Water Use Efficiency of Field Pea Genotypes of Contrasting Morphology

M.K. Khan, S.H. Shah and L.O'Brien

The University of Sydney, Narrabri, NSW.

Abstract

Semi-leafless pea genotypes have consistently performed better than conventional and tare-leaf types in comparisons conducted at Narrabri over the last five years. In an attempt to understand the basis for this observation, three morphologically different field pea varieties, namely, Dundale (conventional), Jupiter (tare leaf) and Dinkum (semi-leafless) were compared under field conditions at Narrabri in the 1996 growing season. The crop was grown on a self-mulching black soil at a density of 60 plants/m^2 at different row spacings. The semi-leafless variety Dinkum produced significantly higher grain yield than Jupiter and Dundale. Water use efficiency was also significantly higher for Dinkum than for Jupiter and Dundale when calculated on the basis of grain yield per unit of cumulative evapotranspiration. The greater water use efficiency of the semi-leafless genotype provides a potential explanation for its better yield performance compared with other plant types.

Key words

Field peas, semi-leafless, evapotranspiration, water use efficiency, morphology.

Introduction

Water use efficiency (WUE) is defined as the ratio of grain yield to water consumed expressed as either evapotranspiration (Et) or total water input to the system in a defined season (3). Differences in plant architecture might be expected to influence the ability of the crop canopy to use available soil moisture and thus affect water use efficiency. Under reduced soil moisture, lower water use efficiency of leafless or semi-leafless peas might be the result of the more open crop canopy (5). In two separate studies, no difference was found in water use efficiency between a conventional (Rover) and a semi-leafless (Rover x Semi-leafless) pea when grown in irrigated conditions (8, 9), but the semi-leafless variety made more efficient use of available soil moisture in dryland conditions (8). In contrast, later studies under dryland conditions indicated that tall conventional types (Dundale and Wirrega) had higher water use efficiency than the semi-leafless type (1). Similarly, Bailey and Groves (2) reported that a semi-leafless pea (Solara) appeared to be more responsive to irrigation than a conventional pea (Bohatyr) under relatively dry, sandy conditions. In recent years, semi-leafless pea varieties have consistently out-yielded both conventional and tare-leaf types and appeared to be the most successful of the germplasm evaluated at Narrabri (7). The objective of this study was to test whether a semi-leafless pea used water more efficiently than a conventional and tare-leafed pea.

Materials and Methods

Three morphologically different field pea varieties, Dundale (conventional), Jupiter (tare-leaf) and Dinkum (semi-leafless) were grown on a self-mulching black soil at The University of Sydney, Plant Breeding Institute, Narrabri, in the 1996 growing season. The crops were in 7-row plots with rows 13, 25 and 50 cm apart at a plant density of 60 plants/m^2. The experimental design was a randomised complete block with three replications. The experiment was planted with the soil at field capacity and no irrigation was applied during the growing season. Soil moisture was measured at weekly intervals using a Neutron Moisture Probe (NMP) model 503 DR inserted in one-metre access tubes in the centre of each plot. Readings were determined in 10-cm increments starting 10 cm below the soil surface and ending at 80 cm. A calibration curve was used to convert the counts into volumetric soil moisture contents. Seasonal water use (Et, mm) of each genotype was estimated from sowing to maturity. For the initial period of 58 days after sowing (DAS) when plants were still very small, Et was considered to be equal to moisture loss from the bare soil surface. For successive intervals up to 130 days, Et was estimated from the equation: Et =

Ds + P where Ds was the change in water stored in the soil profile over the study interval measured by NMP, and P was the precipitation recorded for the same interval (1, 8). Determination of Ds took account of changes in soil water down to a depth of 80 cm. At maturity, grain yield was recorded from 8.5 m^2 of machine harvested plots. Water use efficiency based on dry matter production (WUE_{dm}) was estimated as the ratio of the above ground biomass at maturity to accumulated evapotranspiration (Et). Water use efficiency for grain production (WUE_{gy}) was based on the ratio of machine harvested grain yield to accumulated evapotranspiration.

Results and discussion

The profile of extractable water through the soil to 80 cm depth showed small differences due to row spacing and larger ones due to cultivar at 36 and 130 DAS (Figure 1). These cultivars were unable to extract water below 70cm depth in this experiment.

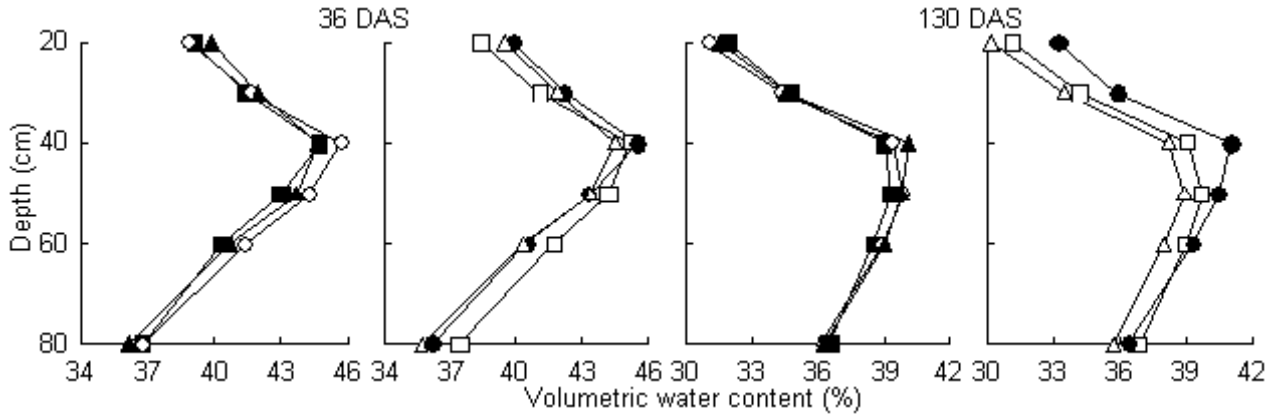

Figure 1. Change in volumetric soil water with depth for three pea cultivars (□ Dinkum; ●Dundale; ▲, Jupiter) at three row spacings (■, 13 cm; ○, 25cm; ▲, 50 cm) at 36 and 130 days after sowing in 1996.

Water usage by the different cultivars was similar until about 88 DAS, which coincided with the onset of flowering. It then became increasingly divergent until harvest at 130 DAS (Figure 2). Jupiter was most effective at extracting soil water, as shown by the greater decrease in the total soil water column and the greater increase in Et, and Dundale was least effective. Row spacing had no effect on cumulative water use of the crops throughout the growing season.

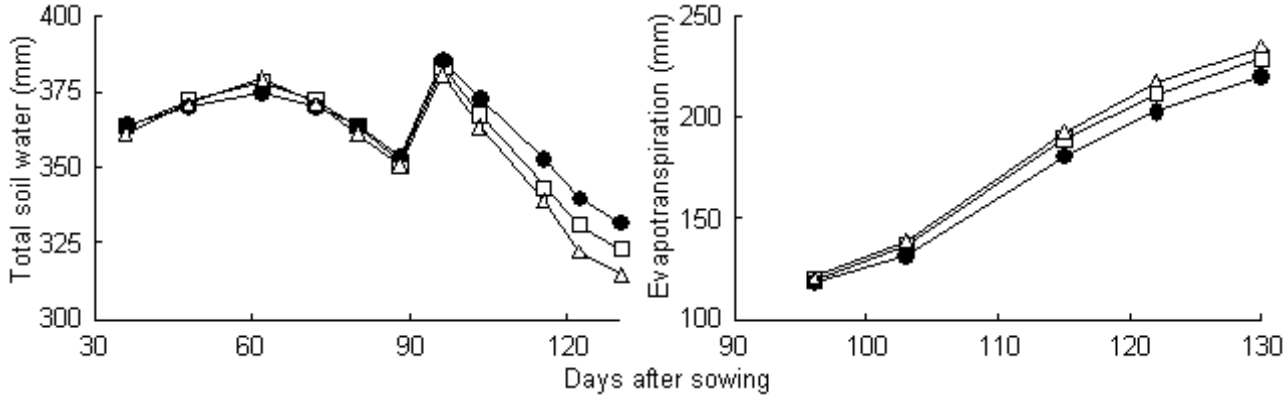

Figure 2. Change in total soil water content and cumulative crop water use by three pea cultivars (□, Dinkum; ●, Dundale; ▲, Jupiter) in the 1996 growing season.

Jupiter had the highest WUE_{dm} at all row spacings (Figure 3) and this trait was most stable across row spacings in this cultivar. Dinkum had the most sensitive WUE_{dm} to variation in row spacing. WUE_{gy} was highest for Dinkum at all row spacings followed by Jupiter and then Dundale. These results are contrary to the findings of Armstrong et al (1), who found that Dundale had higher WUE_{dm} than Dinkum and Progreta (tare). The difference may be related to the sensitivity of Dinkum to row spacing in contrast to the other cultivars.

Jupiter was the best genotype to utilize the available resources for dry matter production, but Dinkum made the best use of water for grain yield production. In all cases WUE_{gy} decreased with increasing row spacing, but the differences were not always significant (Figure 3). Harvest index was much higher in Dinkum, 46%, than in the other two cultivars, 23% in Dundale and 25% in Jupiter.

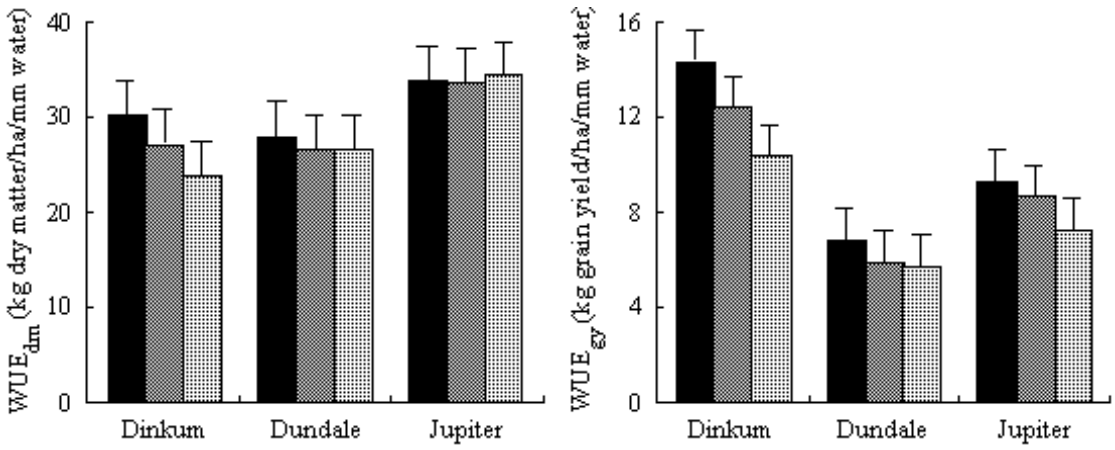

Figure 3. Water use efficiency in three cultivars of pea at three row spacings (left to right, 13, 25 and 50 cm) in 1996. Left figure, WUE for dry matter production, right figure, WUE for grain yield. Error bars show 1 LSD.

References

1. Armstrong, E. L., Pate, J. S. and Tennant, D. 1994. Aust. J. Plant Physiol. **21**, 517-532.

2. Bailey, R. J. and Groves, S. J. 1991. Aspects Appl. Biol. **27**, 299-304.

3. Cooper, P. J. M., Campbell, G. S., Heath, M. C. and Hebblethwaite, P. D. 1988. In: World Crops: Cool Season Food Legumes. (Ed. Summerfield, R.J.) (Kluwer Academic Publishers, Dordrecht, Netherlands). Pp. 813-829.

4. Heath, M. C. and Hebblethwaite, P. D. 1985. Agronomic problems associated with pea crop. In: The Pea Crop. (Eds. Hebblethwaite, P. D., Heath, M. C. and Dawkins, T. C. K.) (Butterworths, London, UK). pp. 19-29.

5. Heath, M. C. Pilbeam, C. J., McKenzie, B. A. and Hebblethwaite, P. D. 1994. In: Expanding the production and use of cool season food legumes (Eds. Muehlbauer, F. J. and Kaiser, W. J.) (Kluwer Academic Publishers, Dordrecht, Netherlands). Pp. 771-790.

6. Martin, I., Tenorio, J. L. and Ayerbe, L. 1994. Crop Sci. 34, 1576-1583.

7. Moore, S. G., Wheatly, D. M., O'Brien, L. and Jessop, R. S. 1996. *Proceedings 8th Australian Agronomy Conference*, Toowoomba, Pp 438-441.

8. Wilson, D. R., Hansen, R. and Jermyn, W. A. 1981. Proc. Agron. Soc. NZ, 11, 35-39

9. Zain, Z. M., Gallagher, J. N. and White, J. G. H. 1983. Proc. Agron. Soc. NZ, 13, 95-102.