Effect of water deficit on yield of Pasja forage brassica

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Abstract

Pasja is a popular summer forage brassica in New Zealand's pastoral systems. Its yield response to timing and intensity of water deficit was determined in a field experiment which was covered automatically by a mobile rainshelter whenever rain occurred. Pasja was sown in early December and eight irrigation treatments were applied weekly from late December to late March. Water deficits were measured weekly, and total (leaf, stem and root) and forage (grazeable leaf and stem) yield was measured in early February, 60 days after sowing (DAS), and again in late March after a 60 day regrowth period. Yields were similar at maximum potential soil moisture deficits (MPSMD) less than 180 mm, but overall they decreased linearly with increasing MPSMD. These decreases were greater in the first 60 day growth period than between 60 and 120 DAS (13 versus 9.4 kg/ha/mm for total biomass).

Key Words

Soil moisture, evapotranspiration, water use, biomass, leaf area

Introduction

Pasja is a versatile, multi-graze, leafy forage brassica which is grown widely in New Zealand to supplement pasture production from mid-summer to early winter. It is a Chinese cabbage x turnip hybrid which can be sown from spring to late summer and grows rapidly between grazings, which are usually about 60 days apart. Pasja is thought to be sensitive to water deficit because it is shallow-rooting. Its yield response to timing and intensity of water deficit was determined in a field irrigation experiment with all rainfall excluded by a rainshelter.

Materials and Methods

The rainshelter at Lincoln, Canterbury, New Zealand, is a mobile 55 m x 12 m greenhouse which automatically covers the experimental crop during rainfall, but is otherwise positioned some 50 m away (Martin et al. 1990). The soil is a deep (>1.6 m) Templeton sandy loam (*Udic Ustochrept*, USDA Soil Taxonomy) (New Zealand Soil Bureau 1968) with an available water holding capacity of c. 190 mm/m of depth. "Superstrike" coated seed of Pasja forage brassica (3.35 mg seed weight) was sown on 3 December 2003 in 12 cm rows at a seeding rate of 6 kg/ha. The crop was spray irrigated with 4 mm of water on most days from 5 to 21 December to ensure even establishment. On 30 December, eight irrigation treatments were started, and continued to late March. These ranged from applying the weekly actual soil moisture deficit (ASMD) in a split application four days apart to applying one third the three weekly ASMD every three weeks (treatment 13W).

The experiment was a randomised complete block design with three replicates. Plot size was 5 m x 3 m. Each plot had its own trickle irrigation supply, with emitters spaced 300 x 450 mm apart. ASMD was measured each week to 1.6 m depth by time domain reflectometry (0-20 cm) and a neutron probe (20-160 cm at 20 cm intervals). The potential soil moisture deficit (PSMD) was calculated for each treatment as the cumulative difference between daily Penman potential evapotranspiration (PET), calculated from meteorological data collected 500 m away, and the amount of irrigation applied to that treatment. The maximum PSMD (MPSMD) attained during the growth of the crop was used as a measure of drought severity in each treatment (Penman 1971).

Best fertiliser and weed, pest and disease management practices were used to minimise any limitation to growth and yield apart from drought. Samples were dug up from 1 m^2 quadrats for plant counts and yield and leaf area determinations on 9 February (H1) and 6 April (H2). Yield was separated into leaf, stem and root components. After the H1 quadrats were removed, the whole crop was mown to simulate a grazing. All leaves were removed, but residual stems and roots were left as a base for regrowth.

Results

The crop was 50% emerged on 11 December. The weekly irrigations after 30 December ranged from 5 to 99 mm. Water use over the four month period ranged from about 450 mm for the most frequently irrigated treatments down to 150 mm for the least irrigated treatments. Penman PET from 1 December to 31 March was 441 mm, 86 % of the long term mean. In the drier treatments, such as 13W, almost all water extraction up to H1 on 9 February was from the 0-40 and 40-80 soil layers (Figure 1). From then to H2, water was also extracted from the 80-120 and 120-160 cm layers.

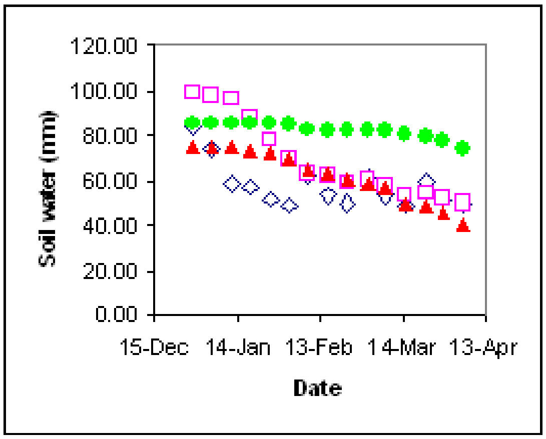

Figure 1. Soil water (mm) in the 0-40 (◊), 40-80 (□), 80-120 (▲) and 120-160 (●) cm depths in the 13W treatment.

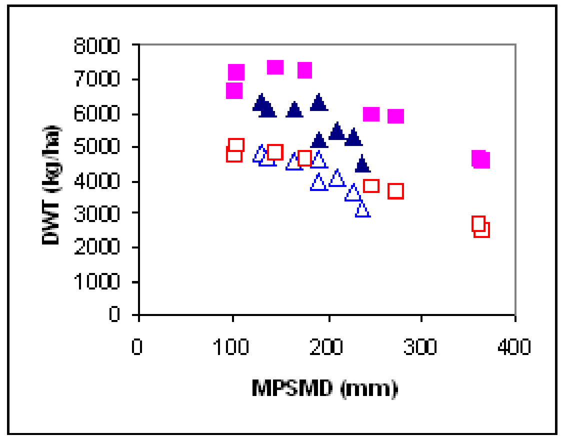

Figure 2. Dry weights at 9 February (H1) (Forage ∆, Total ▲) and 6 April (H2) (Forage □, Total ■) harvests.

Yields were similar from the treatments that were fully irrigated at up to three weekly intervals, and MPSMDs did not exceed 180 mm. The means of these treatments were about 6.2 t/ha of total biomass and 4.7 t/ha of leaves at H1 and 7.1 t/ha of total biomass and 4.8 t/ha of leaf regrowth at H2. Overall, yields decreased linearly with increasing MPSMD, but the decrease was greater at H1 (Figure 2), probably because the roots had not extended below 80 cm by that time and therefore had access to less water than later in growth. A linear plot through all total biomass points gave a slope of 13 kg/ha/mm of deficit for H1 and 9.4 for H2. Forage (grazeable leaves and stem) was a greater proportion of total biomass at H1, but showed similar responses to MPSMD as total biomass at both harvests. Leaf area index had a similar response to increasing MPSMD as yield. Harvest index and plant populations increased with increasing MPSMD, the former because of proportionately more leaf on smaller plants, and the latter to less intense competition between the slower growing plants.

Conclusions

Although Pasja was thought to be shallow rooting, it was extracting water from below 120 cm depth after three months in this experiment. The decrease in biomass production with increasing MPSMD was less at the second harvest because the roots were extracting water from deeper in the soil profile by then. The results of this experiment are consistent with results for other crops where changes in grain, seed and root yields have been linearly related to increasing MPSMD (Martin et al. 2004).

Acknowledgements

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