PREDICTING MUNGBEAN RESPONSE TO WATER STRESS

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Abstract

Crop simulation models are being used to evaluate alternative management options in dryland farming systems. A field study was undertaken to quantify the response of mungbean under three contrasting water regimes in terms of leaf area, biomass and N accumulation, harvest index and grain weathering, in order to improve model predictive ability. The results are discussed in terms of common assumptions about the physiological response of grain legumes to water deficit.

Key words: Water stress, mungbean, nitrogen, harvest index, simulation model.

Dryland mungbean is exposed to varying timing and severity of water deficit, which results in variability in grain yield, nitrogen accumulation and grain quality.? Crop simulation models are being used to evaluate alternative management options in dryland farming systems (2). Better physiological understanding is required so that grain yield and quality under variable water supply may be more accurately predicted. In particular, little is known of how a crop such as mungbean, which continues to produce vegetative biomass during pod-filling, responds to variable water supply. This paper reports on the results of field experiments which aim to quantify the response of key physiological attributes to varying timing and intensity of water deficit.

Materials and methods

Mungbean cv. Emerald was subjected to three contrasting water regimes on a vertisol soil at Lawes, South East Queensland. In one sowing (28 November, 1996) the crop was either fully-irrigated or rainfed. The rainfed crop experienced severe water deficit between 40 and 60 days after sowing (DAS), after which time rainfall ensured little stress until maturity (Fig. 1). In another sowing (9 January, 1997) the crop was rainfed. In contrast to the earlier sowing, water deficit here occurred between 60 DAS and maturity (Fig. 1). For convenience, the three crops will be referred to as irrigated, intermittent stress and terminal stress. Except for rainfall, environmental conditions were similar for the two sowing dates. Crops were sampled throughout growth for leaf area index (LAI), above-ground biomass, grain and nitrogen (N), and degree of weather damage, an important determinant of grain price in mungbean. All crops flowered at about 45 DAS. Soil water content to the maximum depth of root water extraction (150 cm) was recorded regularly with a neutron moisture meter. Previous crops at the site had depleted the soil of mineral N, and limited measurements of N^{15} natural abundance confirmed that most of above-ground N was fixed from the atmosphere.

Results and discussion

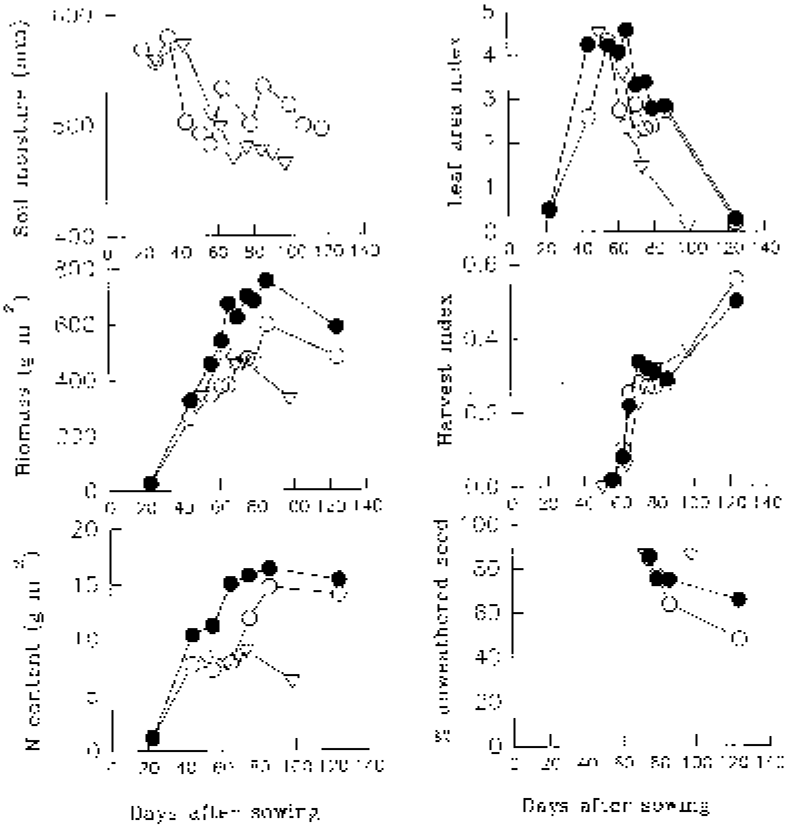

Figure 1 The effect of water regime [irrigated (●), intermittent stress (○), terminal stress (▽)] on time course total soil water (0-150 cm), leaf area index, above-ground biomass, above-ground N content, harvest index and grain quality

While pre-flowering water stress in the intermittent crop slowed LAI increase, subsequent relief of stress resulted in a slight increase and then maintenance of LAI during grain-fill (Fig. 1). In contrast, terminal stress caused a sharp drop in LAI during grain-fill. Current models do not account for leaf growth from branches during grain-fill.

Most simulation models assume that N fixation is more sensitive to water stress than dry matter accumulation (3), and that N fixation ceases during grain-filling (4). In the intermittent crop, biomass continued to increase, albeit more slowly, during the stress period, while N accumulation effectively ceased (Fig. 1). However, N accumulation resumed rapidly upon relief of stress and approximately doubled during grain-filling.? In contrast, there was little further increase in N accumulation after 50 DAS in the terminal crop.

In current models, grain yield is simulated assuming that harvest index (HI) increases linearly during grain-filling (3). The results here show that linear HI was appropriate for prediction of the first flush (Fig. 1) and this is relevant to most commercial crops. However, more work is needed to accommodate the second flush under favourable water supply, which has a lower rate of increase, as also recorded by Bushby and Lawn (1).

Weathering and grain quality of mungbean at maturity is thought to largely be controlled by the number of wetting and drying cycles from rainfall during grain-filling (5). Fig. 1 shows that the intermittent crop had greater weather damage than the irrigated, despite receiving less rainfall or irrigation during pod-filling.? This suggests that other factors may be involved in weathering.

Conclusion

This study has shown that some of the commonly-held assumptions about physiological response to water deficit in grain legumes, do not apply. In particular, relief of water deficit around flowering stimulated an increase in N accumulation during grain-fill, and HI did not follow the assumed linear increase to maturity. Work is in progress to further quantify and parameterise the processes of interest, so that simulation models can be applied with confidence to a wide range of dryland environments.

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