Water use and carbon dioxide exchange of lucerne in relation to leaf conductance and leaf water potential

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Recent studies of lucerne production on irrigated red-brown earths show that both frequent irrigation and previous gypsum application stimulate growth and increase yields. This paper attempts to understand the physiological basis of yield formation in irrigated lucerne under these conditions.

Methods

The stand was initially established in 1979. A short term experiment was superimposed on gypsum treated (12 t ha^{-1}) and untreated control bays in 1983 to investigate effects of weekly as contrasted with the usual fortnightly irrigation schedule. The experiment extended for 45 days, encompassing the rapid growth and maturity phases in an extended cutting cycle. Temporal and diurnal changes in CO2 exchange and water use of the canopy were measured in situ with field chambers. Stomatal conductance and leaf water potential (1)) were measured independently on upper leaves.

Results and Discussion

During the pre-flowering phase there was little change in mid-afternoon 1 of weekly irrigated treatments (c. - 1.5 MPa), while declined from -1.6 MPa to -2.6 MPa in the fortnightly treatments. Greater stress during the afternoon led to incomplete overnight recovery by flowering. The water status of the gypsum treated plot under fortnightly irrigation tended to be better than the control but the differences in 11) were not significant ($P<0.05$).

Net photosynthesis (Pn, gm^{-2} h^{-1}) declined linearly with decreasing U during the pre-flowering phase for all treatments according to the relationship, Pn=-3.500+13.2 (R^2=0.71, $P<0.05$), for values of It) between -1.2 MPa to -2.8 MPa. A similar linear response for water use (Ea, mm h^{-1}) was also observed, Ea=-0.5(0+1.84 (R^2=0.67, $P<0.05$). After flowering Pn and Ea again declined with decreasing 4, but the degree of correlation was considerably less. Decreasing rates of Pn and Ea below a 4 of c. -1.6 MPa were closely associated with a decline in leaf stomatal conductance.

These results demonstrate that lucerne exhibits poor stomatal control, with little evidence of stomatal adjustment to water stress. Maximum production of dry matter was therefore only achieved when the crop had sufficient soil water to maintain above c. -1.6 MPa. This agrees with the measured yield data which show greater yields under more frequent irrigation.