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Short communication

Mysterious circles in the Namib Desert

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Abstract

There is currently still no scientifically sound explanation as to the origin of the so-called "fairy circles" in the Namib. An *in situ* experiment was conducted in the NamibRand Nature Reserve to test the latest hypothesis that the circles are the result of a semi-volatile gas that inhibits plant growth. *Stipagrostis ciliata* grass plants were planted in containers filled with soil from the circle or from outside the circle. Some containers were sealed at the bottom, to prevent any gases from entering from below, while others were left open. Containers were placed both inside the circle as well as outside the circle. The origin of the soil, i.e. whether it came from inside or outside the circles, did not affect the performance of the plants when they were growing in the same position and container type. All plants growing outside the circle, irrespective of the origin of the soil or the container type, performed better than those growing inside the circle. It is concluded that there is a factor inhibiting plant growth in the circle and that this factor could possibly be a semi-volatile gas, because growth was more negatively affected in the open containers than in the sealed containers.

Keywords: Desert; Fairy circle; Namib; Termites

1. Introduction

In 1978, a group of researchers from the University of Pretoria started investigating the origin of the mysterious 'fairy circles' in the Namib Desert (Van Rooyen et al., 2004). These circles (Fig. 1) occur roughly between 60 and 120 km inland along the west coast of Africa from just north of the Kunene River in Angola, through Namibia, to just south of the Orange River. The existence of these so-called "fairy circles" has become a phenomenon of international interest as reflected by the worldwide reaction received after a publication in the New Scientist magazine of April 2004 (Cochlan, 2004).

The earliest reference to these fairy circles in the scientific literature is found in Tinley (1971) who proposed that they were fossil termitaria formed when the annual rainfall was considerably higher. Theron (1979) suggested that an allelopathic compound released by *Euphorbia damarana* was responsible for the circles. However, a bio-assay done on the soils beneath live and dead *E. damarana* plants could not support an allelopathic origin for the fairy circles (Van Rooyen et al., 2004). Eicker et al. (1982) reported on a microbiological study of the barren patches in the Giribes Plain, but offered no explanation for their origin. Moll (1994) suggested that these bare circles were caused by termites consuming all the grass seeds in the immediate vicinity of their nests and implicated *Hodotermes mossambicus* as the most probable termite species. Becker and Getzin (2000) elaborated on Moll's hypothesis without providing conclusive evidence. The latest hypothesis proposed by Albrecht et al. (2001) postulated that the barren patches were caused by a semi-volatile chemical substance associated with termite nests.

This project was initiated to follow-up on the different hypotheses. Most hypotheses refer to termite activity in some way or another. Because it seemed unlikely that the circles were caused simply by the foraging activity of *H. mossambicus* as was suggested by Moll (1994) and Becker and Getzin (2000) it was decided to follow-up on Albrecht et al.'s (2001) hypothesis.

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Fig. 1. Typical fairy circles in the Namib Rand Nature Reserve indicating the barren circle surrounded by an edge of taller growing grasses (photo by H. Burger).

The aim of this short communication is to report on the first *in situ* pilot study to test the hypothesis whether a semi-volatile substance was inhibiting plant growth.

2. Materials and methods

Two distinct circles were selected in the NamibRand Nature Reserve. Site A was located on a level area (S 25° 01′ 35.6" and E 15° 58′ 36.6") and Site B was located on the southern aspect of the dune with a slope of approximately 4° (S 25° 01′ 35.3" and E 15° 58′ 34.1"). Both sites were fenced off with jackal proof fencing to prevent grazing by large herbivores. In the present study the vitality of *Stipagrostis ciliata* grass plants was evaluated in different treatments. Three factors were examined:

(a) The origin of the soil: The effect of the soil from inside the circle was compared with that of soil from the matrix between the circles. This involved interchanging soils from the circle with that of the matrix and *vice versa.*
(b) Sealed containers: The presence of a gas was investigated by comparing the vitality of grass plants growing in containers that were sealed at the bottom versus containers that were open at the bottom.
(c) The position of the pots: This refers to whether the pots were placed inside the circle or in the matrix between the circles, and not to the arrangement within the circle.

In total seven different treatments were used with ten replicates per treatment. A mature plant of *S. ciliata,* which is the dominant perennial grass species, was planted into each container. The containers which were placed in the circle, were arranged in a cross-like pattern, with each spoke of the cross representing a different treatment. The experimental design is not ideal and has spatial pseudoreplication. To avoid the spatial location/direction of the spoke being able to explain the variation between treatments, the directions of the treatments were not duplicated between site A and site B. The linear arrangement was opted for, because preliminary observations indicated that the growth inhibition was the strongest in the centre of the barren patch and gradually decreased towards the edge of the patch. Treatments in the matrix were arranged in parallel rows at least 2 m from the circle at site A, with each row representing a different treatment. Matrix treatments were not repeated at site B.

Before transplanting the grasses, the root systems were washed to ensure that the residues of the original soil were removed. To avoid leaching when watering the grass plants, the amount of water that could be applied to the specific volume of soil in the containers was established. It was determined that for watering purposes, 500 ml water penetrated almost to the bottom of the containers without actually reaching the bottom. To avoid further leaching, the plants were watered only once every 2 weeks.

To measure the vitality of the transplanted grasses an evaluation of each plant was done on a scale ranging from 0 to 10. This was done every 2 weeks from 5 May 2005 to 14 June 2005 while the grasses were watered. Results were analyzed using the PROC GLM procedure in SAS® (SAS® Software Version 8.2 supplied by The SAS Institute Inc., SAS Campus Drive, Cary,

Table 1
Vitality (maximum score is 10) of *Stipagrostis ciliata* plants grown in different positions, soils, and container types at two sites in the NamibRand Nature Reserve as scored on 31 May 2005

Site	Position: inside circle				Position: between circles (matrix)		
	Soil origin: circle		Soil origin: matrix		Soil origin: circle		Soil origin: Matrix
	Open container	Closed container	Open container	Closed container	Open container	Closed container	Closed container
A	$1.2^{a}\pm1.4$	$4.8^{c}\pm4.3$	$2.1^{ab}\pm2.2$	$3.8^{bc}\pm3.3$	$7.5^{d}\pm1.5$	$7.7^{d}\pm2.5$	$8.5^{d}\pm1.4$
B	$2.1^{ab}\pm2.9$	$4.2^{bc}\pm2.6$	$0.6^{a}\pm0.5$	$4.2^{bc}\pm2.6$			

Vitality scores are given as the mean ± standard deviation.
[a–d] Values followed with the same superscript do not differ significantly.

NC 27512, USA) to investigate the effect of the origin of the soil, container type and position of pots, nested within site.

3. Results and discussion

The results of the vitality scores done on 31 May 2005 are presented in Table 1. This date was considered to represent the peak condition of the grass plants before winter dormancy commenced. The GLM model was highly significant ($p < 0.0001$) and produced a R^2-value of 0.54. The most salient features can be summarised as follow:

- In no instance was a significant difference found between the two sites for a particular treatment (Table 1: compare site A versus site B).
- Plants growing in similar soils and containers performed significantly better when they were growing in the matrix than in the circle (Table 1). For example, grass plants growing in open containers in circle soils scored a vitality of 7.5 in the matrix, versus a mean of 1.7 in the circle. This indicates that being in the circle exerts a negative effect on grass growth. The difference was the most pronounced in the case of plants grown in open containers.
- The origin of the soil, i.e. whether the soil came from inside or outside the circles, did not significantly affect the performance of the plants when they were growing in the same position (circle or matrix) and type of container (open or sealed). Grass plants growing in open containers in the circle performed poorly, irrespective of the origin of the soil (mean vitality score 1.5). Plants growing in the sealed containers in the circle showed improved vitality (mean vitality score 4.3), but vitality was still significantly lower than that of plants growing in the matrix (mean vitality score 7.9). There was no significant difference in the vitality of plants when planted in the matrix, irrespective of soil origin and type of container (Table 1).
- There was a significant interaction between location and container type. The vitality of the plants in the sealed containers was greater than those in open containers when the plants were growing inside the circles (although this difference was not always statistically significant), however, when the plants were growing in the matrix, vitality was not improved by sealing the containers.

The results of this *in situ* investigation indicated that the circle soil does not retain its growth inhibitory capacity when placed in containers in the matrix. Likewise, the matrix soil does not continue to support good growth when placed in the circle. These observations can not be explained by the hypotheses on fossil termitaria, allelopathic compounds released by *E. damara* plants, or termites consuming plant material. The fact that plants in sealed containers fared better than plants in open containers when they were grown in the fairy circles could be interpreted as support for the contention of Albrecht et al. (2001) that a semi-volatile gas produced in the circle soil inhibits grass growth. Whether this semi-volatile gas is associated with an active termite nest or other microbiological activity in the circle will need further investigation.

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