Water use efficiencies of dryland brassica forage crops on contrasting soil types

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ABSTRACT

Yield (kg dry matter (DM)/ha) and water use efficiency (WUE) (kg DM/ha.mm water) of three brassica forage crops were assessed under dryland conditions at two sites with contrasting soil types in SW Victoria. Turnips, Rape and Pasja were sown at two times in seedbeds prepared using three methods (mouldboard plough + power harrow, chisel plough + power harrow, over-worked-multiple chisel ploughings) at each site. Irrespective of sowing time and site, turnips gave the highest DM yields and WUE of all the crops. Differences of 30 to 40% in WUE for all crops between the two sites were found. This may be due to differences in soil fertility, soil water holding capacity and weed competition. At one site mouldboard ploughing produced a higher DM yield possibly through a reduction in weed competition brought about by seed burial.

KEY WORDS

Water use efficiency, brassicas, cultivation, soil moisture, soil type.

INTRODUCTION

The growing of brassica crops in spring and summer is a common way to fill the summer feedgap on farms in southern Victoria. An estimated 70% of dairy farms in these regions grow such crops each year (3). They provide feed of high dry matter (DM) digestibility (5) in summer when pasture quality is normally low (2) due to the onset of moisture stress under rainfed conditions. However, a survey showed DM yields can be variable with turnip yields ranging from 0.4 to 19.2 t DM/ha in SW Victoria (J. Jacobs, pers. comm.). The survey also found that two factors, which had the greatest effect on DM yield of the crop, are the total water received by the crop (rainfall and irrigation) during the growing period and the moisture content of the seedbed at sowing. Clearly, under dryland conditions water supply usually limits crop yield and there are few management options to try and improve this. The aim of this study was to determine the effectiveness of different seedbed preparation techniques for different brassica crops to maximise DM yield from stored soil moisture and rainfall during the growing period.

MATERIALS AND METHODS

The study was conducted at two sites in SW Victoria in 1999 with contrasting soils that had differing drainage and water holding capacities. Site A at Nullawarre (38°29'S 142°44'E) was a brown Sodosol (1) with a relatively free draining loamy sand topsoil. Site B at South Ecklin (38°23'S 142°54'E) was a brown Chromosol (1) with a very fine sandy clay loam topsoil. Total plant available water in the top 30 cm soil horizons were 21 and 35% volumetric soil water for sites A and B respectively. Soil fertility (0 – 10 cm) was 13 and 54 mg P/kg (Olsen P), 160 and 330 mg K/kg (available K) and 11 and 30 mg S/ha (CPC S) for sites A and B respectively. A common experimental design of two sowing times (early and late), three seedbed preparation techniques (mouldboard plough + power harrow (MP), chisel plough + power harrow (CP), over-worked-multiple chisel ploughings (OCP)) and three brassica crops (Turnips *cv Barkant*, Pasja, Rape *cv Bonar*) with three replicates were used at each site. Crops were sown at site A on 21 September and 18 October, and at site B on 15 October and 19 November. Plots (6 x 20 m) were sown with 20 kgP/ha as single superphosphate and seeding rates of 1.25 kg/ha for turnips and 4 kg/ha for rape and Pasja. Crop and weed seedling densities were assessed four weeks after sowing. Soil moisture in the 0-30 cm profile was assessed twice weekly using Time Domain Reflectometry with permanently installed waveguides in each plot. Weather parameters were recorded for the duration of the experiment using an automatic weather station and Class A evaporation pan at each site. Water use efficiency (WUE) was determined by dividing the DM yield of the crop by the change in soil profile water content between

sowing and harvesting plus rainfall. Final DM yields were assessed at site A on 20 December and 6 January 2000, and at site B on 7 January and 1 February respectively. DM yield was assessed by harvesting all crop plants in six randomly selected 0.5 x 0.5 m quadrats in each plot. For turnips, both the top and the root were included, while all above ground plant parts were harvested for rape and Pasja. Plant material was oven dried at 100°C for 48 hours to determine DM content.

RESULTS

Irrespective of sowing date, turnips outyielded ($P<0.001$) rape and Pasja at site B (5.77; 4.17 and 4.44 t DM/ha respectively), while at site A turnips outyielded ($P<0.05$) rape (3.23 and 2.64 t DM/ha respectively). Again irrespective of time, at site A MP produced a higher DM yield ($P<0.05$) than OCP (3.36 and 2.53 t DM/ha respectively). At site A MP at the first sowing time produced a higher ($P<0.05$) DM yield than at the second sowing time (4.19 and 2.53 t DM/ha respectively). These DM yield differences were reflected in the WUE results (kg DM/ha.mm) for the crops. At site B, irrespective of time, turnips had a higher ($P<0.001$) WUE than either rape or Pasja (27.7; 20.1 and 21.1 kg DM/ha.mm respectively). Similarly at site A, irrespective of time turnips had a greater WUE ($P<0.05$) than rape and Pasja (16.44; 13.05 and 14.94 kg DM/ha.mm). Also at site A irrespective of time, the MP treatment gave higher ($P<0.05$) WUE than the OCP treatment (16.71 and 12.51 kg DM/ha.mm respectively). At site A the CP treatment had a higher WUE ($P<0.05$) at the later sowing than the earlier sowing (17.66 and 12.74 kg DM/ha.mm respectively). At site A, capeweed (*Arctotheca calendula*) was a major invader of some treatments. Irrespective of time, the CP (90.8) and OCP treatments (106.3 seedlings/m^2) treatments gave rise to a higher ($P<0.05$) germination of capeweed after cultivation than the MP treatment (37.7 seedlings/m^2). Within each of these chisel plough treatments there was a higher ($P<0.05$) germination of capeweed at the first sowing than at the second sowing time (155.9 V's 25.7 seedlings/m^2 for the CP and 175.9 V's 36.6 seedlings/m^2 for the OCP treatment).

DISCUSSION AND CONCLUSIONS

Results from this study show that turnips were the most productive and had the highest WUE of the three brassica crop species used. This is consistent with the findings of Nielsen et al. (4) for the same crops grown under a range of levels of supplementary irrigation in Tasmania. This may be due to the turnip plant producing both an edible top and root, and as speculated by Nielsen et al. (4), a possible ability of turnip root to act as a buffer to moisture stress between rain events. Differences of 30 to 40% in the WUE for all three species were found between site A and B in this study. It is likely that the lower WUE of site A was due to a number of factors. Firstly, site A had a low level of P, K, S soil fertility compared to site B. As the level of P fertiliser applied was comparatively modest, it is possible that the full growth potential of these crops were not realised when soil moisture was not limiting, leading to a poorer conversion of soil water into plant growth. Secondly, the lower water holding capacity and free draining nature of the site A soil type is likely to lead to an earlier onset of and greater severity of moisture stress to the crop. Thirdly, especially at the first sowing time of the chisel plough treatments, lead to heavy capeweed infestations. Competition from capeweed may reduce the apparent WUE of crops grown under these conditions. The high DM yield of crops grown on the mouldboard plough treatments at this site may be due to a reduction in the germination of (through seed burial) and later competition by capeweed. There was no evidence of superior soil moisture conservation by any of the seedbed preparation techniques and the mouldboard plough treatment did not give any advantage at site B where no capeweed problem existed. It is concluded that turnips are superior to both rape and Pasja in total DM yield and in WUE under dryland conditions and that in some cases seedbed preparation by a mouldboard plough may produce higher DM yields through a reduction in weed competition brought about by seed burial.

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