relief and soil texture on water availability and plant development, thus allowing to evaluate water availability at a site relative to others.

ACKNOWLEDGEMENTS

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