Towards developing a general model for optimizing partial rootzone drying irrigation (PRD) in differing soil and environmental conditions

Ryan J.L. Ramsey and Hamlyn G. Jones

Introduction
Partial rootzone drying (PRD), where irrigation is applied alternately to different parts of the root system (e.g. Dry et al. 1996) has been proposed as a means of improving the crop water use efficiency (WUE) with no (or small) losses in yield. It has been successfully applied to several crops including grape vine. We have shown previously that WUE can be doubled by use of PRD on raspberries (Grant et al. 2004), but there are several reports of a failure to achieve benefits of PRD in some systems. Here we report some studies on the use of PRD on raspberries and potatoes grown in polyethylene tunnels on a loamy sand soil in Scotland (Fig. 1, 2, 3)

Figure 1. Raspberries growing in a tunnel.

Figure 2. Potato plants grown under Control (top) and PRD (bottom) irrigation

Figure 3. Soil moisture pattern across the rootzone of a potato plant grown in PRD. Each grid square is 10 cm.

Methods.
Raspberries (cv. Glen Ample) and potatoes (cv. Maris Piper) were grown in tunnels at the Scottish Crop Research Institute (Invergowrie, Scotland). The soil was comprised of sand 71%, silt 19%, clay 10% (field capacity (FC) 26%) over a coarse sand/gravel layer that begins at 35-40 cm depth. Soil moisture (θ) was monitored using either a PR1 Profile Probe or a Theta-probe ML2x (Delta-T, Cambridge). Irrigation treatments were PRD or Control; volume of water applied was based on maintaining the 100% treatments at, or close to, FC. Irrigation was with drip emitters of different flow rates (Netafim, Tel Aviv, Israel) with 1 or 2 emitters per plant. Evaporation (E) for water balance calculations was estimated from irradiance assuming 50% of energy was used for evapo-transpiration. Soil water balance was calculated using $D = I - E - d\theta$ where D is drainage and I is irrigation.

Results 1
Fig. 3 illustrates the soil moisture distribution under a PRD potato plant, suggesting sub-soil seepage. This effect is also seen in Fig. 4 which shows seasonal trends of soil θ for the two sides of PRD 50% and PRD 100%. Initial rates of irrigation were inadequate to maintain soil moisture close to FC, even for the well watered treatment. It is clear that the irrigation required to maintain soil θ close to field capacity is much in excess of that required solely to satisfy evaporative demand and plant growth – implying high rates of drainage (Table 1).

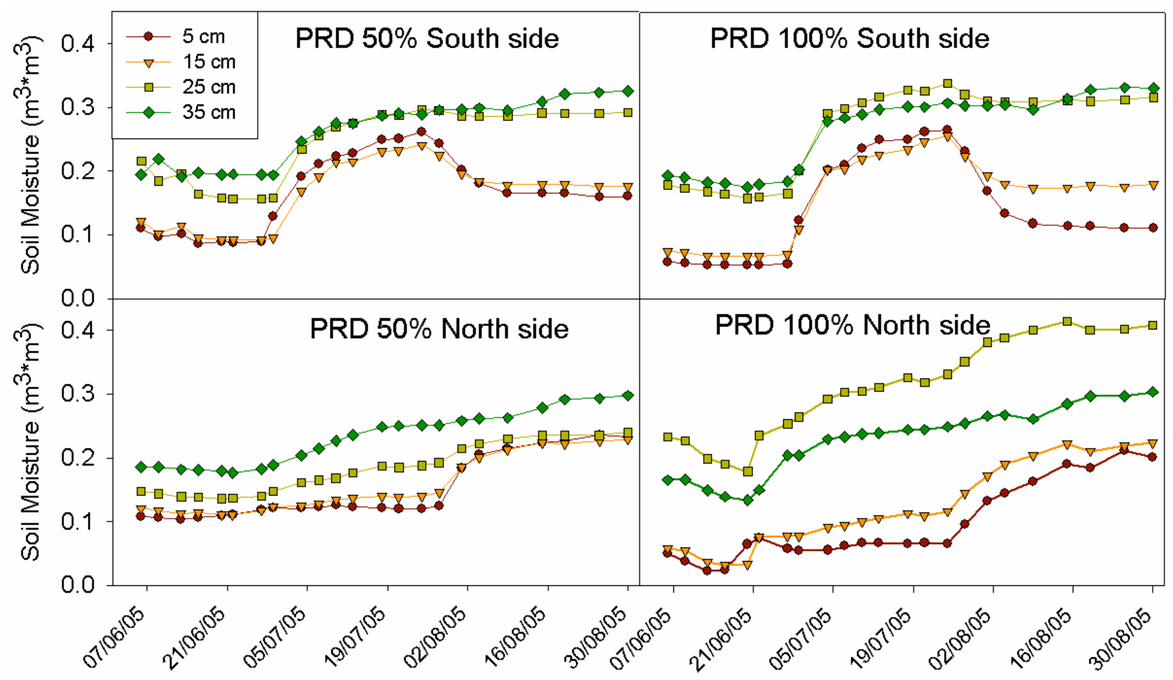

Figure 4. Soil θ at 5, 15, 25 and 35 cm for each side of PRD 50 and PRD 100 raspberry plots

Results 2. Therefore even the lowest water application rate supplied an excess of water, and this may explain the lack of differences in observed yield or stomatal conductance, and the small differences in _ (Fig 5). A further problem with the soil was the ready transfer of any excess irrigation throughout the plot via the gravel layer (Fig. 3,4)

Table 1. Mean seasonal drainage (raspberry) inferred from water balance (100% I = 790 mm).

Irrigation rate	Drainage (mm)	
	RDI	PRD
50	3.86	0.17
75	192.79	203.14
100	391.87	394.10

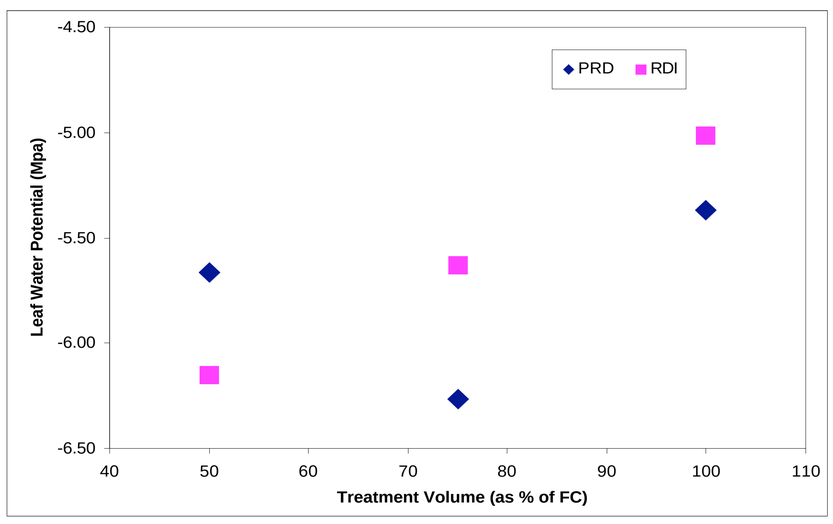

Figure 5. Mean leaf water potential of raspberry leaves vs. irrigation volume.

Conclusions
- The combination of the very sandy soil in the present tunnels and the drip emitters used limits water spread, thus tending to enhance drainage.
- In such situations we believe that irrigation with a broader spread may be advantageous.
- The applicability of PRD is strongly dependent on the method of irrigation and on the soil hydraulic characteristics.
- Subsidiary pot experiments showed that it was not sand *per se* which causes problems, as sand gave the best yields of several media tested.

References
Dry, P.R., Loveys B.R. Botting, D., During, H. 1996. Effects of partial root-zone drying on grapevine vigor, yield, composition of fruit and use of water. Proceedings of the 9th Australian Wine Industry Technical Conference. p 126-131
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