The low productivity of irrigated agriculture - is irrigation method a key factor?

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Irrigated crop yields in S.E. Australia are, on average, about 50% of those obtained with the best systems of management. For example, mean yields for maize, sorghum, wheat, sunflower and soybeans in the MIA from 1973/74 to 1975/76 were 5.10, 4.68, 1.98, 1.38 and 0.68 t ha^{-1}. Australian irrigated agriculture has been based on imported technology, mostly from the US, where well drained soils predominate. In contrast, poor internal and external drainage have been suggested as the major factors limiting yield in S.E. Australian irrigation areas. Flood and furrow irrigation can lead to saturation of the root zone, causing anaerobic conditions with effects on root activity, root diseases and denitrification losses. Our hypothesis is that the present watering cycle with large infrequent irrigations causes the depth at which soil conditions are optimum for root activity to fluctuate, thus forcing crops constantly to redirect assimilate supplies to new root growth areas.

Data collected during the summer of 1980/81 have shown that surface irrigation can have a severe effect on the soil environment. Water intake is rapid in MIA soils, up to 80% of the total water intake occurring in the first half hour of irrigation with effective saturation occurring after about 4h. This soil saturation causes severe anaerobic conditions; soil 0_2 levels of less than 2% develop below the cultivated layer and persist for several days. Following irrigation, root development is rapid in the crop hill or row where drainage and reoxygenation first occur. Root length densities of up to 18 x 10^4m m^{-3} have been measured under maize in the top 0.1 m of the crop row. However, during a 14-day irrigation cycle the water content of the top 0.2 m of soil is reduced to near wilting point, so that many fine roots are lost, while major root development into the wetter subsoil layers is necessary to meet E requirements. Thus the irrigation cycle begins with a saturated anaerobic profile, forcing surface root development and probably damaging the deep root system, and progresses to a stage where surface roots are in dry soil and deeper water extraction is necessary.

Traditionally, these root zone drainage problems have been alleviated with deep tillage practices and soil ameliorants. In general their benefits have been transitory. We suggest that a more permanent solution to these irrigation cycle problems lies in better water management. At least three alternative methods of flood/furrow irrigation are now in use. Low-pressure, high-volume pumps are replacing syphons in some of the northern cotton growing areas so that ponding time can be reduced from 12h to less than 2h, thus preventing soil saturation. Frequent irrigation with added N is being used for maize production in the Riverina so that water and N are always available in the surface soil of the well-drained crop row. Going one step further than this, soybeans are being grown with continuous irrigation applied down every alternate furrow, allowing a dense mat of roots and nodules to develop in the areas where water tension and 0_2 supplies are optimum. If the cost of water rises, or if considerable yield advantages from avoiding soil saturation can be demonstrated, then alternative irrigation methods such as low-pressure lateral move systems may become important. These systems have the great advantage of allowing control of both the timing of irrigations and the volume of water applied.