The response of sorghum and sunflower to short-term waterlogging

I. Effects of stage of development and duration of waterlogging on growth and yield

P. W. ORCHARD and R. S. JESSOP
Department of Agronomy and Soil Science, University of New England, Armidale 2351, Australia

Received 5 December 1983. Revised February 1984

Key words Duration of waterlogging Leaf area Plant height Sorghum Sunflower Yield

Summary The effect of waterlogging on sunflower and sorghum was investigated in relation to stage of development (sunflower—6-leaf, buds-visible, anthesis; sorghum—5-leaf, initiation, anthesis) and duration of waterlogging (3, 6 and 9 days) under glasshouse conditions. Additionally, the potential adaptation of the two crops was observed by waterlogging some plants at all three growth stages. With sunflower, leaf expansion and stem extension were inhibited by waterlogging at the 6-leaf and buds-visible stage although these effects did not always persist until maturity while, with anthesis waterlogging, rapid desiccation of leaves was observed. Yield was most affected by the anthesis waterlogging but no consistent effect on seed number or 1000 seed weight was recorded.

Waterlogging sorghum plants suppressed normal tillering but had little effect on dry weight of the main stem. Late tillering was stimulated by waterlogging. Reductions in leaf area occurred at all stages of development in response to waterlogging with these effects being more marked at initiation. Similarly, yield was most reduced by the initiation waterlogging largely as a result of reduced seed number.

In neither species was there a clear relationship between duration of waterlogging and subsequent reduction in growth and yield. With respect to yield, stage of development seemed to be of greater importance than the duration of waterlogging. The growth and yield of multiple-waterlogged sunflowers was less affected by the anthesis treatment than that in plants experiencing a single waterlogging, suggesting that some form of adaptation was induced. In contrast, no such response was seen in sorghum.

Introduction

The response of plants to waterlogging is usually considered to be dependent on genotype, environmental conditions, stage of development and the duration of the waterlogging period\(^2,17\). It is well documented that considerable variation in waterlogging tolerance exists both between and within species\(^6,7,8\). Further, under conditions of short-term waterlogging (\(i.e.\) up to 10 days), numerous authors have shown that the greater the duration of waterlogging, the more damaging the effect\(^8,10,14\) although this is not true for all species or all environments\(^9\). With respect to stage of development, no consistent pattern of
plant damage can be discerned from the literature and this is suggested to be due to variations in experimental technique, environmental conditions and definitions of growth stages. There is considerable fragmentation of information relating plant response to waterlogging. A wide range of effects have been reported but few attempts have been made to establish the relative contribution that each makes to waterlogging damage or to place them in a specific time-scale. Again, many observations have been limited to plants waterlogged only during the seedling stage of growth.

In the following experiment, the interaction between stage of development and the duration of waterlogging was investigated in relation to growth and yield of sunflower and sorghum. These species were selected since they are both important summer crops and provide contrasting plant types (dicotyledonous and monocotyledonous, respectively). Further, the potential adaptation of the two species was also examined by imposing waterlogging at several growth stages. The differences and similarities between the applied treatments were documented to provide a basis for the later investigation of changes in the soil environment, the physiological response of the two species and factors contributing to waterlogging damage.

Materials and methods

The experiment was performed using the 2–10 cm layer of a grey lateritic podzolic soil (Plinthustalf) which had been air-dried and passed through a 2 mm sieve. The moisture characteristic of disturbed samples of this soil, together with chemical and physical properties, have previously been described. The drainage holes of 23 cm diameter pots were sealed by pressing silastic-covered corks over each hole and 5 kg of soil was added. Three seeds of sunflower (Helianthus annuus var. Suncross 52) or sorghum (Sorghum bicolor var. E57) were sown and pots were watered to 90% field capacity. The soil was maintained at approximately this level by weighing 10 pots at frequent intervals with due additions of water to the soil surface. Allowance was also made for the increase in plant weight with time from previously reported work with these species under similar cultural conditions. Plants were thinned to 1 per pot at the 2–leaf stage to give a uniform population.

Waterlogging treatments were imposed for 3, 6 or 9 days by slowly adding sufficient water to raise the water table to the soil surface where it was maintained for the required period. Treatments were released by breaking the silastic seals and allowing free drainage. Sunflowers were waterlogged at 6–leaf (V), buds-visible (I) or anthesis (A) growth stages. For sorghum, these coincided with the 5–leaf (V), initiation (I) and anthesis (A) stages of development, respectively. A further series of treatments consisted of waterlogging at all three growth stages for 3, 6 and 9 days. These treatments are designated as VIA 3, VIA 6 and VIA 9. In such cases, pots were resealed with silastic prior to the imposition of waterlogging. All treatments were replicated three times.

The experiment was conducted under glasshouse conditions between August and December 1979, under a temperature regime of 27°C (± 2°C) maximum and 18°C (± 2°C) minimum. Leaf area and plant height were measured frequently throughout the experiment as indices of plant growth. The former was measured non-destructively using the relationship leaf area = max. leaf length × max. leaf width × 0.7 for sunflower and max. leaf length × max. leaf