SYMBIOTIC NITROGEN FIXATION AND VEGETATIVE GROWTH OF COWPEA (VIGNA UNGUICULATA (L.) WALP.) IN WATERLOGGED CONDITIONS*

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SUMMARY

Various periods of waterlogging (up to 32 days duration) were imposed upon cowpea plants grown in pots under controlled glasshouse conditions. Particular attention was paid to treatment effects on nodule cortication, nitrogenase activity and fixation efficiency, and the consequent differences in plant dry weight and nitrogen content.

All waterlogging treatments increased nodule cortication as compared with the unstressed controls; a 16-day stress period being of critical duration with respect to the bi-phasic nature of this anatomical response. Conspicuous lenticel-type protuberances were present on nodules formed under waterlogged conditions but were markedly reduced, or indeed absent, in the controls. Total dry weight of nodules per plant was reduced by 60 per cent after only 8 days waterlogging, but nitrogen fixation efficiency of nodules which persisted was only 18 per cent less than those on control plants; mean nodule cortex having increased from 39.8 (control) to 51.5 per cent. After 16 days waterlogging, total plant dry weight was decreased by ca 60 per cent as compared with control plants; reflecting similar adverse changes in leaf, stem and root dry weight. The most severe treatment (32 days waterlogging) did not further reduce plant dry weight but mean nodule cortex area increased from 55.9 (16 days) to a maximum of 59.3 per cent. With the exception of nodules, percentage nitrogen content of various plant components was unaffected by the treatments imposed.

Both the formation of enlarged 'lenticels' and increased nodule cortication are regarded as adaptive anatomical responses which facilitate continued symbiotic nitrogen fixation and vegetative growth of this legume under waterlogged conditions.

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INTRODUCTION

Seed yields of cowpea (*Vigna unguiculata* (L.) Walp.) growing in the tropics show considerable seasonal variation and are influenced adversely not only by pests and diseases but also by environmental factors which impose physiological stress \(^{15}\). This legume, like many others, is reported intolerant of waterlogged conditions and should therefore be grown on free-draining soils \(^{1}\). This recommendation, however, is based on field observations only and we are unaware of any other quantitative data for cowpea.

Sensitivity to waterlogging stress has been reported for several temperate legumes \(^{6,14}\) and ascribed largely to reduced symbiotic nitrogen fixation as a result of impaired oxygen transport to, and within, the nodules \(^{9,11}\). For soyabean, the nodule cortical tissues and, more especially, lenticel protuberances on the nodule surface have been implicated as physical agencies in the transport of oxygen to internal bacterial tissues \(^{8,13}\). However, 'lenticel-type' structures are very reduced, if present at all, on nodules of cowpea \(^{8}\).

Optimum seed yields in cowpea depend on the number of main stem and, especially, side branch nodes produced during vegetative growth \(^{16}\) and on effective nodulation and prolonged symbiotic nitrogen fixation \(^{15}\). Clearly, any environmental factor which reduces either of these attributes of plant/symbiont development can have adverse consequences with respect to ultimate seed yield. This present investigation was designed to assess, quantitatively, the effects of various periods of waterlogging, imposed throughout the phase during which nodulation and nodule development proceed most rapidly (under stress-free conditions) on nodulation *per se* and on vegetative growth. Furthermore, changes in gross nodule structure were recorded in order to test the hypothesis that increased cortication and/or formation of lenticel protuberances may prevent degeneration of bacterial tissues and thus facilitate continued symbiotic nitrogen fixation, and vegetative plant growth, during even prolonged waterlogging conditions.

MATERIALS AND METHODS

Cowpea cv. K 2809, a relatively photoperiod-insensitive cultivar in terms of flowering response \(^{4}\), was used throughout the investigation and was grown...