

6. ECOLOGICAL DUNE RESEARCH WEEVERS' DUIN

6.1. SEPARATE AND COMBINED EFFECTS OF TRAMPLING AND SOIL COMPACTION ON THE GROWTH OF FOUR *PLANTAGO* SPECIES ON EXPERIMENTAL PLOTS (C.W.P.M. BLOM)

Introduction and methods

The research on the effects of trampling and soil compaction on the growth and development of four *Plantago* species was continued in trampling experiments performed on artificial plots. The aim was to separate the effects of trampling and soil compaction; the influence of soil compaction being studied separately and the effects of trampling and compaction on the behaviour of the plants in combination. In analogy with greenhouse experiments (BLOM 1976, 1977), three series of plots were prepared; the dune-sand soil of series A was not compacted, that of series B was moderately compacted, and the substrate of series C was strongly compacted. Each series comprised three plots. In April of 1976 four-week-old seedlings of *P. lanceolata*, *P. coronopus*, *P. major* ssp. *major*, and *P. media* were planted in rows; the distance between the plants was 15 cm. The plants growing on half of each plot were trampled by means of a trampling machine (see photograph Progress Report 1974); in the other half the effects of soil compaction on growth, flowering capacity, and seedling production were studied. The following trampling regimes were applied: each plant in series A was trampled once a day (lightly trampled), in series B the trampling frequency was three times a day (moderately trampled), and in series C each plant was trampled six times a day (heavily trampled). The force applied to the plants was 0.25 kg/cm^2 which roughly equals that applied by a man of medium weight (cf. LIDDLE 1975; CANAWAY 1975). The duration of each trampling treatment was 5 seconds, and the trampling regimes were started a month after planting.

Preliminary results and discussion

The data of the first three plots (A_1 , B_1 , and C_1 ; each treatment 12 plants per species) have been analysed and the diameters of the rosettes give a good idea of differences in reaction between the four species. With reference to the factor soil compaction, the largest differences in reaction between the three treatments were found for *P. lanceolata* and *P. coronopus*. Both species showed larger plants on the untrampled loose soils than on the moderately or strongly compacted substrates (Fig. 9a,c); the highest numbers of leaves per plant were also found on the loose soils. The differences in the size of *P. major* and *P. media* between the untrampled treatments were much smaller (Fig. 9b,d). Compacted soils provided even better conditions for the growth of these species than did loose sandy soils, which can be ascribed to the relatively high water availability in compacted sandy soils (cf. LIDDLE & GREIG-SMITH 1975). In the field, *P. major*, and to a lower degree *P. media*, occur mainly on relatively moist sites. It is probable that on the plots with the loose soil the growth of both species was inhibited by the low moisture content. As described below, also root competition caused a reduction in growth, especially in the case of *P. major*.

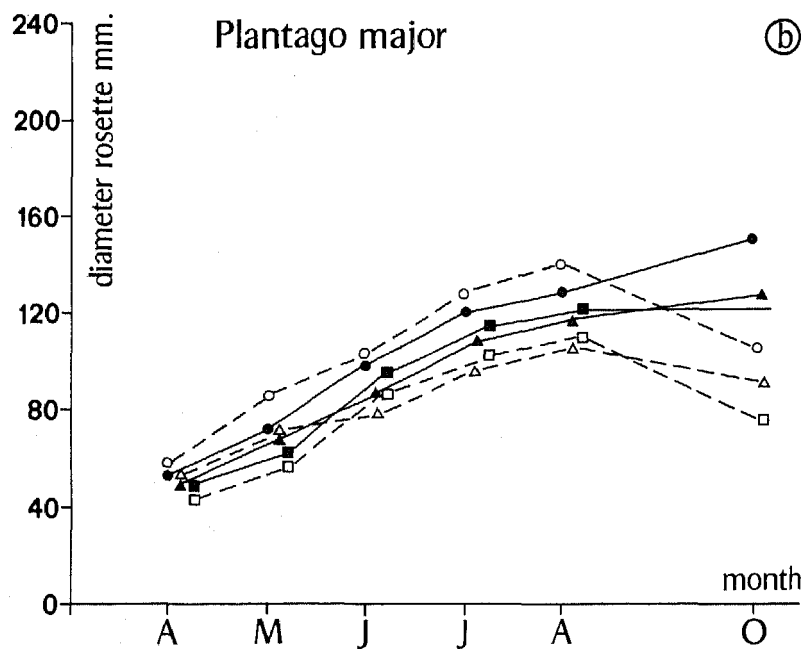
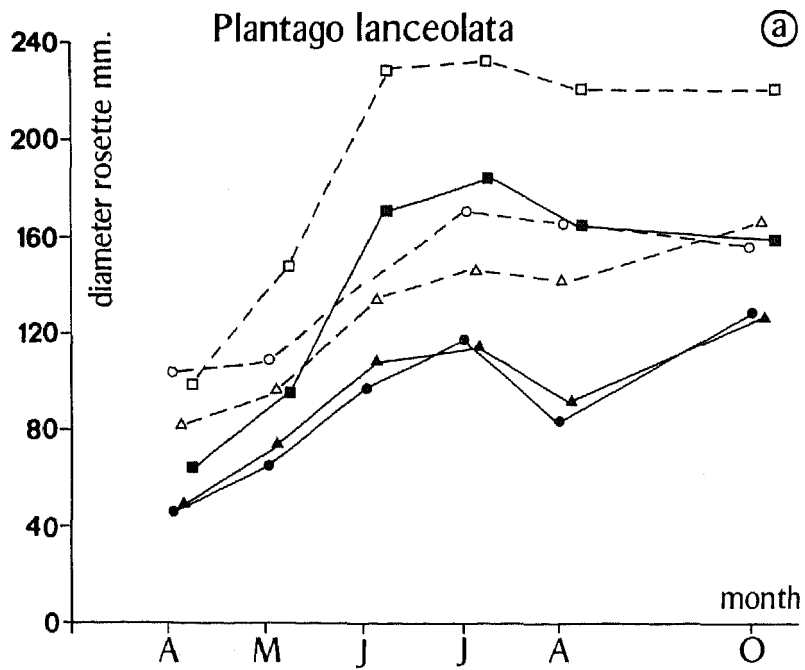
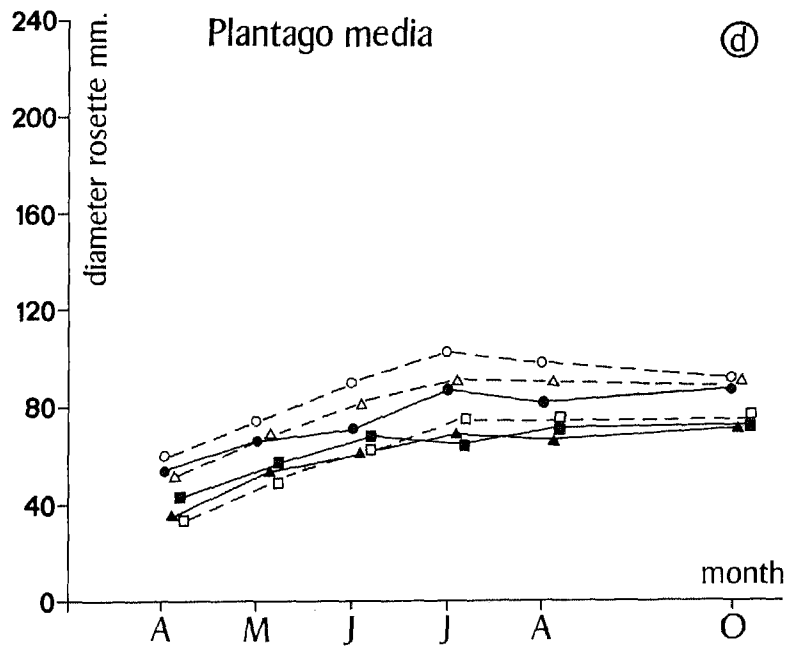
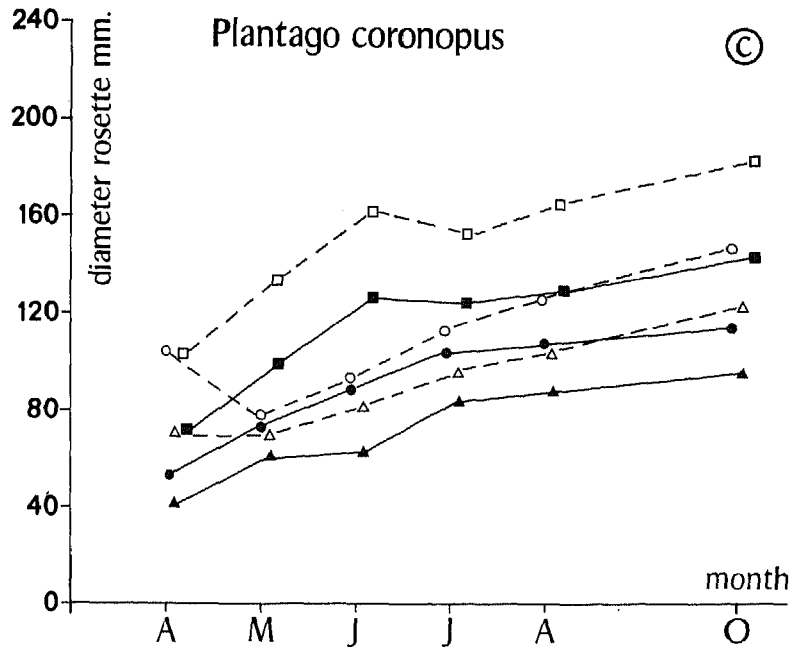


FIG. 9. The effects of soil compaction (open symbols) and of compaction in combination with various trampling regimes (closed symbols) on the rosette diameter of four *Plantago* species growing in experimental plots. The diameters measured during 1977 are given



○—○ *strongly compacted* ●—● *heavily trampled*
 △—△ *moderately compacted* ▲—▲ *moderately trampled*
 □—□ *loose soil* ■—■ *lightly trampled*

The combined effects of trampling and soil compaction are also given in Fig. 9. For *P. lanceolata* and *P. coronopus*, an increase in trampling resulted in a considerable decrease of rosette diameter (Fig. 9a,c). *P. major* and *P. media* were more resistant to trampling (Fig. 9b,d), which was also the case during earlier stages in their life-cycle (BLOM 1977). Comparison of the effects of compaction alone and trampling combined with compaction shows larger differences in diameter for *P. lanceolata* and *P. coronopus* than for *P. major* and *P. media* (Fig. 9). This striking contrast demonstrates that under these conditions reduced growth of *P. major* and *P. media* plants must be attributed more to limited factors due to physical soil conditions than to vulnerability to trampling.

Besides the rosette diameter, the number and size of leaves and spikes as well as the number of seeds produced in 1977 were determined. The first results show clearly for *P. lanceolata* and *P. coronopus* the mean values of all these characteristics decrease with increasing compaction and trampling. For these species the values for the trampled plots are in general much lower than those found for the untrampled sites; only the numbers of spikes of *P. coronopus* were more than two times lower on the untrampled than on the comparable trampled plots, as was also found for *P. lanceolata* on the loose and lightly trampled plots. The differences in the vegetative characteristics of *P. media* and *P. major* between untrampled and trampled series were much smaller; especially for *P. major*, the fewest and the smallest leaves were found in the untrampled series.

The data on produced seeds indicate that the seed production of *P. lanceolata* and *P. media* increased strongly with decreasing trampling and compaction; for the other species this increase seems to be smaller. *P. major*, and to a lesser degree, *P. coronopus*, were the only species able to produce a reasonable number of seeds in the heavily trampled series.

As shown in Table 12, the density of the soil of all trodden plots was much

TABLE 12. The compaction of the dune-sand soil in the open plots of the trampling experiment. The values were obtained by measurement with a penetrometer (conus A, see BLOM 1977) 5 and 10 cm below the soil surface. Mean values of 10 measurements are given in kg/cm²

| | loose soil | | moderately compacted soil | | | | strongly compacted soil | | | | | |
|-----------|------------|------|---------------------------|------|------------|------|-------------------------|------|------------|------|------------------|------|
| | untrampled | | lightly trampled | | untrampled | | moderately trampled | | untrampled | | heavily trampled | |
| | 5cm | 10cm | 5cm | 10cm | 5cm | 10cm | 5cm | 10cm | 5cm | 10cm | 5cm | 10cm |
| 1974 | | | | | | | | | | | | |
| \bar{X} | 5.8 | 8.8 | - | - | 10.0 | 21.2 | - | - | 10.2 | 24.2 | - | - |
| S.D | 1.2 | 1.4 | - | - | 1.4 | 1.8 | - | - | 1.2 | 2.6 | - | - |
| 1977 | | | | | | | | | | | | |
| \bar{X} | 4.8 | 8.0 | 11.0 | 16.0 | 10.8 | 20.4 | 15.8 | 29.8 | 13.6 | 29.6 | 19.9 | 35.4 |
| S.D | 1.2 | 3.0 | 0.8 | 2.2 | 0.6 | 1.4 | 1.2 | 1.8 | 2.2 | 0.7 | 2.0 | 0.6 |

higher at the end of 1977 than in 1974. Probably due to relatively intense vertical soil-water movements, the density of the untrampled, strongly compacted soil had also increased. Compared with the 1974 values, the density of the soil in the other untrampled plots had slightly decreased in 1977, which can be ascribed to the mechanical activity of the roots in these plots. In September of 1977, the root systems in plots A₃, B₃, and C₃ were studied with the "pinboard" method (see SCHUURMAN & GOEDEWAAGEN 1965). All species showed a marked increase in length, width, and weight of the root systems with decreasing compaction. The smallest root systems were observed in the heavily trampled plots. Between the treatments, the largest differences in size and shape were found for *P. lanceolata* followed by *P. media* and *P. coronopus*; *P. major* showed relatively small differences. It was remarkable that the large root systems of *P. lanceolata* seemed to inhibit the growth of *P. major* roots.

References

- BLOM, C.W.P.M. - Effects of trampling and soil compaction on the occurrence of some *Plantago* species in coastal sand dunes. I. Soil compaction, soil moisture and seedling emergence. *Oecol. Plant.*, 11, 225-241 (1976).
- BLOM, C.W.P.M. - Effects of trampling and soil compaction on the occurrence of some *Plantago* species in coastal sand dunes. II. Trampling and seedling establishment. *Oecol. Plant.*, 12, 363-381 (1977).
- CANAWAY, P.M. - Fundamental techniques in the study of turfgrass wear: an advance report on research. *J. Sports Turf Res. Inst.* 51, 104-115 (1975).
- LIDDLE, M.J. - A selective review of the ecological effects of human trampling on natural ecosystems. *Biol. Conserv.*, 7, 17-36 (1975).
- LIDDLE, M.J. & P. GREIG-SMITH - A survey of tracks and paths in a sand dune ecosystem. I. *Soils. J. Appl. Ecol.*, 12, 893-908 (1975).
- SCHUURMAN, J.J. & M.A.J. GOEDEWAAGEN - Methods for the examination of root systems and roots. Centre for Agricultural Publications and Documentation, Wageningen (1965).

6.2. THE AVAILABILITY OF NITRATE AS A NITROGEN SOURCE IN NATURAL GRASSLANDS (A.J. SMIT & J.W. WOLDENDORP)

As part of a study on the specific adaptations of grassland plants to their environment, special attention is being paid to nitrogen nutrition. In this respect it was necessary to determine the contribution of nitrate and ammonium to this nutrition in the various grasslands under study. To develop the appropriate techniques for this purpose, attention was focussed on *Plantago* species occurring in an old established dune grassland on the island of Goeree.

It has been claimed in the literature that nitrate plays a minor role in permanent grassland soils due to a suppression of nitrification by allelopathic compounds excreted by plant roots (THERON 1951). Such suppression should occur particularly in climax vegetations (RICE 1974). However, other investigators (e.g. PURCHASE 1974) have ascribed the low nitrification rate to the absence of sufficient ammonium ions thought to be used preferentially in nitrogen immobilization and uptake by plant roots.