# EX SITU HORTICULTURE OF *WELWITSCHIA MIRABILIS*

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*Welwitschia mirabilis* Hook.f. occurs in the Namib Desert of Namibia and Angola. It survives on fog which condenses on its leaves, supplemented by flooding every six to ten years. The seeds contain germination-inhibiting alkaloids which must be washed out by rainfall before germination can take place. Many seeds are also infected with the fungus *Aspergillus niger* which causes high levels of mortality in newly germinated seeds. A strategy for the control of this black smut fungus is described along with techniques for seed sowing and cultivation.

## INTRODUCTION

*Welwitschia mirabilis* Hook.f., or N'tumbo as it is known locally, is a plant with a remarkably bizarre habit that survives in extremely harsh conditions. Seed germination and plant maintenance in *ex situ* collections are problematic and special horticultural treatments are key elements for successful cultivation.

The plant was first found in 1860 by the Austrian botanist Friedrich Welwitsch, after whom it was named in recognition of his botanical research as well as his discovery and collection of the plant. *W. mirabilis* is a two-leaved gymnosperm that is dioecious, bearing either large female, or small male, cones. The leaves are attached to a hypocotyl and this special transition zone between the leaves and the root is fast-growing, forming a bizarre deformed structure where the parallel veined leaves are split into several ribbons. Attached to the hypocotyl a single, fennel-shaped root grows straight down.

## DISTRIBUTION AND ECOLOGY

*W. mirabilis* only occurs in the saltpans and lagoon plains of the Namib Desert of Namibia and Angola in south-western Africa. The Namib Desert stretches approximately 2000 km from the Olifants River in northern Namaqualand in South Africa to San Nicolau in southern Angola. Situated between the South Atlantic Ocean and the Great Western Escarpment, most of the desert is less than 200 km wide. The Namib Desert includes a remote coastline, the Namib dunes, which at some places border the beaches. More inland, the landscape of dunes changes to the Namib plains, with granite outcrops. Adjacent to this is an escarpment in the east. The Desert has an average rainfall of 15mm per year at the coast, ranging up to about 100mm on the eastern escarpment. Precipitation is nearly always as fog, or occasionally as drizzle, and is generally very irregular. In some years the rainfall exceeds the average by several hundred percent, while in other years there is no rainfall at all.

The crucially important source of moisture in the Namib is the fog that extends inland for tens of kilometers on most mornings. This fog condenses on all surfaces such as rocks, outcrops, escarpments and other obstacles on the landscape, including *W. mirabilis* plants. If fog-water catchment is sufficient, succulents and *W. mirabilis*

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plants will thrive. Due to the incoming fog, along with high humidity and open skies at night, temperatures are generally cool in the mornings. However, further inland (50 to 70km) the temperature and humidity fluctuates drastically from cool and humid in the morning to hot and dry during the rest of the day. After sunset the temperature drops and the fog occurs again the next morning, just before sunrise.

In the fog-belt at the coast the climate is humid for long periods and the soil contains a lot of gypsum. Gypsum also occurs in the plains but does not seem to affect the survival of mature plants of *W. mirabilis*. It does, however, appear to affect regeneration. No young plants or seedlings could be observed on the plains of Namibia (Ursem, 1994). An excessively wet climate also appears to limit the spread of *W. mirabilis*. High moisture levels encourage a fungus which infects the seeds (see section on germination problems below).

The rainy season, if any, occurs from October to late May. Ironically this overlaps with the season when the hot, dry easterly winds blow. Between April and August strong hot winds prevent the formation of morning fog, but bring in life-giving detritus which provides minerals and a food source for plants and small animals.

Once in every six to seven or even ten years, true, flooding rainfall has been recorded. This flooding rainfall is of great importance for the continued occurrence of *W. mirabilis* in this extreme desert region. Its annual growth (in the form of leaf extension) is 100 to 200mm per year (average 138mm per year), but it can be up to 100mm a month during a wet year. Because *W. mirabilis* is not a succulent plant the amount of water absorption relates directly to the speed of growth of the plant. Normally, it depends on its relatively thin leaves to absorb the desert fog by the approximately 22,200 stoma per square centimetre (Bornman, 1972 and Court, 1981). In addition to the accelerated growth during these floods, newly produced seeds will take up enough water to ensure successful germination.

## SEED GERMINATION PROBLEMS

Before germination can take place, a number of toxic alkaloid compounds must be released from each seed. These alkaloids inhibit germination and even a trace left on the seed coat after a rain wash can kill seedlings. As noted above, fungal infection also causes problems in the germination of seeds. Only about 50% of the seeds are fertile and 80% of the *W. mirabilis* seeds collected in the wild are infected with a fungus, *Aspergillus niger*. Recent studies on wild-collected seeds show a significantly high level of this black smut-fungus growth starting at the same time as seed germination. Within two weeks, or even less, the spores develop into a mycelium covering the surface of the seeds and the fungus kills the seedlings within a few weeks of germinating. This is one of the main problems of germinating *W. mirabilis* in horticulture and in botanic gardens.

A wild-collected seed sample (100 winged seeds) from the famous Welwitschia Plains at the confluence of the Khan and Swakop rivers in the Namib examined by the Botanic Institute of Windhoek, Namibia, showed a 95% *Aspergillus* infection (spores and filaments) on the seed coat (Ursem, 1993). This was before sending the seeds from the Plains where they had already been selected for fertility.

Another problem occurs if the wet period is prolonged. Seeds that are too wet do not germinate, but develop an extremely unpleasant odour due to rotting processes. On the

other hand, seeds that survive years of dryness frequently become victim to a beetle species, *Probergrothius sexpunctalis*, which eats the protein germ. However, these beetles can also help with the pollination of female cones, although wind pollination is the normal form of pollination. In total, perhaps less than one percent of all seeds of wild *W. mirabilis* in the Namib will germinate and develop into mature plants.

Old plants do not seem to be damaged by the fungal infection. Some plants are more than 1500 years old according to Carbon-14 dating, or even 2000 years or more, according to field observations and estimation. Around 8000 plants survive in the wild.

## N'TUMBO IN HORTICULTURE

Quite a number of botanic gardens have *W. mirabilis* in their living plant collections including the Botanic Garden of Delft University of Technology. The species is not considered to be endangered but is none-the-less listed on CITES (Appendix II) as its total area of distribution is quite small and because plants are in great demand for private collections. This may be because of its interesting evolutionary position in the Plant Kingdom and its bizarre growth form. For these reasons plants in the wild could become endangered if care is not taken.

As mentioned before, during the visit to the Namib Desert very little regeneration was observed and it was noticeable that nearly all the plants were mature. It is presumed that, as well as beetle predation and seed infertility, the fungus is a major reason for the lack of seedlings.

The largest number of *W. mirabilis* plants known in international collections can be seen in the Botanic Garden of Berlin Dahlem, Germany. This excellent living plant collection is in a very healthy condition and produces many fertile cones and seeds. Many other botanic gardens have either grown individual plants or have tried to obtain them for their collections. The species of black smut fungus survives for a long time and, although the seeds obtained from the Botanical Institute of Windhoek were collected after several years of drought, they still clearly showed living spores and filaments during germination. 'Captive' breeding in a controlled environment can therefore offer an effective alternative to wild-collected seed.

N'tumbo, which means "onion of the desert", can be grown in protected greenhouses if certain steps are taken. The most successful period for seed germination is in spring or in early summer but, as in the wild, the problem is the black smut-fungus (Herre, 1954). This can be solved by the use of a specific horticulture treatment. First the black smut-fungus is killed by a fungicide (for example: Daconil, Banrot, Mancozeb, Funginex, Liquid Copper Spray or Dormant Lime Sulfur Spray) and they are then washed with tap water. Once the fungus is dead, the seeds have to be soaked in demineralised water or rainwater for two or three hours. The disk-like seeds are then placed on their sides in a well drained soil mixture of potassium free, nutrient rich riverine sand with 10-15% of loam. Others have had good germination results in pots of general greenhouse potting soil (66 % peat, 33 % pumice).

The best results, because of the length of the root, are obtained by sowing in tall or large standard clay pots or, even better, in a drainpipe seated within a pot. The drainpipe should first be placed in the pot and then filled. The seeds should just be covered with a very thin layer of riverine sand. The soil should be heated underneath by underground heating cables. The seeds should be kept humid or well-watered, until

they start to sprout a root and two cotyledons after two to fourteen days. As soon as the true leaves appear, the water requirement declines. After a few weeks, watering slightly more than once per week is sufficient (Von Willert & Wagner-Douglas, 1994). The taproot of each seedling is very sensitive and should not be touched or disturbed during transplanting. It is better to break and release the bottom part of the pot first, and move the whole plant in its old container into a new pot. Once settled into a new pot, the plant should be watered and fertilised with nitrate rich, potassium-free fertiliser. After three to five years, the young plants should be flourishing and may produce their first cones. The plants are dioecious, so strobilation is either male or female.

In the Hortus Botanicus in Amsterdam, The Netherlands, germination by this approach has been very successful, and over 80% plants were brought to maturity. At the time of drafting this article, November 2003, the *W. mirabilis* plants in Amsterdam are still not strobilating.

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