IRON DEFICIENCY IN *PTEROCARPUS ANGOLENSIS* NURSERY SEEDLINGS: SYMPTOMS AND CURE

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MUNYANZIZA, E., KUYPER, TH. W. & OLDEMAN, R.A.A. 1998. Iron deficiency in *Pterocarpus angolensis* nursery seedlings: symptoms and cure. Dieback in *Pterocarpus angolensis* nursery seedlings shortly after germination is reported in Morogoro, Tanzania. These symptoms were cured by applying a 0.5% iron solution on leaves. Experimentally reproduced symptoms on healthy seedlings grown in compacted and overwatered soil confirmed that iron deficiency resulted from poor aeration in the soil due to compaction and overwatering.

Key words: *Pterocarpus angolensis* - soil aeration - iron deficiency

MUNYANZIZA, E., KUYPER, TH.W. & OLDEMAN, R.A.A. 1998. Kekurangan besi dalam anak benih tapak semaian *Ptrerocarpus angolensis*: simptom dan pemulihan. Mati rosot anak benih tapak semaian *Pterocarpus angolensis* sebaik-baik sahaja selepas percambahan dilaporkan di Morogoro, Tanzania. Simptom ini dipulihkan menggunakan 0.5% larutan besi ke atas daun. Simptom yang membiak secara percubaan ke atas anak benih segar yang tumbuh dalam tanah yang dimampatkan dan disiram berlebihan mengesahkan bahawa kekurangan besi terhasil daripada pengudaraan yang lemah dalam tanah akibat pemampatan dan penyiraman yang berlebihan.

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Introduction

In natural conditions of limited rainfall, high temperatures and yearly fires, seedling architecture of *Pterocarpus angolensis* DC. (Leguminosae-Papilionoideae) is characterised by a yearly expanding taproot and short above-ground shoots which die back yearly for some eight years. Then, they grow several meters in one single year, thus minimising the chances of being destroyed by yearly bush fires (Boaler 1966, Celander 1983, Munyanziza & Oldeman 1995).

Attempts by the DANIDA/Tanzania National Tree Seed Programme to raise *P. angolensis* seedlings in the nursery have been unsuccessful. Most seedlings grown in the nursery die before transplanting. Both root and shoot systems are affected. On the shoot the youngest leaves are first, the oldest leaves the last to exhibit symptoms. Leaves initially turn pale, followed by yellow, white and brown before becoming necrotic and dropping. In addition, the terminal bud dies, and the affected seedling produces several short lateral shoots, which have small leaves and eventually die back. The taproot also dies back, stopping lateral root productions. Degradation proceeds slowly, taking several months before death of the seedling. Prior to death, seedlings have shorter shoots and a shorter taproot. At each stage, leaf veins are greener than the rest of the leaf (interveinal chlorosis). The above description is strongly suggestive of iron deficiency (Marschner 1995).

The objectives of this study were (1) to identify the cause of the symptoms, (2) to find a cure for it, and (3) to suggest preventive measures.

Materials and methods

Iron application on diseased seedlings

Ten-month-old seedlings, raised in the nursery, displaying the symptoms described above, were used. Forty-two seedlings were selected. Half were foliar treated with 0.5% iron solution (ferrous sulphate) and the other half untreated. Leafless seedlings received five drops on the substrate surface until they acquired new leaves. Seedlings were watered twice a day if there was no rain (40-60 ml of water per seedling, one half supplied in the morning and the other half supplied in the evening). Iron solution was applied once every 3 weeks for 15 weeks. Observations were made three times a week. Prior to termination, the number of surviving seedlings and the number of leaflets on each seedling were recorded, as well as the total height and fresh total weight. Results were analysed using Student's *t*-test.

Soil compaction and overwatering experiment

We hypothesised that iron deficiency symptoms were due to poor aeration resulting from soil compaction and/or overwatering in the pots in which seedlings were raised. A 2×2 factorial experiment in a completely randomised block design with three replicates was set up. The major factors were soil compaction and overwatering each with 9 levels. Each replicate consisted of seedlings grown in individual open pots filled with fresh soil from the rhizosphere of mature *P. angolensis* growing in the miombo woodlands. In the control enough water was applied to moisten the growth medium without exiting the bottom of the pot. The amount of water applied was adjusted for weather conditions. Between 15 and 30 ml were applied per seedling in the morning and in the evening (30 to 60 ml per day) for normal watering. Double watering was twice the normal watering. Non-compacted soil was used to fill the pot without pressing it down by hand or shaking the pot. The soil was neither ground nor sieved. For compacted soil, the same pot was filled with 1.5 times as much soil as that in the non-compacted soil treatment. Non-compacted soil weighed 435 g dry weight while compacted soil weighed 631 g per pot.

Table 1. *P. angolensis* seedling mean total height (cm), fresh weight (g) and number of leaflets as affected by iron treatment

	Height (cm)	Total fresh weight (g)	Leaflets (no.)
Treated	9.1 ± 2.7b*	5.1 ± 1.4a	19 ± 6b
Untreated	2.1 ± 1.3a	2.0 ± 0.9a	2 ± 2a

*Different letters following a given value denote significant differences ($p < .05$).

Results

Response to iron application

Twenty-four hours after iron application, the leaves of the treated seedlings began to change. Veins first turned green, and the remainder of the leaf followed. One week after application of iron, treated seedlings started to produce new leaves and to grow in height. At the end of the experiment, treated seedlings were taller and had a greater number of leaves and leaflets (Table 1). There was no difference in total fresh weight between treated and non-treated seedlings ($p = 0.07$). Non-treated seedlings did not produce new leaves during the experimental period. Instead, their initial leaves were sometimes shed.

Soil compaction and overwatering experiments

Germination started on the fourth day and was completed nine days later. Initial growth rates were high and homogeneous. During the first months, leaves and cotyledons were green. However, at the end of three months cotyledons turned yellow and started to drop. The symptoms described earlier started to develop concurrently: younger leaves in compacted and/or overwatered treatments turned yellow. The percentage of affected seedlings was: 58% of those in compacted soil and double watered, 29% of the seedlings in compacted soil and watered normally, 24% of those in non-compacted soils and double watered, and 0 % in the control group.

Discussion

As noted by Oldeman (1989), repeated multiple shoot reiteration by diseased seedlings is a survival mechanism of the plant. Affected seedlings also develop a remarkable crown, somewhat resembling that of adult trees. The pattern of degradation from younger leaves to older leaves matches the symptoms of iron deficiency as outlined by Marschner (1995) and Drechsel and Zech (1993). Iron deficiency or inactivation after its being translocated affects chlorophyll formation (Terry & Low 1982) and root development (Romheld & Marschner 1981). In the present study, seedlings were chlorotic and had a reduced root system. Although iron deficiency is a worldwide problem in calcareous soils (Marschner 1995), iron deficiency in forestry in the tropics is not commonly recognised as most tropical soils are acidic and hence show a high Fe-solubility. Miombo soils are generally classified as ferruginous or ferralitic (Celander 1983).

However, iron deficiency symptoms do not necessarily mean an absolute lack of iron, and we did not confirm whether the soil was deficient in iron. The problem described here resulted from nursery soil physical conditions since these symptoms developed in the nursery but not in the field (unpublished observations). The hypothesis that the symptoms were due to poor aeration resulting from manipulation of nursery soil, namely grinding, sieving, and overwatering, was confirmed by reproducing the same symptoms in the nursery. Soil used in some Tanzanian nurseries is passed through a 2-mm sieve (Chamshama & Hall 1987), which destroys the soil structure, further aggravated by overwatering. Since application of iron on diseased seedlings restored seedling vitality, enhanced growth and reestablished seedling shoot and root architecture, we conclude that the symptoms observed were due to poor iron uptake or translocation. Soil with good structure is vital for improved seedling stork production. This can be achieved by incorporating sand and organic soil in the potting mixture. Soil grinding and excess watering should be avoided.

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