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On the Ecology of *Moringa peregrina* (Forssk.) Fiori) Anatomical Responses to Varying Soil Moisture Contents

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ABSTRACT. The stems and leaves of *Moringa peregrina* (Forssk). Fiori were studied at different levels of soil moisture content within the range between permanent wilting percentage and moisture equivalent. The diameter of stem gradually increased with increase of water supply which generally led to progressive formation of vascular elements as well as cortical and pith tissues. Near the permanent wilting percentage, a condition of frequent occurrence in arid regions, *M. peregrina* showed tendencies towards xerophytic adaptation. The leaves were covered with remarkedly dense trichomes, relatively increased in the values of stomatal frequency and index, and a reduction in the proportion of air spaces in the mesophyll tissue. Such decrease in coefficients of mesophytic characteristics of the species gradually disappeared with the increase of the soil moisture content. From the results presented here it was generally concluded that the variation in water supply led only to quantitative changes of the micromorphological attributes of the species but no qualitative modifications took place.

Introduction

The scarcity of water considered as the major problem in arid and semiarid regions. In Saudi Arabia, the moisture stress represents the most important factor affecting plant growth. Several reviews have discussed the effects of water supply on growth and metabolic processes of different species of higher plants, *e.g.*[1-4]; some of which included anatomical responses in different plant organs.

Studies on the effect of water supply on anatomical structure of plants generally indicate that the decrease in moisture content of soil intensifies the formation of vascular elements, cell wall thickening and leads to the development of more xeromorphic structures particularly in leaves[1-4]. Availability of water is thus an especially important factor affecting the form and structure of plants[5].

The effect of different water supply on quantitative and qualitative changes in stomata were reported for some plant species[6-13]. Environmental factors may induce a degree of xeromorphic in normally mesomorphic leaves or intensify the xeromorphic characters in xerophytes[5].

The present study therefore was carried out to show the effects of six different soil moisture contents on the anatomical structure of stem and leaves of (*Moringa peregrina*) which is of considerable economic and medicinal importance. Another objective was to elucidate the extent to which anatomical attributes are stable under varying stressfull soil moistures.

Material and Methods

Seeds of *M. peregrina* were grown in plastic pots (13 cm high × 10 cm diameter) containing mixed soil of sandy loam and peat moss (1:1). Each pot was filled with 835 g of the air-dry mixed soil. The levels of available moisture used in the different treatments were 0-5%, 5-10, 20-25%, 70-75% and 95-100% from the soil field capacity. For every treatment 6 replicates were used. The moisture content was adjusted at different levels of moisture content by irrigating the soil every day after weighing the pots to determine the amount of water to be added. The experimental period extended from September 2nd to December 28th during 1991 and the experiment was carried out under direct 13 hours sun light, temperature ranged between 28-30°C day time and 20-22C° night in the Botanical Garden of the Faculty of Science, King Abdulaziz University, Jeddah, Saudi Arabia.

Samples (stems and leaves) for anatomical studies were taken randomly from each treatment at vegetative stage (after almost four months). Fixation was carried out in F.A.A. Stem and leaf anatomy was studied from cross sections (10-20 μ thick) which were double stained in safranin and light green stain. Drawings were made at bench level with a camera lucida.

*Stomatal frequencies and indexes were determined using a square micrometer after stripping off and fixing the lower and the upper leaflet epidermis in 70% alcohol.

Results and Discussion

The anatomical structures of stems and leaves of *M. peregrina* grown at 0-5%, 5-10%, 20-25%, 45-50%, 70-75% and 95-100% of available moisture are shown in plates 1, 2, 3, 4, 5 and 6 respectively. The values of frequency and index of stomata of this plant are presented in Table 1. The values of Stomatal frequency and index were progressively decreased with increase in soil moisture content.

The internal structure of stem and leaf of this species under the normal conditions (95-100%) is its typical anatomy which is briefly described as follows:

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*Stomatal frequency: No of stomata/mm^2 of the leaflet surface, Stomatal Index S/E + S × 100. Where S denotes the number of stomata per unit area and E the number of epidermal cells of the same area.

TABLE Stomatal frequency and stomatal index of *Moringa peregrina* growing under different levels of available soil moisture.

Available soil moisture %	Stomatal frequency (per mm^2)	Stomatal index
95 - 100	343.854 ± 3	29.3 ± 2
70 - 75	517.104 ± 10	34.2 ± 3
45 - 50	590.625 ± 8	37.2± 1
20 - 25	840.042 ± 14	41.8 ± 5
5 - 10	974.169 ± 18	46.2 ± 5
0 - 5	1021.562 ± 17	48.0 ± 8

A. Anatomy of Stem

In cross-section, stem terete. Epidermal cells tangentially to radially elongated, cuticle thick. Trichomes eglandular and unicellular. Cortex with 2-5 layers of small parenchyma cells containing cluster crystals and starch grains followed by 5-8 layers of large thin-walled parenchyma cells; Vascular cylinder crowned with isolated patches of protophloem which are stratified into hard fiber patches. Vascular tissue in the form of dicttyostele type which is composed of slightly separated vascular bundles. Vascular cambium with 3-4 layers of radially arranged rectangular cells. Xylem vessels with lignified reticulate, spiral and pitted thickenings. Pith formed of thin walled parenchymatous cells containing cluster crystals and starch grains.

B. Anatomy of Leaf

Epidermal cells tangentially and radially elongated. Trichomes eglandular and unicellular. Mesophyll of dorsoventral type. Palisade tissue of 1-2 layers which are discontinuous adaxially at the midrib region. Mid vein crescent-shaped and surrounded by parenchymatous sheath. Mechanical tissue of collenchyma was recorded abaxial and adaxial at the midrib region.

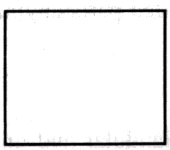
It is obvious (plates: 1-6) that various anatomical changes were obtained in stems and leaves of *M. peregrina* in response to variations of soil moisture content. The diameter of stem increased gradually as water supply increased. Such effect is usually a feature concomitant to increase of soil moisture[4,7]. The number of parencymatous layers of cortex progressively increased with increase in the available moisture from the lowest level (0-5%) to the highest (95-100%). Also, gradual increase of sclerenchymatous mass of pericycle, phloem and xylem elements as well as the diameter of pith was observed to accompany the elevation in the soil moisture content. Furthermore, xylem and phloem were in the form dictyostele with much reduced medullary rays in the stem of plants growing under low moisture level (0-5%). The less intensified formation of vascular elements in stem at low moisture level (0-5) disagreed with conclusions of some authors which have studied the effect of water stress on wheat[2,14-15]. They stated that there was an increase information of vascular elements with decrease of water supply. The present findings however agreed with those of Sperry and Tyree[16] and seemed of be the result of relatively retarded growth and decreased diameter of stem.

Plates (1-6) : Micromorphology of *Moringa peregrina* growing under different levels of available soil moisture.

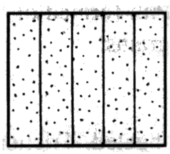
Plate 1 = 0 - 5 % available moisture
Plate 2 = 5 - 10 % available moisture
Plate 3 = 25 - 30 % available moisture
Plate 4 = 45 - 50 % available moisture
Plate 5 = 70 - 75 % avbailable moisture
Plate 6 = 95 - 100 % available moisture

(A) stem diagram
(B) leaf diagram
(C) foliar trichomes (Unicellular)
(A_1) stem sector
(B_1) leaf sector
(D) stomata of the leaf (Anomocytic)

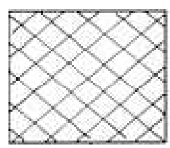
Key for anatomical structure :



Parenchyma

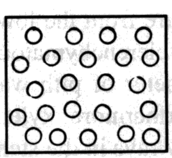


Palisade tissue

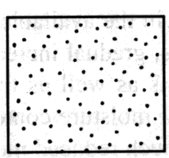


Collenchyma

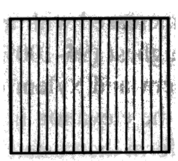
Scelerenchyma



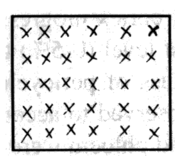
Spongy tissue



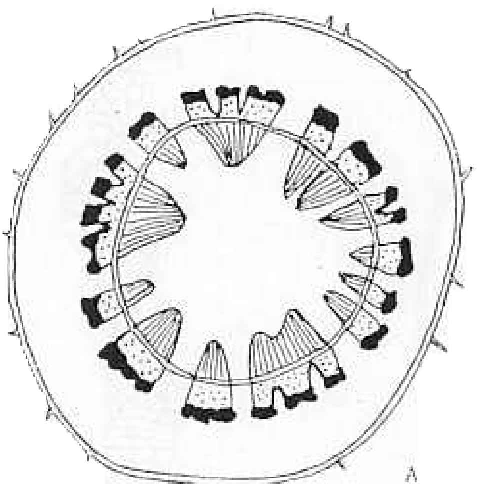
Phloem



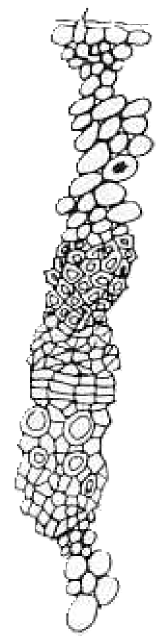
Xylem



Parenchymatous sheath

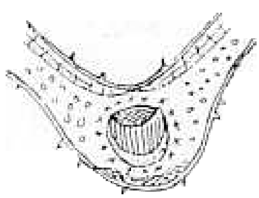


100μ

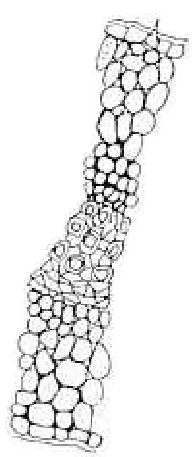


A

50μ



100 μ



B

50

PLATE (1)

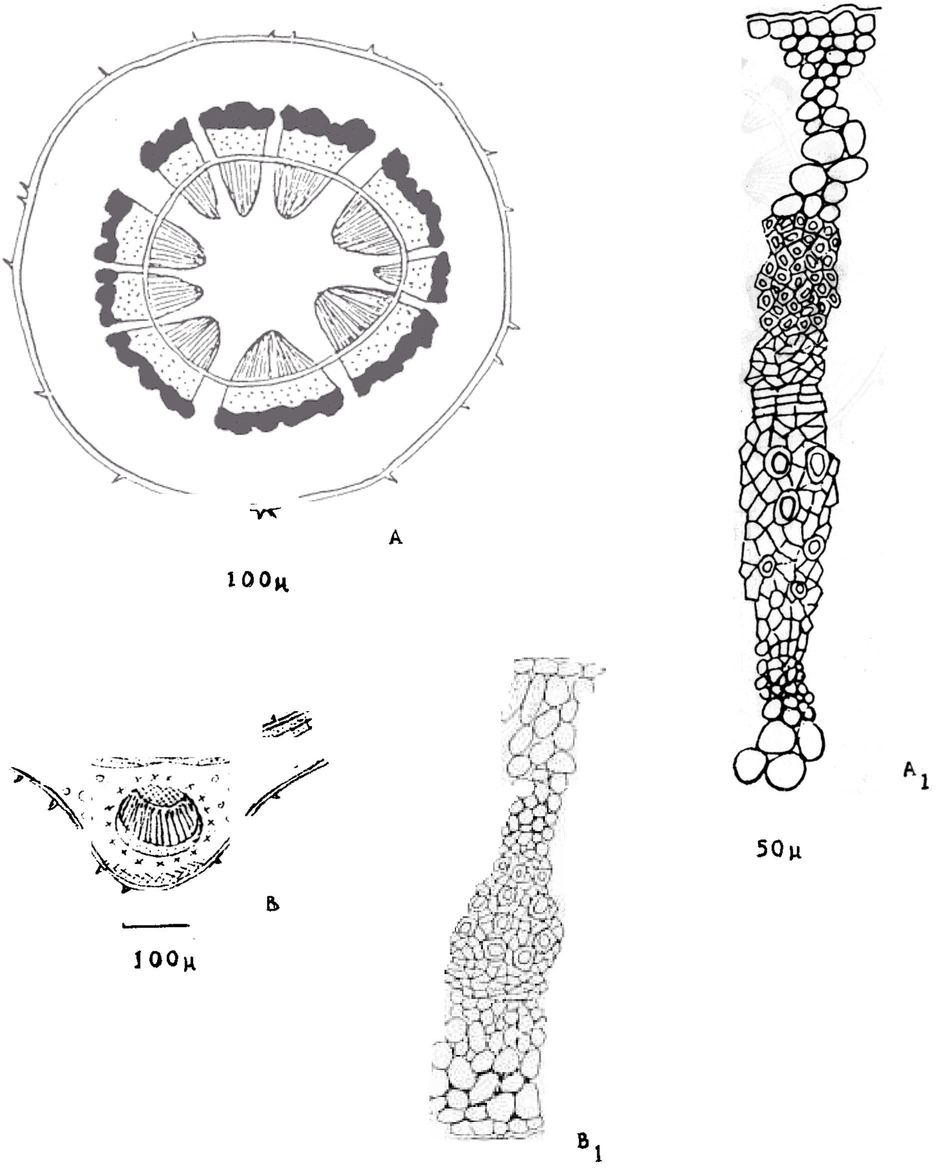


PLATE (2)

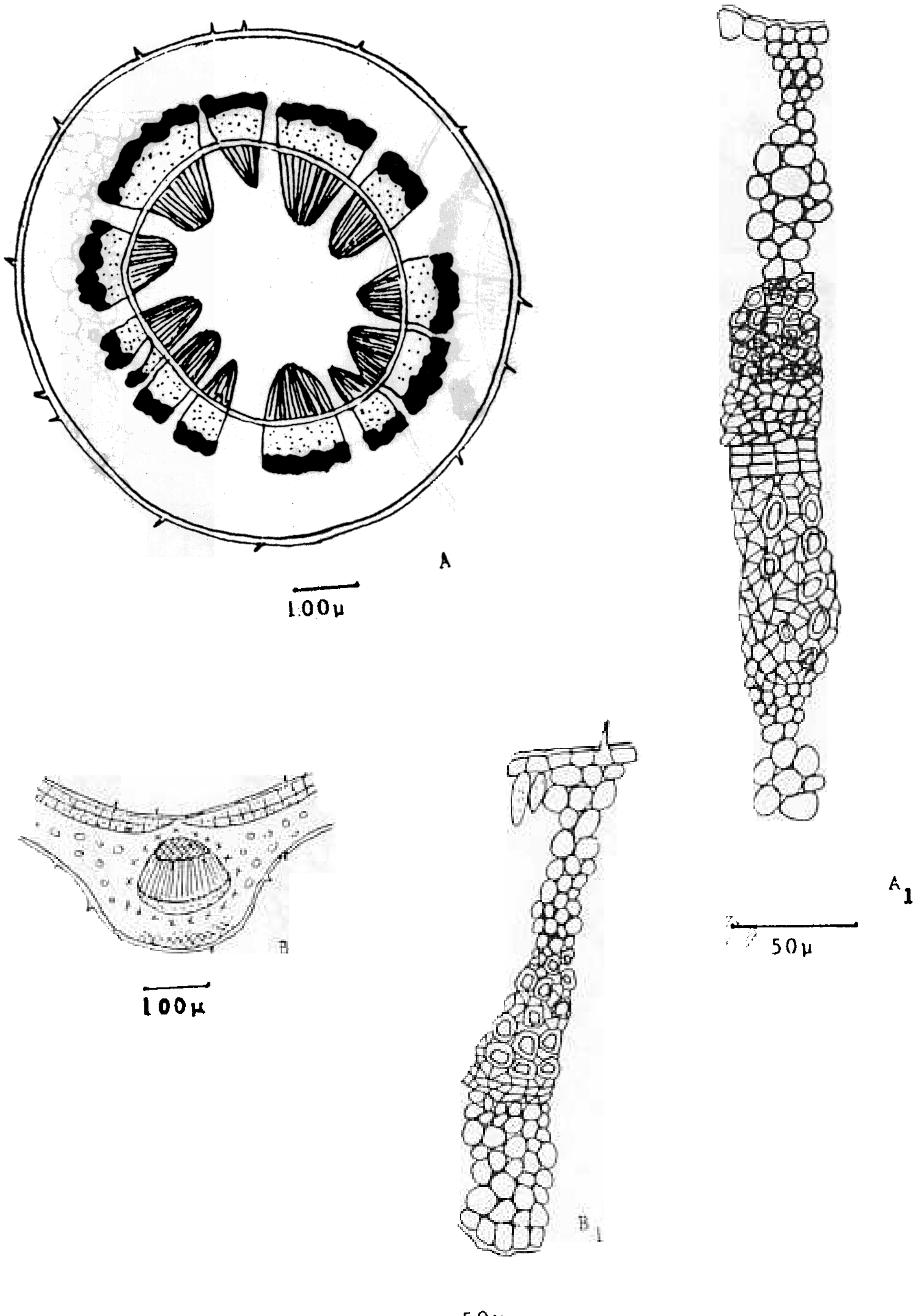


PLATE (3)

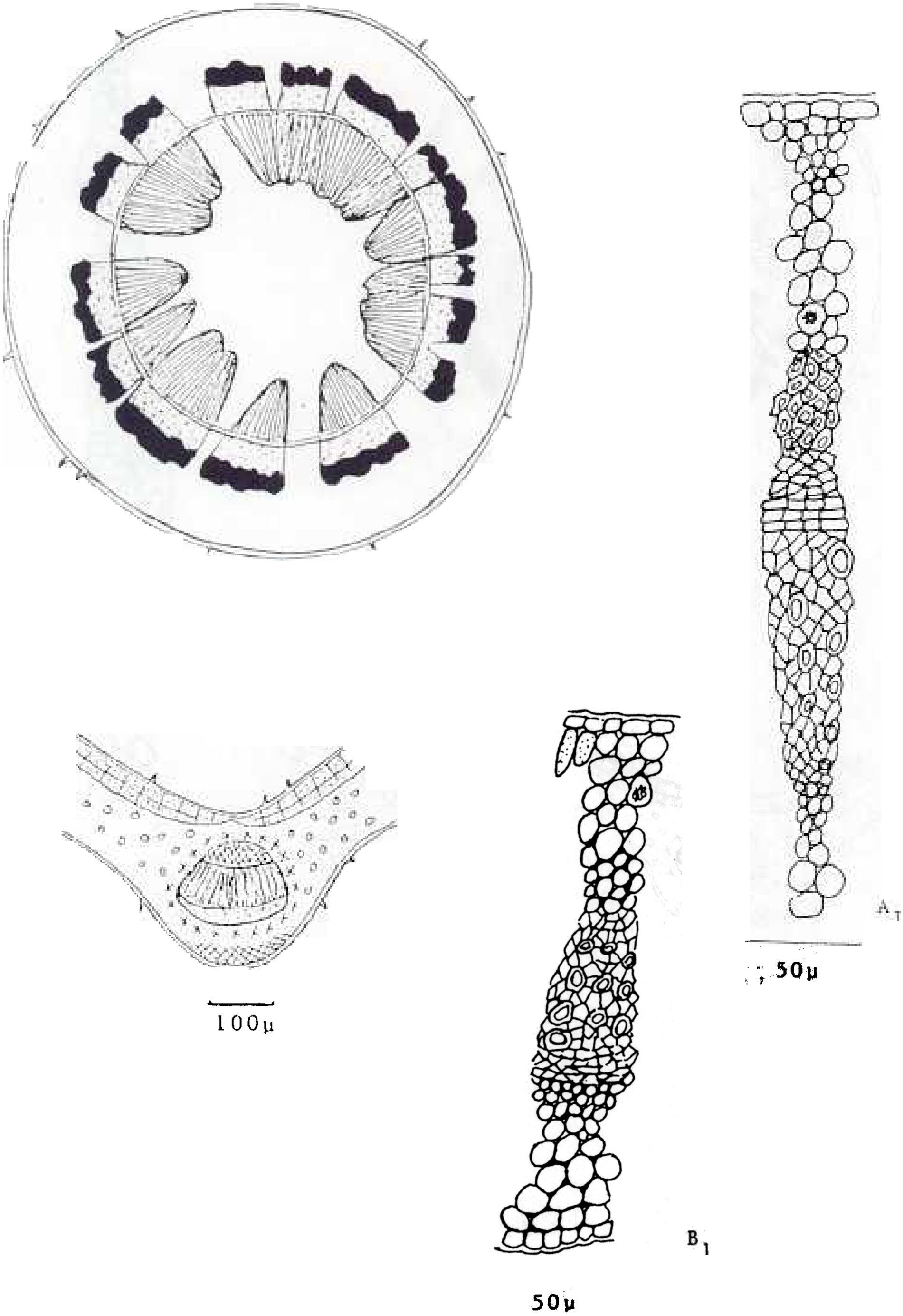


PLATE (4)

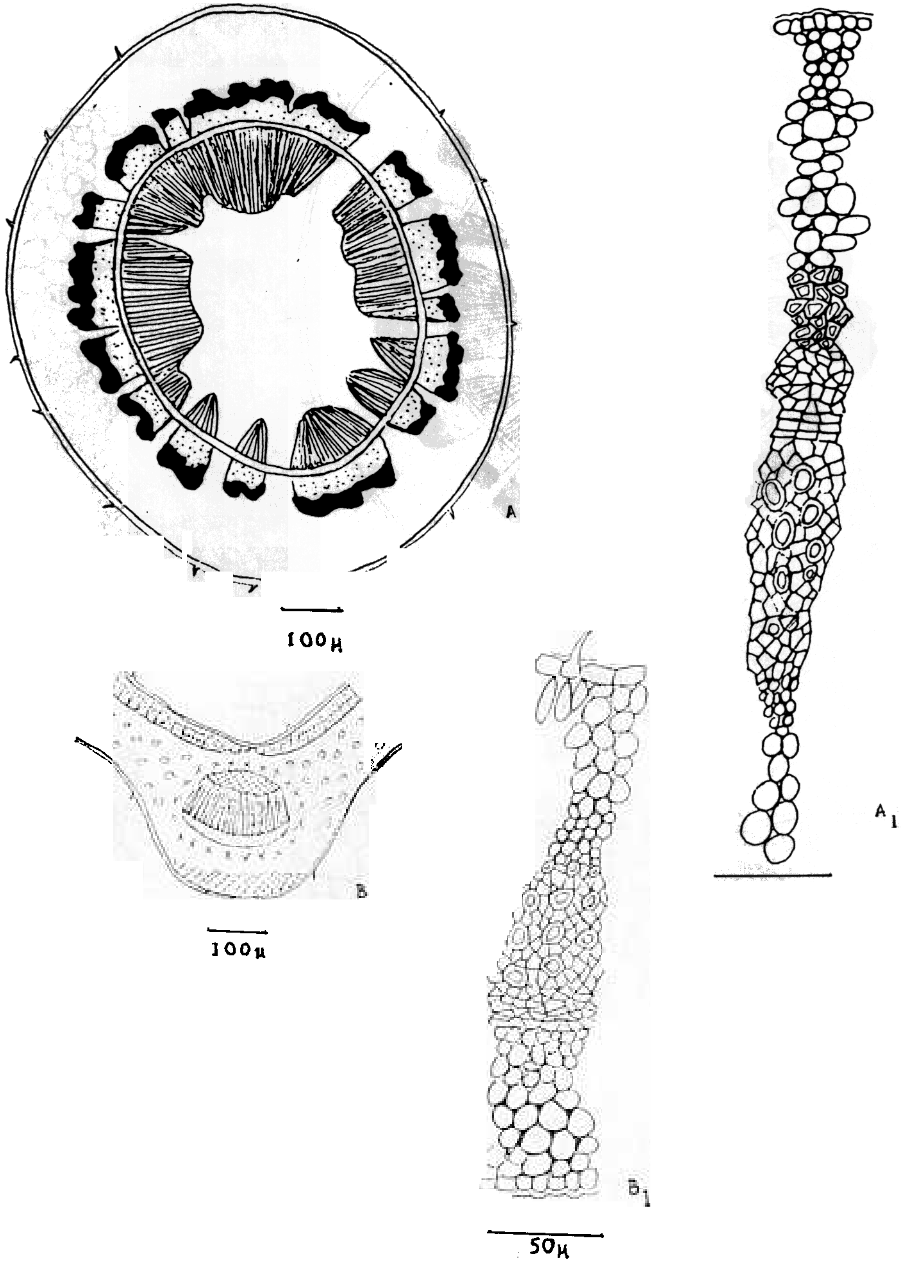


PLATE (5)

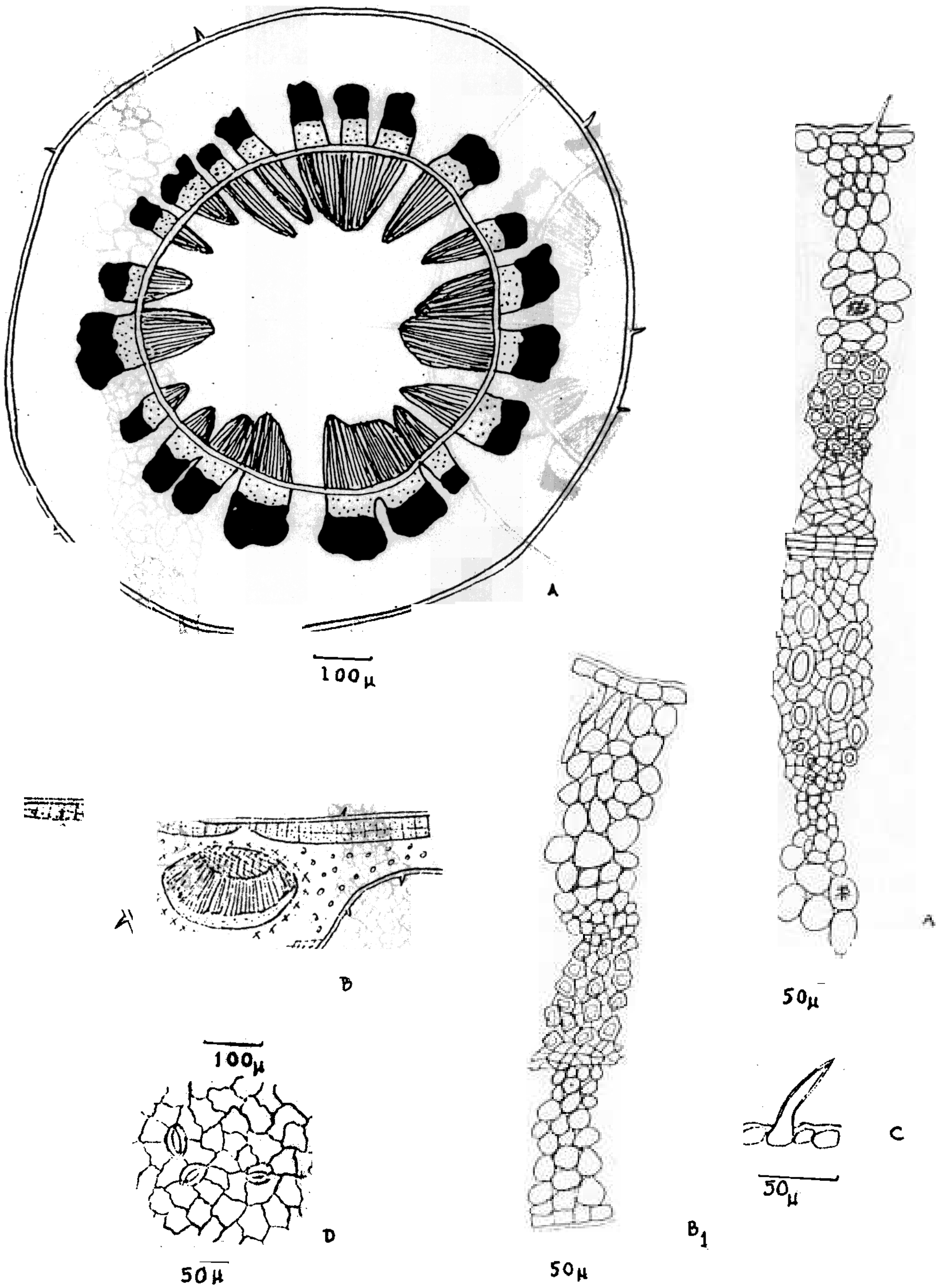


PLATE (6)

In leaves, the remarkedly dense cover of hairs was one of the most important feature that accompanied the growth of *M. peregrina* under low moisture level (0-5%). Such effect was assumed to provide a protective layer of the transpiring surface from air currents and to keep the thin layer of air adjacent to the surface humid[17].

The values of stomatal frequency as well as the stomatal index (Table 1) were progressively decreased with increase in soil moisture content. These results are in agreement with those of Kaulfmann[6]; Ninova *et al.*[7]; O'Toole and Gruz[8]; Ludlow[10]; Jones[12] and Djekoun & Planchon[13].

In leaves, the mesophyll tissues gradually increased as the water supply increased. A reduction in the proportion of air spaces at high moisture stress (0-5%) was observed. This probably caused extreme reduction of the internal evaporating surface which may have been accompanied by a limited accumulation of water vapour and slower rate of its movement to the stomatal chambers, thus leading to lower transpiration rate[18, 10]. Esau[5] stated that one of the most prevalent characteristics of xeromorphic leaves is the high ratio of volume to surface, therefore, the leaves are small and compact. This character is associated with distinct internal characteristics such as thick mesophyll, with the palisade tissue more strongly developed than the spongy parenchyma, small intercellular-space volume, and compact network of veins. Similarly Kramer[19] reported that wide variability in the internal volume of air spaces in leaves could be obtained by the moisture content of the environment in which the leaves develop.

In vascular bundles of the leaves of *M. peregrina,* the phloem and xylem elements increased as water supply increased. Likewise, similar response was shown by the adaxially and abaxially situated collenchymatous cells. However, this might be attributed to the increase of the leaf area at relatively higher water supply.

The characteristic tendency of plants to be genotypically selected or phenotypically developed by water deficit is accompanied with xerophytic modification, including reduce surface to volume ratio, leaf rolling, hair covering and increased frequencies and indexes of stomata[20]. In view of this and the results obtained in the present study, it might be concluded that with progressive decrease in the available soil moisture from the highest level (95-100%) to the lowest (0-5%), *M. peregrina* plant in general showed gradual tendencies to achieve xerophytic characteristics, thus to tolerate dry climate prevailing in Saudi Arabia.

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دراسة بيئية على نبات البان *Moringa peregrina* (Forssk.) Fiori
( ) الاستجابات التشريحية لنبات البان لتغيير محتوى رطوبة التربة

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جـــــدة - المملكة العربية السعودية

المستخلص . تناولت الدراسة أثر المحتوى المائي للتربة لمقننات مائية ستة هي (صـفـر - ٥٪) ، (٥ - ١٠٪) ، (٢٠ - ٢٥٪) ، (٤٥ - ٥٠٪) ، (٧٠ - ٧٥٪) ، (٩٥ - ١٠٠٪) من السعة الحقلية لمخلوط من التربة الرملية الجيرية والبتموس على الصفات التشريحية لأوراق وسوق نبات البان *M. peregrina* . وقد اتضح أن الزيادة في المحتوى المائي للتربة يتبعها زيادة في محيط الساق وزيادة في تكوين العناصر الوعائية وأنسجة القشرة والنخاع ، وعلى العكس من ذلك فإن النقص في المحتوى المائي يؤدي لميل النبات لاكتساب الصفات الجفافية وذلك بزيادة كثافة الشعيرات على أسطح الأوراق وزيادة قيم معامل الثغور وترددها واختزال حجم المسافات البينية للنسيج الوسطي للأوراق . وقد لوحظ أن هـذه الصفات الجفافية تختفي بالتدريج مع زيادة المحتوى المائي للتربة . وقد دلت النتائج بوجه عام على أن التغيير في المحتويات المائية للتربة يؤدي فقط لبعض الاختلافات الكمية في الصفات التشريحية لنبات البان ولا تحدث أي تغيرات وصفية .