FERNS AND FERN-ALLIES OF RAJASTHAN--ANATOMY AND EXPERIMENTAL STUDIES IN RELATION TO DROUGHT RESISTANCE

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ABSTRACT

Anatomy is related with the drought resistance in some of the pteridophytes found growing in the Thar desert of India. The bio-regulants like morphactin ceases differentiation of xylem and higher doses of the chemical prove lethal for such plants. The drought resistant ferns possess sufficient amount of carotenoid contents and show minimum degradation of chlorophylls.

INTRODUCTION

Quite a good number of pteriodphytes are found growing luxuriantly during rainy season at several places in Rajasthan (BIR & VERMA, 1963 ; MITAL, 1968). However, some of them survive year round (SHARMA & BOHRA, 1977) and possess sufficient resistance to drought, e.g. *Actiniopteris radiata, Adiantum lunulatum, Cheillanthes albomarginata,* etc. Many of these pteridophytes show resurrection habit and turn green with the first shower of rain. Their vascular system is modified accordingly, i.e., they possess efficient water conducting mechanism. The photosynthetic pigments of such plants show variations from the normal moisture loving ferns and are less affected during desiccation (BOHRA *et al.*, 1979). On the other hand, the bio-regulants show more effective results on the morphology and anatomy of drought resistant forms in comparison to the mesophytic types (BHARADWAJA & SHARMA, 1976 ; BOHRA *et al.*, 1979a).

MATERIAL AND METHODS

The material was collected from different places throughout Rajasthan. Many of these plants were grown in the botanic garden of the department for experimentation. The effects of bio-regulants like morphactin (EMD 7311) was studied on the potted plants by spraying the chemical on them. The chlorophyll estimations were done by the method of ROBBELEN (1957). The material was preserved in F.A.A. for anatomical studies. Maceration was done by the method suggested by GHOUSE AND SABIR (1973).

DESCRIPTION

Anatomy—By maceration technique the tracheary elements of different species of pteridophytes found in Rajasthan were studied. The vessel elements occur in addition to *Equisetum, Pteridium* and *Marsilea* (BHARADWAJA & BAIJAL, 1977 ; SHARMA & BHARADWAJA, 1978 ; SINGH *et al.*, 1979a) also in the rhizome of *Actiniopteris radiata* (SINGH *et al.*, 1979b ; Pl. 1, Figs. 1, 2). They are showing variations in shape as well as size. The vessel elements of the drought resistant forms, e.g., *Equisetum ramosissimum* subsp. *ramosissimum* (Pl. 1, Fig. 3), *Actiniopteris radiata* and *Marsilea aegyptiaca* (Pl. 1, Fig. 4) are comparatively shorter in length than those of the mesophytic or hydrophytic plants, e.g., *Marsilea minuta* (Pl. 1, Figs. 5, 6 ; Table 1). The apical pore is more or less horizontal in the former while it is oblique in the latter types.

Table 1—Showing length (in mm) of vessel elements in different species of pteridophytes found in Rajasthan

Species	Root	Rhizome	Aerial stem
Equisetum ramosissimum subsp. *ramosissimum*	0.33—1.42	0.12—0.42	0.68—2.74
Actiniopteris radiata		0.45—1.19	
Marsilea aegyptiaca	0.8—3.5		
M. rajasthanensis	2.7—8.9		
M. minuta	1.5—3.5		

Similarly, the tracheids are also showing variations in length in different species of pteridophytes found growing in varied ecological conditions (work in progress).

Isoetes coromandelina occurs frequently in the fields in south-east part of the State i.e. Daosa, Bharatpur, Jhalawar and Atru (GENA *et al.*, 1976 ; MISRA & BHARADWAJA, 1978 ; SHARMA & BOHRA, 1978). Plants are large, 40-60 cm long with well-developed rhizomorphs. The latter survives in soil for 3-5 years or more, and successive rings of secondary xylem are produced (Pl. 1, Fig. 10). The vascular elements in these plants are comparatively smaller and wider than those of the *Isoetes* sp. found during rainy season at Mt. Abu. In the latter type, the plants are small and the rhizomorph survives only for 1-2 years. Successive secondary xylem rings are not seen in the Abu material.

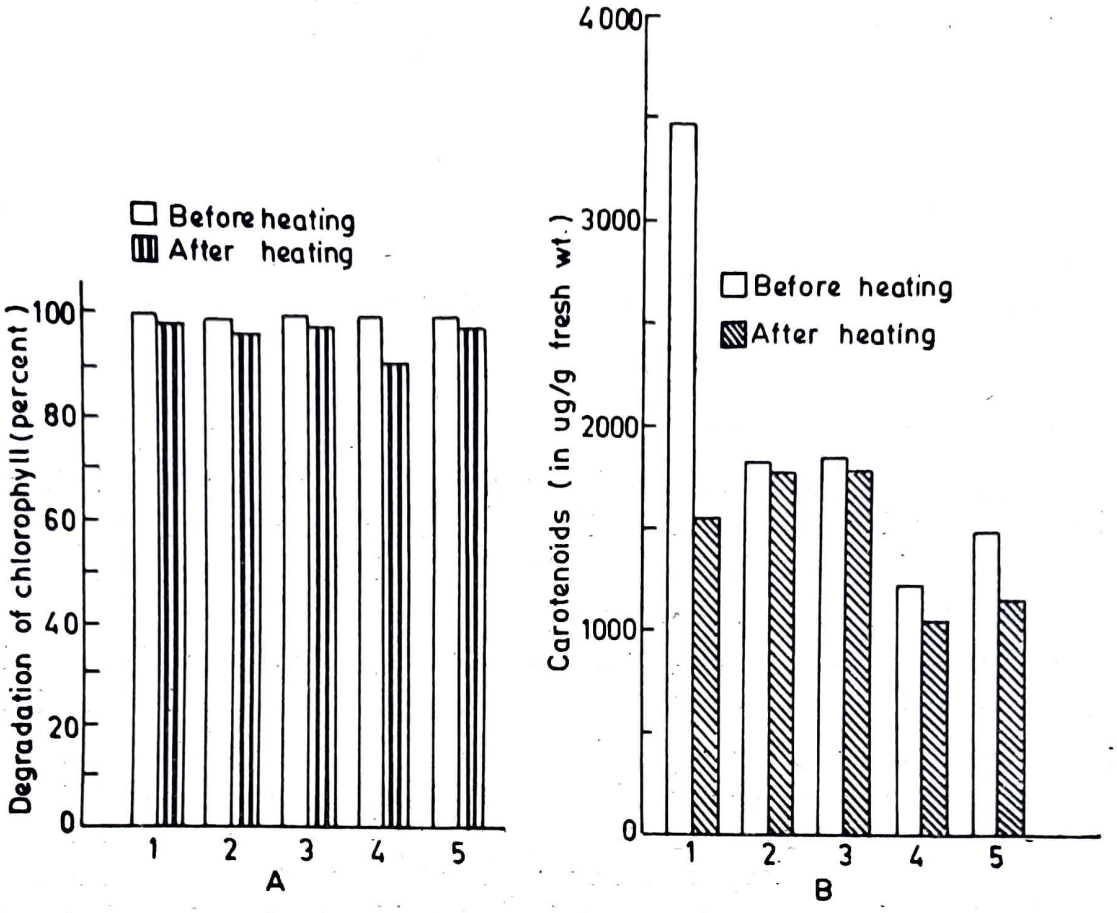
Experimental studies—Chlorophylls and carotenoid contents of the following species of ferns were determined and correlated with drought resistance:

Actiniopteris radiata, Adiantum lunulatum, A. incisum, Athyrium pectinata, Cheilanthes albomarginata.

The degradation of chlorophyll-a, chlorophyll-b and the total chlorophyll is shown in Graph A. *Actiniopteris radiata* shows the minimum degradation while *Athyrium pactinata* the maximum. The former is a drought resistance form while the latter grows in moist and shady places. The other ferns represent intermediate types and show degradation of chlorophylls according to the capacity of drought resistance.

Actiniopteris radiata possesses the maximum carotenoid contents while minimum occurs in *Athyrium pectinata* (Graph B). The former, like the chlorophylls, show maximum degradation of carotenoids, i.e. more than 50% on heating at 60°C. *Cheilanthes albomarginata* comes second which is also a good drought resistance form of ferns found in Rajasthan.

The effects of morphactin (EMD 7311) were studied on two ecologically distinct species of *Marsilea*, i.e. *M. aegyptiaca* and *M. minuta*. The former is a drought resistant type and occurs widely in the north-west arid part of the State, i.e. Jodhpur and Barmer, while the latter is a true hydrophytic form of the genus. The potted plants were sprayed with three concentrations, i.e. 10 ppm, 50 ppm and 100 ppm of the chemical, four times at regular intervals of seven days. In addition to the morphological changes, anatomical deformations were also observed. *M. aegyptiaca* shows more pronounced stunting and curling of leaves than *M. minuta*. However, the higher dose, i.e. 100 ppm proved lethal to the former while the latter species survived very well at this concentration. Anatomy of the effected parts of the treated plants was studied and found that the morphactin ceases differentiation of xylem. In the rhizome, though the xylem ring has become 2-3 cells thick (Pl. 1, Fig. 7) but the differentiation of protoxylem and metaxylem cells is not visible. In the petiole, on the other hand, the metaxylem cells have disappeared



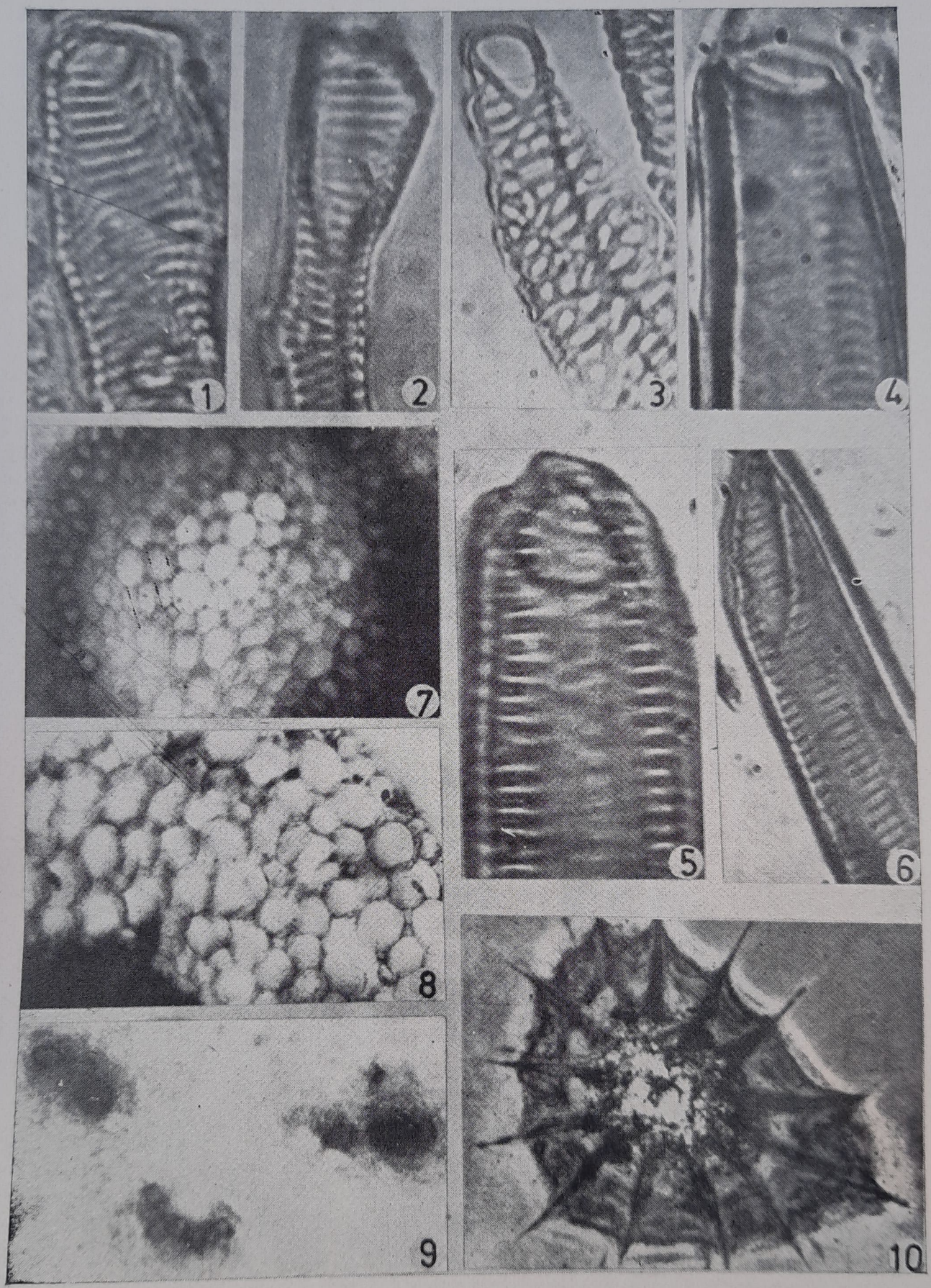
Graph A. Showing percentage degradation of chlorophylls in different species of ferns after heating at 60°C for two hours.

Graph B. Effect of 60°C temperature for two hours on carotenoids of some ferns collected from Rajasthan. (1. *Actiniopteris radiata*, 2. *Adiantum lunulatum*, 3. *A. incisum*, 4. *Athyrium pectinata*, 5. *Cheilanthes albomarginata*).

and only three patches of protoxylem tracheid are seen (Pl. 1, Fig. 9). The chemical also induces reduction in cavities and thus the cortical air-chambers have disappeared in the treated rhizome of *M. aegyptiaca* (Pl. 1, Fig. 10).

DISCUSSION

Rajasthan forms a part of the Thar desert of India. The annual average rainfall is comparatively low and the area faces scorching heat during summers. Similarly, the dry, cold winters effect the growth of plants adversely. Ferns and fern-allies are generally moisture and shade-loving plants, yet some of them flourish very well in Rajasthan as they have developed resistance to face the drought conditions. Majority of the pteridophytes regenerate through their rhizomorphs or rhizomes which remain embedded in the soil for years together and new leaves develop seasonally from them. However, in resurrection forms, in addition to the new leaves, the old dry leaves also turn green and look fresh with the first shower of rain, e.g. *Actiniopteris radiata*, *Cheilanthes albomarginata*, *C. farinosa*, etc. Such plants require an efficient vascular system for re-establishing the water continuity in xylem from the roots to the leaves (Gaff, 1972). Thus in drought resistant forms the tracheary elements are shorter and wider than those of the mesophytic or hydrophytic types. Some of them possess even vessels in their roots and rhizomes, e.g. *Equisetum*, *Actiniopteris* and *Marsilea*. Probably, the existence of successive rings of secondary xylem in the rhizomorphs of *Isoetes coromandelina* may be related with the drought resistance habit. In smaller forms of *Isoetes* which grow in hydrophytic conditions, successive rings of secondary xylem are absent.



Sharma, Bohra & Singh—Plate 1

In drought resistant ferns the photosynthetic pigments are also modified accordingly. The chlorophylls are not much effected by desiccation and they possess sufficient amount of carotenoid contents. However, the latter show easy degradation and reduce to 50 per cent or so. Thus it seems that the carotenoids protect the plants from photosensitized oxidation and chlorophyll degradation (KRINSKY, 1966).

The exact relationship of morphactin with xeromorphism is not known. However, the present investigation shows that the drought resistant forms are less tolerant to the higher doses of the chemical in comparison to the hydrophytic types. Morphactin is a polyvalent disturbing substance (SCHNEIDER, 1970). It reduces as well as increases the number of leaflets in *Marsilea aegyptiaca* (BOHRA *et al.*, 1979a). Similarly in the rhizome, the number of xylem cells are increased while in the petiole there remains only few tracheids and in three patches.

REFERENCES

BHARADWAJA, T. N. & SHARMA, B. D. (1976). Morphactin induced abberation in the water fern *Marsilea*. *Bot. Jahrb. Syst.*, **97** : 431-435.

BHARDWAJA, T. N. & BAIJAL, J. (1977). Vessels in rhizome of *Marsilea*. *Phytomorphology*, **27** : 206-208.

BIR, S. S. & VERMA, S. C. (1963). Ferns of Mount Abu. *Research Bulletin* (N. S.). *Punjab Univ.*, **14** (III-IV) : 187-202.

BOHRA, D. R., SONI, S. R. & SHARMA, B. D. (1979). Ferns of Rajasthan—behaviour of chlorophyll and carotenoids in drought resistance. *Experientia*, **35** : 332.

BOHRA, D. R., SINGH, R. & SHARMA, B. D. (1979a). Effects of Morphactin on *Marsilea aegyptiaca* Willd. *Geobios*, **6** : 139-141.

GAFF, D. F. (1972). Drought resistance in *Welwitschia mirabilis* Hook. f. *Dinteria*, **7** : 3-7.

GENA, C. B., MITAL, P. L. & BHARADWAJA, T. N. (1977). *Isoetes* in Rajasthan. *J. Bombay. nat. Hist. Soc.*, **73**(3) : 559-562.

GHOUSE, A. K. M. & SABIR, D. (1973). A simple technique to demonstrate three dimentional view of tracheary elements of *Equisetum*. *Acta Bot. Indica*, **1** : 73-75.

KRINSKY, N. (1966). *Biochemistry of chloroplast*. Vol. 1. 423. Ed. Goodwin ; Academic Press, London.

MISRA, S. & BHARDWAJA, T. N. (1978). *Isoetes* in Rajasthan, India. *Fern Gazette*, **11**(6) : 429-430.

MITAL, P. L. (1968). Ferns and fern-allies of Rajasthan. *J. Bombay nat. Hist. Soc.*, **66** : 31-42.

ROBBELEN, G. (1957). *Naturwissenschaft* 1, **44** : 288.

SCHNEIDER, G. (1970). Morphactins : Physiology and performance. *Ann. Rev. Pl. Physiol.*, **21** : 499-536.

SHARMA, P. & BHARDWAJA, T. N. (1978). Tracheary elements of some ferns of Rajasthan, India. *Phytomorphology*, **28** : 102-104.

SHARMA, B. D. & BOHRA, D. R. (1977). Year round pteridophytic flora of Mt. Abu. *Geobios*, **4** : 102-103.

SHARMA, B. D. & BOHRA, D. R. (1978). *Isoetes* in Rajasthan—anatomy of rhizomorph of *Isoetes coromandelina* L. *Acta Bot. Indica*, **6** (Suppl.) : 122-127.

SINGH, R., BOHRA, D. R. & SHARMA, B. D. (1979a). Vessels in the rhizome of *Actiniopteris radiata* (Swartz.) Link. *Phytomorphology*, **28**(4) : 455-457.

SINGH, R. BOHRA, D. R. & SHARMA, B. D. (1979b). Vessel elements in *Equisetum ramosissimum* Desf. *Nova Hedwigia*, (in press).

EXPLANATION OF PLATE 1

1, 2. *Actiniopteris radiata* vessel elements from rhizome with terminal pores of different sizes × 640.
3. *Equisetum ramosissimum* subsp. *ramosissimum* vessel element from rhizome. × 300.
4. *Marsilea aegyptiaca* vessel element with a terminal horizontal pore. × 300.
5, 6. *M. minuta* vessel elements with terminal oblique pores. × 600, 300.
7. *M. aegyptiaca* rhizome from morphactin treated plant showing reduction in differentiation of vascular elements and 2-3 tracheids thick xylem ring. × 600.
8. Same. Disappearance of cortical air cavities in the rhizome. × 60.
9. Same. Petiole with three patches of xylem. × 60.
10. *Isoetes coromandelina* T. S. rhizomorph showing successive rings of secondary xylem. × 24.