THE EFFECT OF NON-LETHAL WATER DEFICITS DURING ESTABLISHMENT ON THE GROWTH OF WHEAT CROPS

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Summary. Early sowing of wheat crops in the Western Australian wheatbelt early can result in high grain yield, but there are risks including a period of early water deficit following emergence. A rainout shelter and an irrigation setup used to generate a wide range of water deficits in the period up to the double ridge stage (62 das), showed that early water deficits can alter the timing of phenological development, reduce the rate of leaf emergence, final mainstem leaf number, fertile tillers and grain yield. These observations suggest that water deficits during establishment, regardless of good finishing rains, can drastically reduce grain production of early-sown wheat crops in the Western Australian wheatbelt.

INTRODUCTION

The early sowing of dryland wheat in the Western Australian wheatbelt depends on early rain with an early break occurring in 1 in 3 years. Sowing early is beneficial as it maximises the potential yield of the wheat crop (a delay may result in a yield penalty of upto 50 kg/ha/day (3) and optimises water use. There can also be risks associated with early sowing in April, including increased frost injury, leaf diseases and extended periods of water deficits during crop establishment. While work has been carried out on maize (1), no studies have examined the influence of water deficits during establishment on wheat crops. Numerous studies have investigated the effects of water deficits on wheat, but these have been confined to its role in later stages of development (2, 6). The experiment reported here is part of a continuing project to assess the risks associated with early sown wheat crops in the Western Australian wheatbelt.

MATERIAL AND METHODS

A field trial was carried out at Merredin Research Station, Western Australia (*lat.* 31^{o} 20'S and *long.* 118^{o} 16'E) in 1994 on a sandy loam duplex soil (*Norpa grey sand*) in a 1:1 lupin/wheat rotation sown to lupins in 1993. Spear wheat (sown on 8 May using no-till and a seed rate of 50 kg/ha, with adequate fertiliser) was grown using a PiGola rain shelter. An irrigation system was used to impose a gradient of water application similar to that obtained with a line source design (4, 5). This design is a practical means of elucidating plant responses to water over a wide range of water availability within an area of limited size, such as a rainout shelter. A limitation of these designs is that they do not permit statistical comparisons among individual water regimes, nor direct association of the water treatment with the effects observed. As argued by (5), the data presented in this paper on rainfall, irrigation and water content of the soil provide evidence that the effects observed were related to water availability. This experiment consisted of 14 watering treatments with each treatment replicated twice. The crop was irrigated with an initial basal watering (15 mm) to allow uniform emergence. The crop emerged after 10 days and was exposed to its first gradient watering (6-19 mm) at 12 days after sowing and 3 subsequent gradient waterings (1-15 mm) at 38, 52 and 56 das respectively. The crop was exposed to an increasing intensity of water deficit through establishment. This deficit was relieved when all treatments reached double ridge (62 das). at which time plots were irrigated to prevent water deficits and the rainout shelter covers removed. All plots were irrigated to prevent any further water deficit uptil grain harvest. The water regime of each water treatment is outlined in Fig. 1.

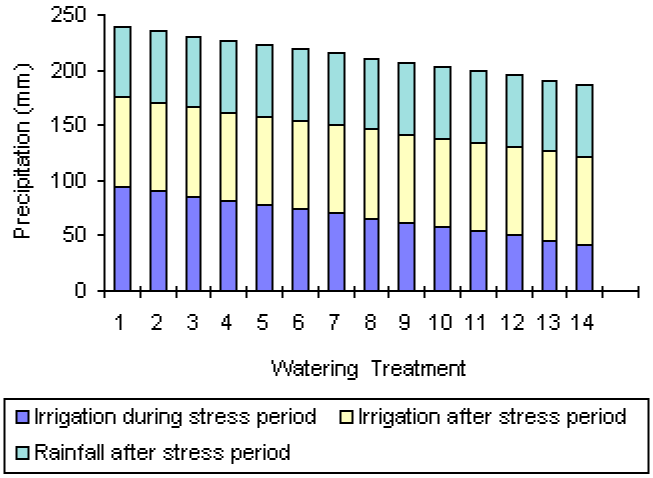

Figure 1. Watering regime treatments of a Spear wheat crop exposed to a systematic gradient of water deficit during establishment using a rainout shelter and T-Tape irrigation setup.

Soil water status was monitored using gravimetric water content of soil cores (0.15 m) and a Neutron Moisture Meter (Hydroprobe, Campbell Pacific) with access tubes installed to 1 m depth. Phenological development (including time to double ridge, terminal spikelet and anthesis), mainstem leaf emergence and tiller emergence, and grain yield components, were recorded at regular intervals.

RESULTS AND DISCUSSION

Measurements of soil water profiles of each water treatment reflected the watering regime, with soil water content reducing as the amount of irrigation was reduced across the water gradient (data not shown). Following uniform crop emergence (*ca.* 90 plants/m^2), those plants exposed to an increasing level of water deficit up to 62 das, showed changes in crop phenology (Fig. 2). Time to double ridge was increased in severe water deficit treatments to 59 das (Treatment 14) compared with 51 das in less stressed treatments (Treatment 1). There was little variation in time to terminal spikelet across the water deficit treatments (72-73.5 das, Fig. 2). This would indicate that under severe water deficits there is a shorter period of spikelet initiation from double ridge to terminal spikelet. There was a slight hastening of time to anthesis in those treatments exposed to severe water deficits (Treatments 13-14) by 1-2 days (127 das) when compared to those exposed to lower levels of water deficits (130 das). Associated with this change in phenological patterns, increasing levels of early water deficit resulted in a reduced rate leaf of emergence (Fig. 3a), and therefore by the end of the water deficit treatment a lower number of mainstem leaves had emerged (Fig 3b). There was a delay in the rate of leaf emergence during the period of water deficit, resulting in plants exposed to most severe level of water deficit (Treatment 14) producing 5.23 leaves compared to 6.14 leaves for plants exposed to least severe water stress (Treatment 1). There was also a reduction in final mainstem leaf number with increasing levels of early water deficits with plants exposed to high water deficits producing in some instances 8 leaves compared to 9-10 leaves in plants exposed to low water deficits (Fig. 4a). Increasing levels of water deficit also resulted in a reduction in the number of tillers which produced grain (Fig 4a). Those plants exposed to a severe water deficit produced 2.6 tillers/plant (Treatment 14) compared to 3.2 tillers/plant in plants exposed to a low water deficit (Treatment 1).

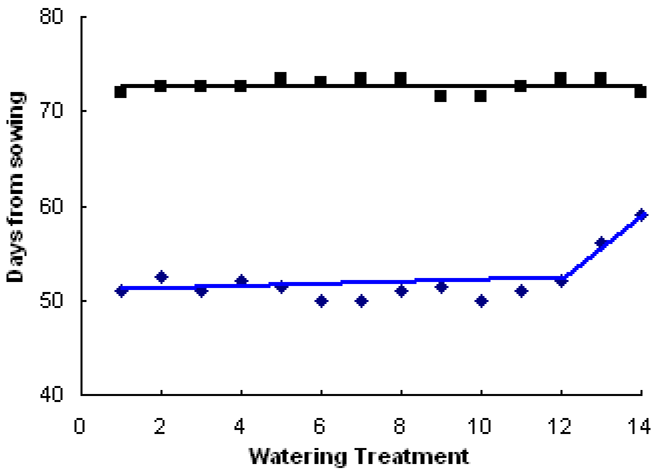

Figure 2. The influence of a systematic gradient of water deficit during establishment on the phenological development (time to double ridge (u), time to terminal spikelet (n)) of a Spear wheat crop.

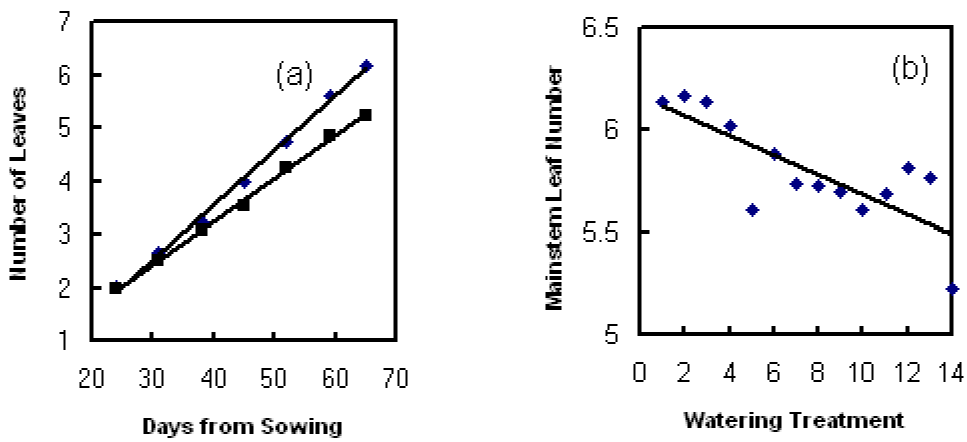

Figure 3. The influence of a systematic gradient of water deficit during establishment on (a) rate of leaf emergence during water deficit period of Treatment 1 (n) and Treatment 14 (u)and (b) number of mainstem leaves at end of water deficit treatment in a Spear wheat crop.

Water deficits during establishment resulted in a decline in grain yield, total grain number, mean grain size and seeds/ear. Final grain production in the severe water deficit treatment was almost halved (Fig. 4b) resulting from a reduction in individual grain size, grains/ear (data not shown) and fewer tillers producing grain (Fig. 4a). Reductions in leaf growth, biomass accumulation (data not shown) and tillering (Fig. 4b) due to early water deficit reduce grain production regardless of whether or not the wheat crop receives good mid- and late-season rains. This investigation suggests that moderate to severe water deficits following emergence can drastically reduce grain yield, but risks may be minimised by sowing on heavier soils and avoiding sandy soils with low water holding capacity.

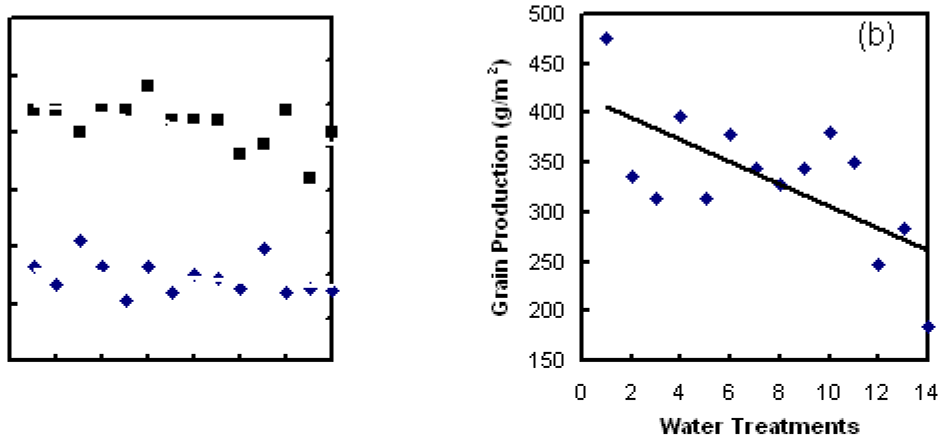

Figure 4. The influence of a systematic gradient of water deficit during establishment on (a) the final number of mainstem leaf number (n) and number of fertile tillers/plant (u) and (b) the grain production (g/m^2) of a Spear wheat crop.

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