RESPONSE OF EUCALYPT SPECIES TO SOIL MOISTURE STRESS IN ACID SOIL

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ABSTRACT

The soil moisture stress significantly affected the growth of the four selected eucalypt species. In case of *Eucalyptus citriodora* the growth improved as the soil moisture content increased up to 53% of field capacity. In case of other species the growth improved up to 67% of field capacity. The root growth was adversely affected with an increase in soil moisture content and therefore there was a decline in the root/shoot ratio. The overall growth was very poor in this highly acid and low fertility level soil.

সারসংক্ষেপ

মৃত্তিকায় আর্দ্রতার পীঁড়ন নির্বাচিত চারটি ইউক্যালিপটাস প্রজাতির বৃদ্ধিকে উল্লেখযোগ্যভাবে প্রভাবিত করেছে। ইউক্যালিপটাস সাইট্রিওডোরার ক্ষেত্রে মাঠের ধারণ ক্ষমতা ৫৩% পর্যন্ত এবং অন্যান্য প্রজাতির ক্ষেত্রে ৬৭% পর্যন্ত চারার বৃদ্ধিতে উন্নতি পরিলক্ষিত হয়েছে। মৃত্তিকায় আর্দ্রতার পরিমাণ বৃদ্ধির স্যথে শিকড়ের বৃদ্ধি প্রতিকূলভাবে প্রভাবিত হয়েছে এবং শিকড়/চারার উপরিভাগ অনুপতি হ্রাস পেয়েছে। অত্যন্ত অম্ল এবং নিম্নমানের উর্বরতা সম্পন্ন এই মৃত্তিকায় চারার বৃদ্ধি খুবই সামান্য ছিল।

INTRODUCTION

A stress in soil moisture higher than required for the optimum growth is known to limit the plant growth (Marshall and Holmes 1988). The level of soil moisture was also reported to affect lime response of subterranean clover (Horsnell 1984). More recently, the soil moisture stress was reported to affect Al tolerance of barley (Krizek and Foy 1988) and sunflower (Krizek *et al*, 1988) grown in acid soil. Since eucalypts are found to grow in many acid soils (McColl 1969; Talsma 1983) it was considered necessary to examine the effect of soil moisture stress on the growth of some important eucalypt species in an acid soil high in exchangeable Al. Since attempts are being made to grow some eucalypt species in Bangladesh and for a major part of the year they do not receive sufficient moisture, such a study may provide an useful information for planning eucalypt growth in Bangladesh.

MATERIALS AND METHODS

The acid soil samples were collected on the basis of Talsma (1983) for selecting an acid soil site for final selection of soil. The soils were analyzed for p^H in water (p^Hw), p^H in 0.01M $CaCl_2$ solution (p^Hs), particle size distribution (Bouyoucos, 1928) and organic matter (Walkley and Black 1934). From an 1N. NH_4Cl extract Ca, Mg and Mn were determined with atomic absorption spectrophotometer and Al was determined by the Ferron method (Belyayeva, 1966). After previewing soil analysis data, compartment 152 of the Uriarra Forest was selected because it was low in p^H, organic matter, exchangeable Ca and Mn and high exchangeable Al and % Al saturation. The site is located at the Blue Range, Brindabella, A C T about 25 km west of Canberra (35°17"S and 148°52"E) and is at an altitude of 850 m.

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The selected soil was further analysed for exchangeable K (1N NH_4Cl extract), available P (Colwell 1965), extractable mineral N (Bremner 1965), the lime requirement (Shoemaker *et al* 1961) and field capacity (Wilde *et al* 1979).

One kilogram of air dry (812g oven dry weight), sieved (5 mm mesh size) soil was transferred to each pre-weighed bag inside a plastic pot. A plastic access tube (16 mm internal diameter) was inserted vertically in the centre of each pot before packing the soil. The lower ends of the tubes were filled with cotton wool to prevent soil entry and the upper ends were covered with a cap to prevent evaporation via the tube. As it is difficult to water soils in pots to a uniform moisture regime which is below field capacity, the plastic access tube was used to overcome it (Bachelard, 1986) when moisture stress was implemented. The seedling of *E. camaldulensis, E. citriodora, E. gummifera* and *E. saligna* were raised in vermiculite-perlite mixture and five weeks' old seedlings were transplanted @ three seedlings/pot. After establishment, the seedlings were thinned to two per pot. After 12 weeks, 30 mg N/kg soil was applied in solution as urea. After another 15 weeks, a further 30 mg N/kg soil was applied in the same way. The soil surface of the pots was covered with about 5 mm of plastic pellets as a mulch.

Three pots were allocated to each of the four moisture stress levels 23 weeks after transplantation. At this stage the shoot heights were measured and the pots were selected to provide seedlings of identical heights and vigour for each moisture stress level. The pots were arranged in a completely randomized design and the experiment was conducted in a glasshouse with day/night temperature of 26/18°C. All the pots were watered to field capacity. The estimated pot weights required for specified moisture levels of 40, 53, 67 and 80% of field capacity were calculated. Thereafter the pots were watered daily to a moisture stress weight. About half the water was added through the tube and the remaining half was added on the soil surface. Daily losses of water were recorded for the levels and an average minima of 35.5, 46.5, 58.4, 70.1% (of field capacity) respectively were reached before watering. The shoot heights were recorded before the moisture stress was imposed and then every two weeks until harvest at 18 weeks after the moisture stress began. The seedlings were cut at the soil surface, the shoots were washed in distilled water and dried in an oven for 48 hours at 70°C. The roots were washed out of the soil and then dried in the same manner.

RESULTS AND DISCUSSION

The characteristics of only the selected soil are shown in Table 1. Soil p^H, available P and exchangeable Ca in this soil were low. The factors complicating soil acidity situation such as organic matter and exchangeable Mn were also low. Exchangeable Al and the percentage of Al saturation were very high in this soil and the ratio Ca/Al was low. Therefore, the soil may be considered ideal to be a poor acid soil where Al is probably the main soil acidity factor.

Table 1. Characteristics of the soil

Properties	Values
Clay (g/100 g)	28.60
Organic matter (g/100 g)	1.69
$p^{H}w$	5.35
$p^{H}s$	4.04
Exchangeable Ca (me/kg)	0.18
Exchangeable Mg (me/kg)	4.02
Exchangeable K (me/kg)	2.08
Exchangeable Mn (me/kg)	0.06
Exchangeable Al (me/kg)	66.00
Extractable mineral N (mg/kg)	16.10
Available P (mg/kg)	Tr.
Lime requirement to attain pH 6.0	8650 kg/ha
Field capacity (g/100 g)	46.60
Ca (me/kg)/Al (me/kg)	0.006

The parameters used to evaluate the effects of soil moisture stress on the eucalypt species were shoot height at harvest, shoot dry weight, total seedling biomass and the root/shoot ratio (Figure 1). The species differed in their response to moisture stress. At the lowest moisture level, an average shoot height ranged from 2.9 cm to 3.7 cm for *E. camaldulensis*, 11.7 cm to 14.6 cm for *E. citriodora*, 6.8 cm to 7.8 cm for *E. gummifera* and from 4.8 cm to 5.2 cm for *E. saligna* (values of shoot height before the beginning of moisture stress are not shown).

The shoot height of all the species increased slightly with an increase in soil moisture level except for *E. citriodora*, in which the shoot height declined beyond a field capacity of 67% (i.e., at 80%). The shoot dry weight and total seedling biomass increased in *E. camaldulensis* and *E. saligna* with an increases in the soil moisture level. The shoot weight and total biomass increased first, and then declined beyond 67% and 53% of field capacity for *E. citriodora* and *E. gummifera* respectively (i. e., 80% and 67% respectively). In the case of *E. gummifera* both the shoot weight and total biomass declined with moisture levels at 67% or wetter and in the case of *E. citriodora* these parameters declined beyond a moisture level of 53% of field capacity. In all the species the root/shoot ratio declined at higher moisture levels. It has happened due to more adverse effects on root growth of the seedlings. The difference in this ratio was significant in cases of *E. camaldulensis* and *E. saligna*. However, it also implies that the shoot growth of these two species sustained even when the root growth was adversely affected.

In general, the growth of all the species was very poor and they produced a low biomass even over the long growing period. Some seedlings of *E. camaldulensis*, *E. citriodora* and *E. gummifera* and many *E. saligna* showed some physiological disorders. The disorders occurred in older leaves and after about 12 weeks from transplantation. The symptoms were brown to dark brown spots in older leaves; in a few cases edges of leaves became purple. In *E. gummifera* some leaves became yellowish and in *E. saligna* some developed signs of necrosis and purple edges. The symptoms were similar to those reported for P deficiency in E. pilularis (Truman and Turner, 1972) and may be due to same reason here since the soil is also extremely low in available P.

The generally very poor growth of seedlings may have concealed the response of the species to soil moisture stress.

REFERENCES

Bachelard, E. P. 1986. Effects of soil moisture stress on the growth of seedlings of three eucalypt species. II. Growth effects. *Aust. For. Res.* 16 : 51-61

Belyayeva, N. I. 1966. Determination of aluminium in the presence of iron : spectrophotometric method using the reagent ferron. *Soviet Soil Sci.* 1 : 218-220

Bouyoucos, G. J. 1928. The hydrometer as a new method for the mechanical analysis of soils. *Soil Sci.* 26 : 233-238

Bremner, J. M. 1965. Inorganic forms of nitrogen. *In* C. A. Black (ed.) 'Methods of Soil Analysis', part 2, pp 1179-1237, Agronomy Monograph 9, Am. Soc. Agron., Madison, Wisc.

Colwell, J. D. 1965. An automatic procedure for the determination of phosphorus in sodium hydrogen carbonate extract of soils. *Chem. and Ind.* pp 893-895

Horsnell, L. J. 1984. Effect of soil moisture on the response of subterranean clover to lime. *Plant and Soil.* 81 : 295-7

Krizek, D. T. and Foy, C. D. 1988. Role of water stress in differential aluminium tolerance of two barley cultivars grown in an acid soil. *J. Pl. Nutr.* 11 : 351-67

Krizek, D. T.; Foy, C. D. and Wergin, W. P. 1988. Role of water stress in differential aluminium tolerance of six sunflower cultivars grown in an acid soil. *J. Pl. Nutr.* 11 : 387-408

Marshall, T. J. and Holmes, J. W. 1988. Soil Physics (second edition). Cambridge University Press.

McColl, J. G. 1969. Soil-plant relationships in a eucalyptus forest on the south coast of New South Wales. *Ecol.* 50 : 354-362

Shoemaker, H. E.; McLean, E. O. and Pratt, P. F. 1961. Buffer methods for determining lime requirement of soils with appreciable amounts of extractable aluminium. *Soil Sci. Soc. Am. J.* 25 : 274-77

Talsma, T. 1983. Soils of the Cotter catchment area, A C T : distribution, chemical and physical properties. *Aust. J. Soil Res.* 21 : 241-255

Truman, R. and Turner, J. 1972. Mineral deficiency symptoms in *Eucalyptus pilularis*. Forestry Commission of N. S. W., Technical Paper No. 18

Walkley, A. and Black, C. A. 1934. An examination of the digtijareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.* 37 : 29-38

Wilde, S. A.; Corey, R. B.; lyer, J. C. and Voigt, G. K. 1979. Soil and plant analysis for tree culture (5th ed.), Oxford and IBH Publishing Co., India.