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LITTER FALL, NITROGEN AND PHOSPHORUS REABSORPTION IN *ZYGOPHYLLUM ALBUM* (ZYGOPHYLLACEAE) IN THE MEDITERRANEAN COASTAL REGION AND IN SUEZ DESERT REGION

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Plant litter of *Zygophyllum* was collected in the desert region (Suez desert region and Mediterranean coastal region). The litter was subdivided into leaves, stems, flowers and fruits. The mean total litter production was 173.3 g per shrub per year in the Mediterranean region and 138.3 g per shrub per year in the Suez region. Leaves constitute generally the largest litter category composing 70–76% of the total litter. The nitrogen and phosphorus concentration of fresh leaves was found to be twofold more than that of nitrogen and phosphorus found in the litter.

Key words: litter falls, nitrogen, phosphorus, *Zygophyllum album*

INTRODUCTION

The shedding of plant parts contributes essentially to the mineral cycling through ecosystems and to the nutrient supply of plants. Release of mineral elements during decomposition of plant litter alters the chemical properties of desert soils and increases soil fertility under shrub canopies (Charley 1972, Charley and West 1975, Romney *et al.* 1977).

The supply of available nitrogen and phosphorus to the plants depends on the turnover of organic matter and results immediately from the mineralisation of organic compounds of these elements. Principally, the supply with these nutrients is positively correlated with amount and turnover rates of the above and below ground organic matter.

Both the amounts and turnover rates of soil organic matter are very low in desert areas. This is due to the aridity of these regions. As a consequence, production of biomass and decomposition of organic substances (and thus formation of soil organic matter) occurs at very low rates compared to ecosystems in humid regions (Noy-Meir 1985). Desert ecosystems frequently lose organic matter and nutrients by wind drift of dead biomass.

The coastal region near Alexandria and the desert near Suez desert are very different in their climatic character. Accordingly, plant distribution and

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species composition differ also considerably between both habitats. But, *Zygophyllum album* is a characteristic constituent of the seminatural vegetation in both regions. This investigation is mainly focused on monthly litter fall, and nitrogen and phosphorus reabsorption in *Zygophyllum album*.

MATERIAL AND METHODS

The study areas

The investigations have been performed in the Mediterranean coastal region, about 40 km west of Alexandria, and in the Suez desert region about 150 km east of Cairo. Whereas the annual rainfall does not exceed 25 mm per year in the Suez region, it is usually nearly 170 mm per year in the coastal region near Alexandria (Fig. 1).

The rainy season in Egypt begins in October, and ends in March. The plant species under study begins to shed its leaves and other organs shortly after the end of the rainy season.

Five mature *Z. album* shrubs of average size (height 103.6 ±3.7 cm diameter 86 ±4.1 cm) were monthly randomly selected. Litter was collected regularly. From the soil under the shrubs, and the samples were transferred to the laboratory, oven dried at 65 °C for 48 h and weighted. Subsamples of 5 g were hand sorted into four categories (leaves, stems, flowers and seeds) and were weighted to obtain the percent composition. Fresh leaf samples were collected throughout the same period from five additional shrubs of the same size and were subjected to the same treatments as the litter. Subsamples of both fresh and litter samples were ground in a Wiley mill to pass 1.0 mm mesh sieve and were kept in closed bottles for chemical analysis. Nitrogen analyses were carried out using a C/N analyser (Model Na–1500, Carlo Erba). Phosphorus was colourimetrically determined according to Gericke and Kurmies (1952).

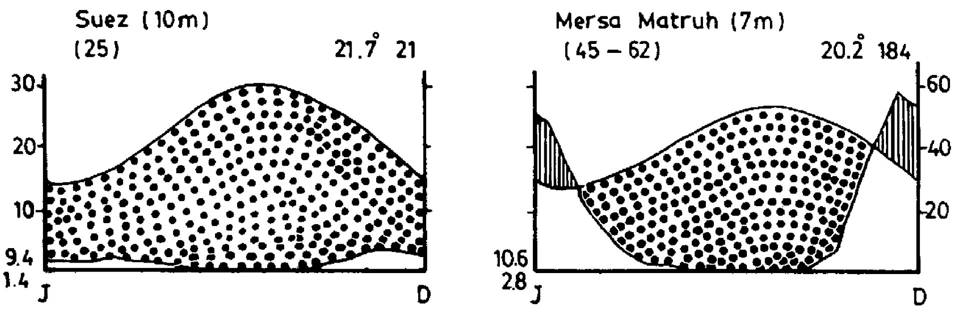

Fig. 1. Climatic diagrams of the two stations inhabited by *Zygophyllum album*

Table 1
Mean monthly litter fall from *Zygophyllum album* g/ha during the study period (Mean ± SD)

Month	Coastal region				Suez region			
	Stem	Flowers	Fruits	Leaves	Stem	Flowers	Fruits	Leaves
January	74 ± 3.8	31 ± 1.6	41 ± 2.0	516 ± 23	47 ± 2.4	24 ± 0.9	33 ± 1.5	214 ± 11.8
February	134 ± 4.8	41 ± 1.9	53 ± 3.0	517 ± 22	50 ± 2.2	18 ± 1.3	42 ± 2.0	389 ± 16.6
March	378 ± 18	106 ± 4.9	218 ± 11	1306 ± 65	204 ± 11	63 ± 3.7	76 ± 4.0	770 ± 44
April	900 ± 38	373 ± 16	416 ± 20	17,560 ± 880	630 ± 32	411 ± 26	378 ± 20.0	12,322 ± 588
May	605 ± 26	260 ± 8.9	321 ± 19	5,300 ± 270	196 ± 8.0	107 ± 4.9	201 ± 10.0	3,210 ± 170
June	307 ± 14	61 ± 3.2	183 ± 8.0	1,411 ± 81	204 ± 10	43 ± 2.1	52 ± 3.0	763 ± 36
July	203 ± 10.4	39 ± 1.9	64 ± 4.0	1,123 ± 83	212 ± 9.6	34 ± 2.1	36 ± 2.0	600 ± 28
August	105 ± 4.3	38 ± 1.9	132 ± 6.0	889 ± 43	112 ± 5.3	23 ± 1.1	108 ± 4.0	388 ± 19
September	96 ± 3.9	28 ± 1.4	31 ± 1.5	796 ± 38	103 ± 5.3	22 ± 1.0	26 ± 1.8	307 ± 19
October	91 ± 4.2	32 ± 1.6	23 ± 1.0	589 ± 32	80 ± 6.0	11 ± 0.8	18 ± 1.0	197 ± 11
November	74 ± 3.5	11 ± 0.5	17 ± 1.0	195 ± 11	71 ± 3.7	12 ± 0.7	14 ± 0.8	106 ± 4.6
December	51 ± 2.4	0.0	5.0 ± 0.3	307 ± 16	62 ± 3.2	0.0	0.0	202 ± 8.6
Total	3,018	1,020	1.089	30,509	1,971	768	974	19,468

RESULTS

During the study period, there was a great difference between the litter fall in the two study regions, in the Mediterranean coastal region it was 173.3 g per shrub per year and in the Suez region it was 138.3 g per shrub per year.

The seasonal changes in litter fall followed the plant phenology which is a function of the climatic factors specially the rain amount. Peak litter fall was recorded in April at the beginning of the dry season. This litter included the shed from new plant growth (Table 1).

In January, February and March, the amount of litter collected represented partly senescent litter from the previous summer and some new growth litter. Production decreased drastically between August and January.

Zygophyllum album leaves fell throughout the year and contributed to litter which far more 76% in Suez region and about 71% in the coastal region than the total of other plant parts (Table 2).

Generally, stems made up a very small part of the litter production representing 3.3% of the litter in the Mediterranean coastal region and 2.7% of the litter in Cairo Suez region, respectively (Table 2). Large dead branches remained on the shrubs throughout the study period.

Flowers contributed up to 10% of the litter in the coastal region and about 8% in the Suez region. Fruits made up 13% and 8% of the litter in the coastal region and in the Suez region, respectively (Table 2).

The nitrogen content of dried leaf litter of April was about twofold higher than that of the litter collected in August in both regions (Table 3).

During the study period, the nitrogen content was found to be significantly higher in fresh leaves of the control plants where it varied between average of 2.7 and 1.9 in the Suez region and average of 2.4 and 1.4 in the Coastal region, respectively.

DISCUSSION

The quantitative litter fall obtained in this work is in accordance with the phenological pattern reported by Evenari *et al.* (1975) (Holzapfel and Mahall

Table 2
The total litter falls from different plant organs (g/dry wt per shrub) of *Zygophyllum album* in the different regions (Mean ± SD)

Region	Leaves	Stems	Flowers	Fruits	Unknown	Total
Coastal Mediterranean region	123.7±5.2	5.8±0.3	17.3±0.8	22.4±1.4	4.1±0.4	173.3±11.3
Suez region	104.9±6.1	3.7±0.3	11.6±0.7	14.5±0.8	3.6±0.2	138.3±5.4

Table 3
Changes in nitrogen content (%) of *Zygophyllum album*. Leaves during the study period (Mean ± SD)

Month	Coastal region		Suez region	
	Leaves	Litter	Leaves	Litter
January	2.4 ± 0.12	1.2 ± 0.06	2.6 ± 0.13	1.5 ± 0.06
February	2.1 ± 0.1	1.3 ± 0.05	2.4 ± 0.13	1.7 ± 0.07
March	2.2 ± 0.11	1.2 ± 0.04	2.7 ± 0.13	1.9 ± 0.08
April	2.4 ± 0.11	1.4 ± 0.05	2.7 ± 0.12	1.9 ± 0.08
May	1.9 ± 0.1	1.1 ± 0.04	2.2 ± 0.12	1.3 ± 0.06
June	1.6 ± 0.11	0.8 ± 0.04	2.0 ± 0.11	1.1 ± 0.06
July	1.5 ± 0.12	0.7 ± 0.03	1.9 ± 0.11	0.9 ± 0.04
August	1.4 ± 0.1	0.7 ± 0.04	1.9 ± 0.12	0.8 ± 0.05
September	1.4 ± 0.1	0.8 ± 0.04	2.0 ± 0.1	0.9 ± 0.05
October	1.5 ± 0.11	0.9 ± 0.05	2.2 ± 0.12	1.0 ± 0.05
November	1.6 ± 0.12	1.0 ± 0.06	2.2 ± 0.12	1.1 ± 0.06
December	1.8 ± 0.12	1.2 ± 0.06	2.3 ± 0.12	1.1 ± 0.06

1999). The peak of the mean monthly litter fall of the different plant organs (leaf, stem and flowers) follows the production peak observed in the field. The only plant parts that show a bimodal litter peak are the fruits that are usually attached to the plant stems and do not fall immediately after maturation. The data show a peak of fruit shedding in August and a second peak in April. The second peak is the direct result of strong winter windstorms that are very common in these areas.

The data of the present study suggest a rapid drought-induce reabsorption of nitrogen and phosphorus from *Z. album* leaves. Leaves shed during periods of peak litter fall had a low nitrogen content of 1.4% and 1.9% N in the coastal and in the Suez region, respectively, and a low phosphorus content of 0.15% and 0.14% P in the coastal and in the Suez region, respectively (Table 4). A comparison with the nitrogen and phosphorus contents of fresh leaves shows that *Z. album* is capable of physiological nitrogen and phosphorus storage through reabsorption. This capability is not only advantageous but, possibly, a precondition for the existence in such a harsh environment where available nitrogen and phosphorus are limiting plant productivity (Charley and West 1975, Holzapfel and Mahall 1999).

Since large fractions of leaf nitrogen and phosphorus are reabsorbed before the leaves are shed, *Z. album* is not closely dependent upon decomposition and mineralisation processes in order to cover its nitrogen and phosphorus demand for subsequent growth. This seems to be particularly important in a

Table 4
Monthly changes in phosphorus content (%) of *Zygophyllum album* leaves during the study period (Mean ± SD)

Month	Suez region		Coastal region	
	Leaves	Litter	Leaves	Litter
January	0.23 ± 0.01	0.13 ± 0.008	0.18 ± 0.015	0.11 ± 0.008
March	0.36 ± 0.02	0.17 ± 0.015	0.31 ± 0.02	0.16 ± 0.01
April	0.34 ± 0.02	0.15 ± 0.015	0.28 ± 0.02	0.14 ± 0.015
May	0.26 ± 0.015	0.14 ± 0.01	0.23 ± 0.015	0.12 ± 0.01
June	0.23 ± 0.01	0.13 ± 0.01	0.21 ± 0.014	0.12 ± 0.01
July	0.22 ± 0.01	0.13 ± 0.01	0.20 ± 0.01	0.11 ± 0.015
August	0.22 ± 0.01	0.14 ± 0.015	0.20 ± 0.01	0.11 ± 0.01
September	0.23 ± 0.015	0.15 ± 0.015	0.22 ± 0.015	0.12 ± 0.01
October	0.24 ± 0.01	0.16 ± 0.015	0.21 ± 0.015	0.12 ± 0.01
November	0.26 ± 0.01	0.17 ± 0.015	0.22 ± 0.015	0.13 ± 0.015
December	0.27 ± 0.015	0.18 ± 0.02	0.23 ± 0.02	0.13 ± 0.015

desert, where nitrogen and phosphorus mineralisation is slow or not synchronous with rainfall. In addition, the dead leaves of *Z. album* provide a low quality substrate for the soil microflora and microfauna, and this could have an increasing effect on the abundance and diversity of soil organisms and on nitrogen and phosphorus immobilisation by the soil microflora (Zayed 1998).

The finding reported here demonstrate that estimation of litter fall can provide a reasonable measure of the net above ground productivity of desert shrubs. Strojan *et al.* (1979) discussed the limitation of this approach, particularly with regard to the desert evergreen shrub *Larrea tridentata*. *Z. album* is drought deciduous and sheds leaves plus stem and reproductive parts during the dry season (May through September), as a function of water availability.

An unexpected phenomenon revealed by this study is the increase in leaf nitrogen content recorded in spite of lower rainfall. This unexpected fact can

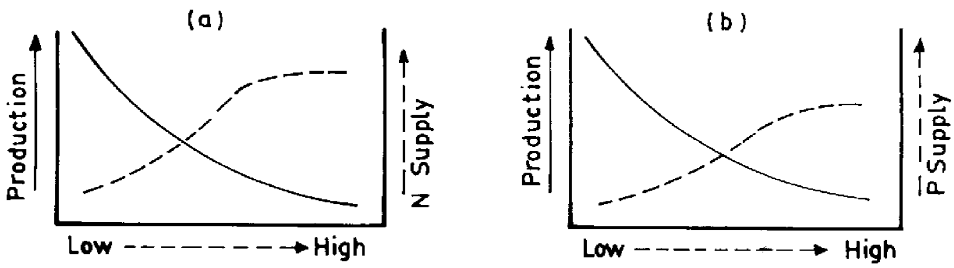

Fig. 2. A model of the effect of soil water content on leaf production in *Zygophyllum album*. a = nitrogen supply, b = phosphorus supply

be explained by a water-nitrogen model and a water-phosphorus model (Fig. 2a, b). In a dry area, leaf production will be limited by rainfall and not by nitrogen or phosphorus supply, which may explain the high content of nitrogen and/or phosphorus in leaves in a dryer area (Huang and Gutterman 1999); (Aerts and Chapin III 2000). An increase in soil water availability will lead to an increase in leaf production, whereas the nitrogen and phosphorus supply remains limited. Therefore, the content of nitrogen and phosphorus in leaves will be more "diluted" towards the end of the growing season.

Thus, the production of the desert shrub *Z. album*, similar to many other arido-passive plants (Evenari *et al.* 1975) is probably limited not only by soil water availability but also by nitrogen and phosphorus supply. This study suggests that future research on both the quantitative and qualitative aspects of nitrogen and phosphorus supply is necessary.

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