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AZOLLA FILICULOIDES : FIRST REPORT FROM HIMACHAL PRADESH

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One of the most fascinating of all plants intimate symbiotic associations is *Azolla -Anabaena* association. It involves a tiny aquatic water fern (*Azolla*) belonging to monotypic family Azollaceae and a microscopic filamentous blue-green alga or cyanobacterium *Anabaena* belonging to family Nostocaceae of Cyanophyceae. In this short communication morpho-taxonomic characters and the practical uses of *Azolla* are described and the species *Azolla filiculoides* is reported for the first time from Himachal Pradesh.

Key words: cyanobacterium, *Azolla*, *Anabaena*, symbiosis, nitrogen fixation.

Kangra district of Himachal Pradesh, which lies between 31^{0}40'–32^{0}25' East longitudes and 70^{0}35'–77^{0}5' North latitudes and ranks fourth in terms of area, has been explored for *Azolla* species. Sample was collected from a pond near Nurpur of district Kangra of Himachal Pradesh in August, 2008. It was fixed in 4% formalin immediately in the field and the collection number and date were also marked on the bottle. Studies on morpho-taxonomy of symbiont were carried out and microphotography was done using Leica DMLS2 microscope attached with DFC320 model digital camera in laboratory at Himachal Pradesh University, Summer Hill, Shimla.

Map of Kangra showing its position within India and Himachal Pradesh and location (Nurpur) of sample collection

Azolla filiculoides Lam. (Plate I, Fig. 1) is a heterosporous floating pteridophyte and often clump together forming compact mats on the water surface. They grow together at the surface of quiet streams and ponds. It belongs to Salviniaceae family but some workers kept it in a monotypic family Azollaceae. *Azolla filiculoide* fern has slender, branched stems which are covered and hidden by minute, alternate, imbricate, overlapping scale like leaves of one mm long. Each plant resembles a little floating moss with slender, pendulous roots on its underside. Examination of *Azolla filiculoides* leaf (3 – 4 x 2 - 3 mm) reveals that it consists of a thick, greenish (or reddish) dorsal (upper) lobe and a thinner, translucent ventral (lower) lobe (1x1 mm) immersed in the water. It is the upper lobe that has an ovoid central cavity, the "living quarters" for filaments of *Anabaena azollae.* Like nitrogen-fixing bacteria living inside the root nodules of legumes, the relationship appears to be mutually beneficial. *Anabaena azollae* trichomes form delicate mucous or floccose colonies (Desikachary 1959). Trichomes are

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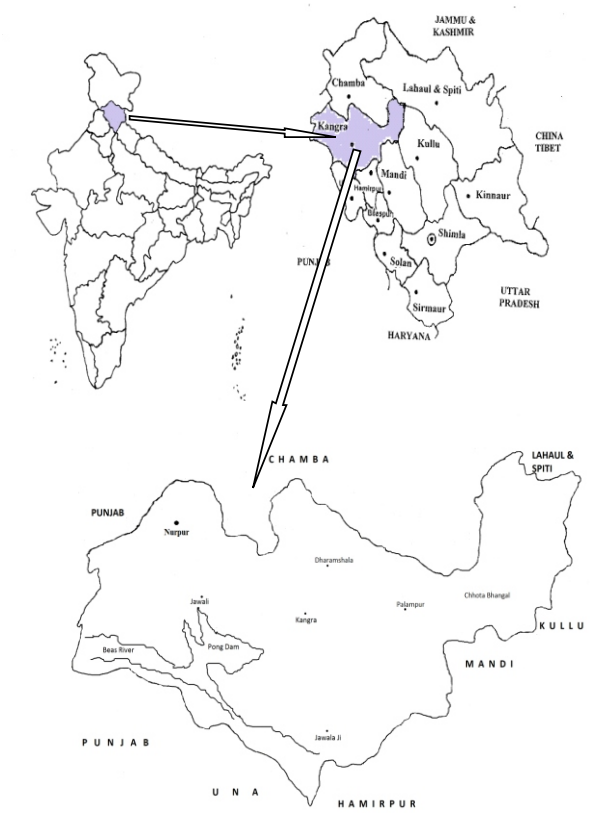
straight, spiral, circinate or variously turned, uniformly thick throughout or very slightly attenuated towards apices; terminal cell 6 - 7 µm long, 4 µm broad, cells globose to barrel-shape, 5 - 6 µm long, 4 µm broad; cell contents homogenous; heterocysts 6 - 8 µm long, 5 - 6 µm broad and akinetes 7 µm long, 8 - 8.5 µm broad, variously shaped, intercalary, solitary or in chains (Plate I Fig.2). Up to 30% of the *Anabaena* cells differentiated into heterocyst



as the leaves of *Azolla* mature.

Azolla - Anabaena symbiosis is considered as an important bio-fertilizer due to its ability to fix atmospheric nitrogen. According to Watanabe et al. (1977) *Azolla*'s nitrogen fixation capacity has been 1.1 kg N ha-1 per day, which is sufficient to meet the entire nitrogen requirement of rice crop within few weeks period (Lumpkin, 1987). This property

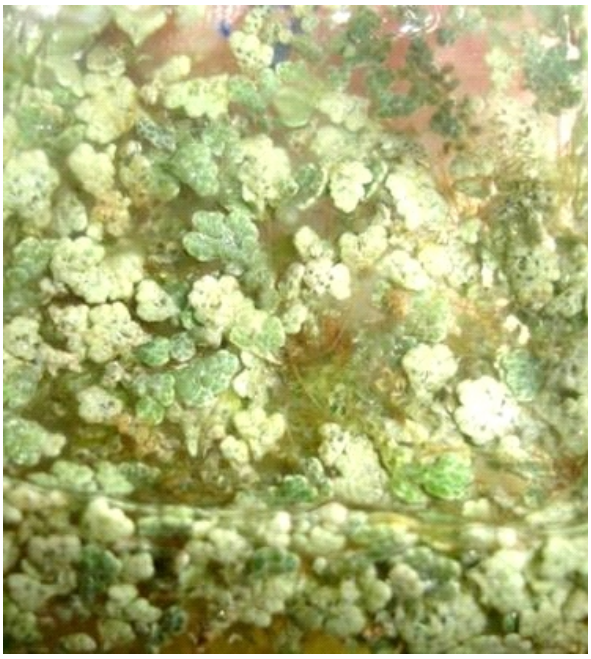


Figure 1 : Compact mass of *Azolla filiculoide*

Figure 2 : *Anabaena azollae* trichomes (100X)

of *Azolla - Anabaena* symbiosis is agronomically an outstanding contribution to the rice field. *Azolla* also supplies 150-300

tons per hectare per year of green manure, which supports the growth of soil microorganisms including heterotrophic N_2 fixers (Kannaiyan 1985). The actual site of nitrogen fixation occurs within the thick-walled heterocysts of algal partner. An added advantage is that the plant multiplies fast and provides higher yields of green compost (200-300 t ha/yr) better than conventional green manure plants such as *Sesbania, Crotalaria,* and *Tephrosia* which are known to yield 30-50 t ha/yr. Fish and shrimp relish the *Azolla.* Fresh *Azolla* can also be used in salads and sandwiches, just as alfalfa and bean sprouts are used. Dried, powdered *Wolffia* and *Azolla* make a nutritious, high protein powder similar to the popular alga (Cyanobacterium) *Spirulina* that is sold in natural food stores. *Azolla* has also proved useful in the biological control of mosquitoes (Clark 1980).

The *Azolla - Anabaena azollae* symbiosis is the only known mutualistic symbiosis between a pteridophyte and a diazotrophic prokaryote. It is of potential use as an alternative nitrogen fertilizer to chemical fertilizer and as a feed for animals. The use of *Azolla* may be an important factor in the world's future food needs and may play an important role in reducing the world's reliance on fossil fuel-based fertilizers. The significance of its symbiotic relationship with *Anabaena* is astounding when one considers that millions of lives depend on these two organisms. *Azolla filiculoide* is the first report from Himachal Pradesh.

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