*Journal of Arid Environments* (1997) 35: 77–86

# Trapping of airborne dust by Eig's meadowgrass (*Poa eigii*) in the Judean Desert, Israel

Avinoam Danin* & Eliezer Ganor†

**Department of Evolution, Systematics, and Ecology, The Alexander Silberman Institute of Life Sciences, The Hebrew University of Jerusalem, Jerusalem, Israel 91904*
*†Ministry of the Environment, Sackler Medical School, Tel Aviv University, Tel Aviv, Israel 69978*

*(Received 3 October 1995, accepted 15 November 1995)*

North-facing slopes above sea level in the Judean Desert are covered with a nearly continuous carpet of the meadow grass *Poa eigii*. The grass functions as a trap for aeolian dust and protects the soil from erosion. The microbiotic crust, composed of mosses, liverworts, lichens, cyanobacteria and fungi, which occur among the tufts of *Poa eigii*, also contributes to trapping and protection. The presence of allochtonous quartz and clays throughout the 60-cm deep soil profile suggests an aeolian origin of the soil. Stones > 2 mm in diameter contribute to only 13–33% of the soil weight. South-facing slopes have a thinner soil mantle, with 67–92% stones, quartz and clays occurring only at the surface layers and are devoid of the meadow grass. Microbiotic crust composed mainly of cyanobacteria protects the crust from erosion and assists trapping of aeolian material in this layer.



**Keywords:** meadow grass; microbiotic crust; aeolian dust; allochtonous quartz; desert

## Introduction

The role of mosses and other components of the microbiotic crust in trapping airborne dust in desert areas is presented by Danin & Ganor (1991) and Danin *et al.* (1989). Mosses trap dust among their caulidia (a caulid resembles a stem with leaf-like structures), trapping and fixing the fine-grained particles. Cyanobacteria and lichens affix soil particles to their polysaccharide sheaths which become sticky when wet.

The present paper reports investigations into the role of an ephemeral perennial grass in trapping airborne dust under desert conditions.

## Location and environment

The study site was at the top of two hills near the Jerusalem–Jericho road, some 200 m south of the 'Sea Level' sign, 8 km SW of Jericho (Fig. 1), 31°47'30" N, 35°24'20" E. It is in the 100 mm isohyet zone (Rosenan & Gilead, 1985). The northern

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slope receives minimal solar radiation whereas the southern and south-western slopes have maximum radiation (Boyko, 1947). The hill is built up of Senonian chalk (Menuha formation; Roth, 1970) covered by brown lithosol (Dan *et al.*, 1975). The plant community covering the north- and north-east-facing slopes is comprised of *Suaedetum asphalticae* (Fig. 2; Danin *et al.*, 1975; Danin, 1978, 1983, Figure 82). The almost horizontal lines crossing the slopes are paths where goats have grazed on these slopes since biblical times (Hareuveni, 1991). When grazing on the wet slopes during winter, they leave prominent long-term footprints (Figs 2–4). *Suaeda asphaltica* (Boiss). Boiss. is almost the only semi-shrub growing there, accompanied by many annual and perennial herbaceous species (Danin, 1978). A microbiotic crust, composed of mosses, liverworts, lichens with chlorophycean phycobiont, cyanophylous lichens, non-lichenized fungi and cyanobacteria, covers the area among the tufts of *Poa eigii* Feinbrun, which is the dominant perennial grass. Sites covered with *Poa eigii* have an almost smooth surface, with very few large or small stones present. The south-west-facing slope (orientation 240°) is sparsely dominated by *Zygophyllum dumosum* Boiss. (Fig. 3). Stones and rock outcrops occur throughout the slope. There are very few annual species growing there and only in rainy years and even then they are in small quantities. Cyanobacteria, cyanophylous lichens, and possibly fungi constitute the microbiotic crust of this slope.

## Materials and methods

Numerous bulks of living and dead tufts of *Poa eigii* from the Judean Desert were examined in the field by magnifying glass. Many were collected, dissected in the


**Figure 1.** Location map; ⊡ = study site.

**Figure 2.** A general view of the study area with the far slope at the centre facing north and covered by an association dominated by *Suaeda asphaltica*. Note the grazing paths on the slopes.

**Figure 3.** The south-western slope with a single *Zygophyllum dumosum* and the soil sampling hole. Note the stony surface and the stony soil dug in the sample. Two oblique grazing paths traverse the area.

laboratory and inspected using a dissecting microscope and scanning electron microscope. An attempt was made to understand the morphology and life history of each of their organs. Their structural fitness to grow in an area with constant dustfall was also considered. Verification was carried out later in the field. Tufts of dormant-dry *Poa eigii* were collected in the study area in summer, irrigated, and used for observations on the first stages of growth.

A soil pit, 60 cm deep, was dug on 17 December 1993, close to the top of the northern slope (Fig. 4). Samples were obtained from depths of 0–5 cm, 15–20 cm, 30–35 cm and 50–55 cm. A second pit was dug at the south-western slope (Fig. 3). Depth of samples were 0–5 cm, 15–20 cm and 25–30 cm.

A 2 mm sieve was used to evaluate the proportions of fine-grained components and stones. The fine-grained component was used for mineralogical, chemical and morphological analyses of the samples from the two slopes.

Mineralogical analysis of selected bulks was carried out by X-ray difractometry (XRD) using a Philips model 1050/80 goniometer and Cu-K irradiation. The chemical composition of selected samples was investigated by X-ray analysis, using a JEOL 840 Scanning Electron Microscope (SEM) equipped with Link 10,000 Energy Dispersive System (EDS). With the EDS, the spectrometer separates the elements according to

**Figure 4.** The site of soil profile at the northern slope with *Suaeda asphaltica* shrubs above th hole, separated by a light coloured grazing path. Note the almost absence of stones on sc surface and soil dug, deposited below the hole.

energy rather than wavelength. Quantitative analysis was performed by ZAF4 programme.

Ten repeated analyses were made on each bulk. Elemental analysis of an area of 6 × 4 mm$^2$ of grains constituting the soil sample concerned was made with the SEM-EDS on a section coated with carbon. Analyses of rock samples were made on surfaces freshly broken in the laboratory.

## Results

### *Morphology of* Poa eigii

*Poa eigii*, like many other species of *Poa*, justifies its common name and produces natural meadows when growing densely. One of its diagnostic characters is its tendency to form continuous lawn-like populations on slopes of the Judean and Samarian Deserts (Feinbrun-Dothan, 1986; Feinbrun-Dothan & Danin, 1991). It is an endemic geophyte with bulbs composed of the swollen sheaths of the two oldest leaves of each stem, and containing two to three embryonic leaves. The base of the bulk is situated nearly 1 cm below the soil surface (Fig. 5). The cell walls of the leaf sheaths are thick and the main food reserves, consisting of carbohydrates, are stored in the mesophyll cells. A similar status is noted for *Poa bulbosa*. (Arber, 1934).

The structure and life cycle of the plant assist its role as the main trap for airborne dust on the slopes of the Judean Desert. When dry in summer, there are remnants of the leaf blades above the ground. The first effective rains fall mostly in November or December. Then, after about 1 week, new leaves emerge from the axillary buds among the swollen leaf bases. Slopes covered with *Poa eigii* become green with 5–10-cm long narrow leaves. During the growing season, provided that there is a sufficient amount of water in the soil, the plants produce flowers and seeds. Viviparity is a common feature among populations of the group of species related to *Poa bulbosa* (Heyn, 1962; Feinbrun-Dothan, 1986), including *P. eigii*, where bulbils are formed in the inflorescence in place of flowers.

The green and compact carpet of this meadowgrass is an excellent trap for airborne particles during the 4 months from November to March. At the end of spring, when the leaves become dry, they remain on the ground throughout the summer and assist in trapping soil. The dead components of the meadowgrass remain in the soil and deteriorate rather slowly (Fig. 5), thus protecting the soil from erosion. New bulbs of *Poa eigii* develop slightly higher than in the previous year, thus promoting growth above the thin layer of dust falling on the slope. In each population there are a few individuals of a form that has the ability to produce short stems terminating in bulbs a few centimeters above the ground surface (Heyn, 1962). Small depressions open in the ground surface at the sites of rotting old bulbs, thus assisting the trapping of soil particles.

In addition to the meadowgrass there are mosses, liverworts, lichens, fungi and cyanobacteria in the space among the tufts and on and among the dead parts of the meadowgrass. Many taxa of these microbiotic groups have filamentous organs that excrete mucilaginous materials. These aggregate soil particles and protect them from being eroded by rain drops and wind.

### *Distribution of* Poa eigii *on the slopes*

Whereas carpets of the meadowgrass cover the vicinity of the sampling site and most of the northern slope, not even a single tuft can be found on the south-facing slopes.

The plant is confined in this part of the Judean Desert to the north-, north-east-, and north-west-facing slopes.

*Soil properties*

The weight ratios of the fine-grained particles and the stone components in the ground samples of the two profiles (Table 1) differ obviously, mainly at depths below 15 cm. The main component of the soil at the north-facing slope is fine-grained particles, as is obvious in Fig. 4, whereas the south-east-facing slope is richer in stones (Fig. 3; Table 1).

Peaks of the X-ray spectrum analysis are presented in Fig. 6. Those of the two crust

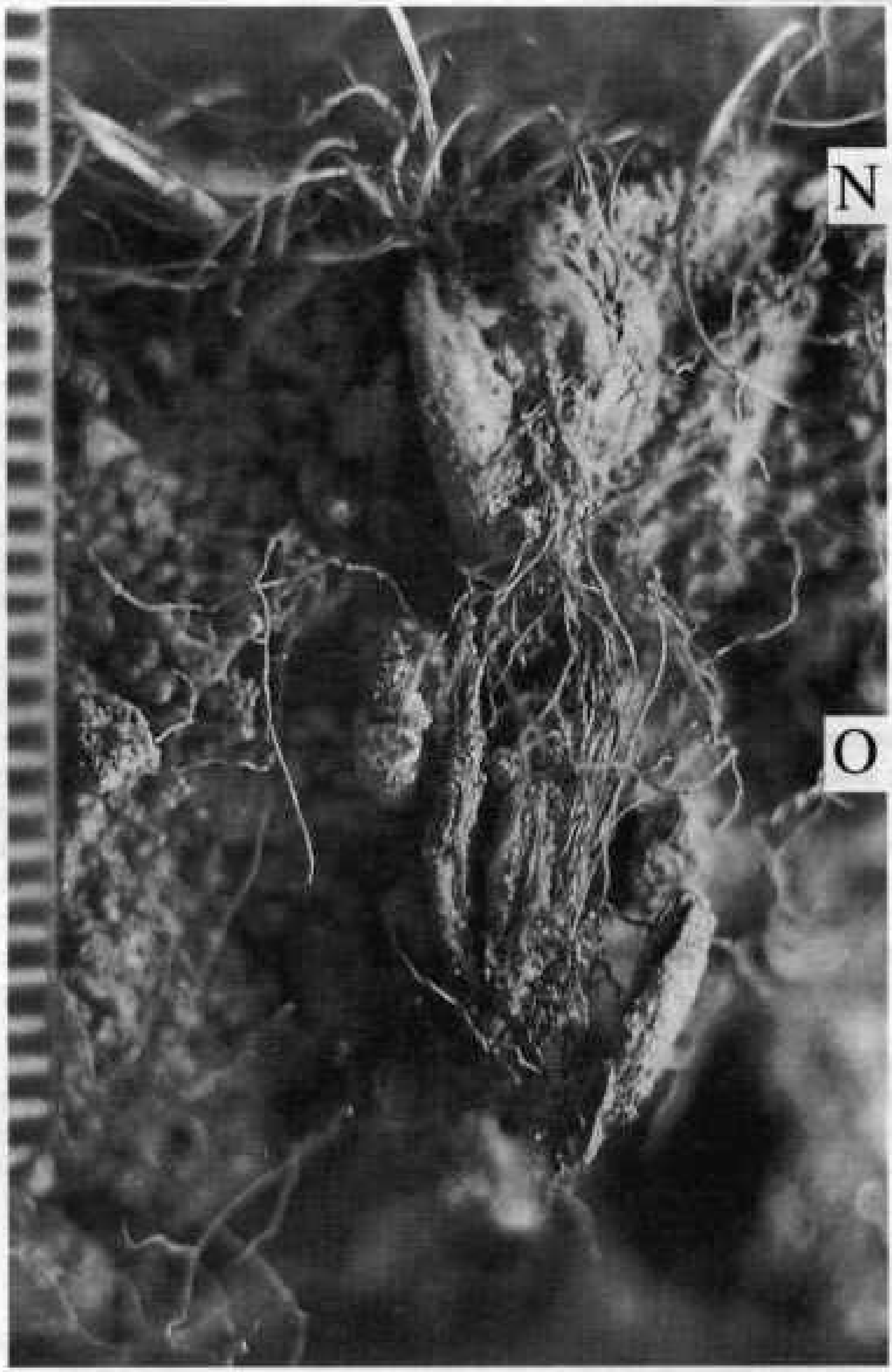


**Figure 5.** A close up of a *Poa eigii* tuft, rich in stems and showing an old dead part (O) at a depth of more than 10 mm below the new (N) soil surface.

**Table 1.** *Soil properties in two profiles on slopes at the Judean Desert, near the Jerusalem–Jericho road, at 50 m a.s.l.*

| Orientation of slope | Depth (cm) | Weight of fines (<2 mm) (g) | Fines (%) | Weight of coarse (>2 mm) (g) | Coarse (%) | Mineralogy |
|---|---|---|---|---|---|---|
| North | 0–5 | 225·1 | 67·3 | 109·5 | 32·7 | clay, calcite, quartz |
| North | 15–20 | 452·3 | 86·8 | 68·7 | 13·2 | clay, calcite, quartz |
| North | 30–35 | 287·0 | 78·0 | 81·2 | 22 | clay, calcite, quartz |
| North | 50–55 | 331·6 | 84·5 | 61·0 | 15·5 | clay, calcite, quartz |
| South-west | 0–5 | 270·0 | 33·3 | 541·8 | 66·7 | clay, calcite, quartz |
| South-west | 15–20 | 49·3 | 8·4 | 535·6 | 91·6 | calcite |
| South-west | 25–30 | 133·1 | 18·9 | 569·5 | 81·1 | calcite |

samples (Fig. 6(a,b)) and that of the northern slope at a depth of 15–20 cm (Fig. 6(c)) are of Si, Ca and Al. Secondary peaks of K, Fe and Mg are present in the same samples. This composition, together with results of X-ray mineral analysis (Table 1), indicates the differential occurrence of particles of alumo-silicates (clay minerals), quartz and calcite. The deeper layers of the north-western slope are almost devoid of quartz and clay minerals (Fig. 6(d)). There are no mineralogical differences between the soil crust of the two profiles, as both have calcite, clays and quartz. However, the deeper layers of the northern slope resemble the crust throughout their depth whereas only calcite is found in the south-eastern slope.

Mineralogical and chemical analyses of the parent rock revealed only calcite; neither clay nor quartz was encountered in this rock.

## Discussion

The profound differences between the northern and southern slopes in the Judean Desert are assumed to have been caused by micro-climatological conditions, and geomorphological and biological processes. These together lead to the final structure of the slopes' surface and govern the texture and composition of their soils. The main pedogenetic process that takes place in the northern slope is an accumulation of airborne material. In addition to calcite, the entire soil profile is composed of clays and quartz. The overlain chalk contains no quartz and therefore this mineral may be used as an indicator of the aeolian origin of the soil. The crust on the south-eastern slope also contains clays and quartz, and it should therefore be regarded as having received contribution of aeolian material as well. However, the layers below the crust comprise only calcite derived from the disintegration of the overlain chalk.

Studying the formation of Red and Brown Mediterranean soils on basalt rocks in northern Israel, Singer & Navrot (1977) and Singer (1978) found allochtonous quartz in the soil. They explained its occurrence as originating from aeolian deposited dust as the basalt rock is devoid of any quartz. A similar approach is taken by Danin *et al.* (1987) concerning the occurrence of quartz particles in rhizofossils. Nannoplankton are used as indicators for aeolian origin of silt and clay in desert soils (Danin *et al.*, 1989; Danin & Ganor, 1991). However, the parent rock in the present study area contains nannoplankton, consequently airborne particles containing nannoplankton cannot be used here as indicators of aeolian origin.

The distribution and accumulation of airborne silt and clay in the semi-desert and desert areas of Israel were reviewed by Yaalon & Dan (1974), Yaalon & Ganor (1973,

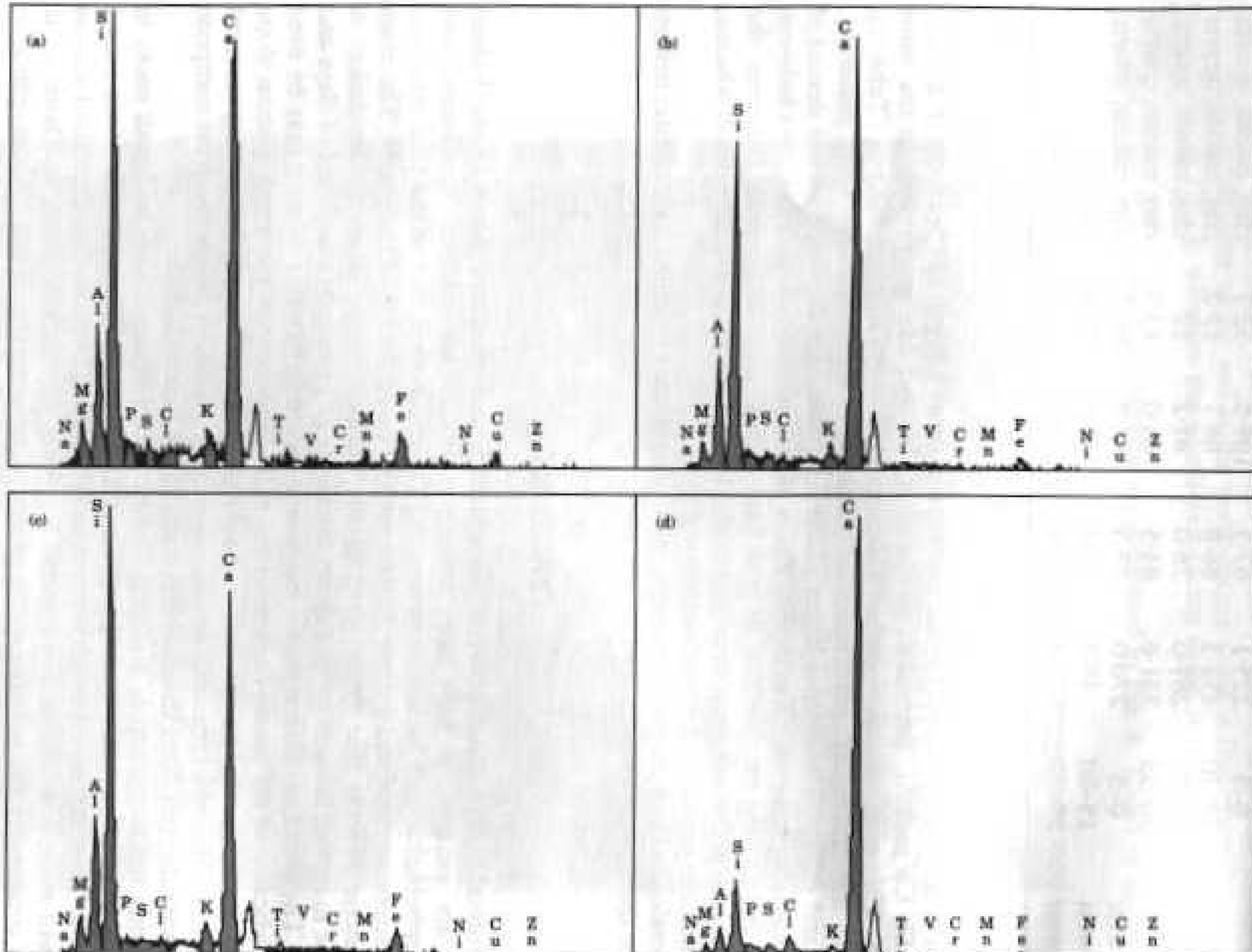


**Figure 6.** Results of X-ray analysis: (a) soil crust from the northern slope; (b) soil crust from the south-western slope; (c) soil from a depth of 15–20 cm at the northern slope; (d) soil from a depth of 15–20 cm at the south-western slope.

1979), and Ganor & Mamane (1982). The main zone of loess sedimentation, according to Yaalon & Dan (1974), is bounded by the 200–300 mm isohyets. Although mean annual rainfall here is only 100 mm, the presence of a north-facing slope induces local moister conditions (Boyko, 1947), which enables the process to carry on here. The dust layer that is deposited in semi-arid areas of Israel is nearly 0·1 mm annually (Yaalon & Ganor, 1973). If trapping of this layer of dust was the only pedogenetic process taking place on the northern slope it would take approximately 6000 years to generate a profile 60 cm deep. The heavy grazing of the slopes, testified by direct findings (Noy-Meir, 1975; Noy-Meir & Seligman, 1979) and by the prominent grazing paths seen in photos, could have induced accelerated erosion. Dating the age of the soil on the slopes needs further investigation, but the order of magnitude of the process may remain as indicated above. The low stone content of the soil on the northern slope indicates hardly any contribution by weathering of the overlain rock. *Poa eigii* is in its ecological optimum on the northern slopes of the Judean Desert. Here it traps and fixes the soil particles among its leaves and in openings at the soil surface that include dead parts of the plant. Of this dustfall, 30% in Israel is organic material (Mamane *et al.*, 1982), which may function as an important source of nutrients for plants. Those individuals that have the ability to add a few centimetres of vertical placement of bulbs above the regular level enable this species to be resistant to exceptional events of cover by soil. The unusual longevity of this species may be exhibited by resprouting of leaves of tufts that were deposited, totally dry, for 7 years in the herbarium (Zohary, 1955). Even dead parts of the plant remain in the soil for several years, fixing particles and protecting the soil from erosion associated with trampling.

The occurrence of *Poa eigii* in continuous lawn-like populations is restricted to the north-, north-east, and north-west-facing slopes; there is no such trapping and fixation of soil particles on the other slopes. Contrary to the accumulation of airborne particles leading to the formation of soil on the north-western slope, there is much erosion on the south-western slope (Danin, 1989). This is due to the high energy of the incident rain and its eroding ability on the bare or sparsely vegetated soil.

We thank Mr M. Dvorachek for his help in the scanning electron microscopy, Dr S. Moshkovitz and Dr A. Rosenfeld for their help in determination of the rock formation by its fossil assemblage, Mr B. Danin for data processing with the computer and Mr J. Gamburg for Figure 3.

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