



Azolla

Lisa Ferentinos¹, Jody Smith¹, and Hector Valenzuela²

Departments of ¹Natural Resources and Environmental Management and ²Tropical Plant and Soil Sciences

CTAHR researchers and Hawaii farmers are optimistic about using azolla as a green manure crop in wetland taro. Grown for centuries in Vietnam and China for rice production, this nitrogen-fixing aquatic fern provides an excellent source of organic matter and nitrogen for crops. As azolla grows, it forms a floating, light-proof mat of living plants that suppresses weed growth, significantly reducing labor costs. In addition, azolla can be fed to a variety of farm animals, it is an effective water purifier, it helps to reduce ammonia volatilization from chemical fertilizers, and it can aid mosquito control.

Characteristics

Azolla develops a symbiotic relationship with a blue-green algae, *Anabaena azollae*. An azolla plant is a fern frond consisting of a main stem growing at the surface of the water, with alternate leaves and adventitious roots at regular intervals along the stem. Secondary stems develop at the axil of certain leaves. Azolla fronds are triangular or polygonal and float on the water surface individually or in mats. Plant diameter ranges from 1/3 to 1 inch (1–2.5 cm) for small species, such as *Azolla pinnata*, to 6 inches (15 cm) or more for *A. nilotica*. *A. filiculoides* was introduced to Hawaii in the early 20th century. A shallow fresh-water pond, similar to the environment found in a taro *lo'i*, is the ideal environment for azolla. When taro reaches maturity, it shades out the azolla below the canopy, gradually killing it and resulting in the release of nutrients into the soil-water system, where they become available for uptake by the taro plants.

Environmental requirements

Azolla is found in ponds, ditches, and wetlands of warm-temperate and tropical regions throughout the world. It

Benefits provided by azolla

EXCELLENT for shading out weeds in aquatic production systems; for contributing nitrogen, phosphorus, and organic matter; for improving soil structure and quality

GOOD feed for ducks, pigs, chickens, and fish

USE IN wetland taro production; grow in ponds for harvest and incorporation into dryland crop soils

AVOID transferring apple snails to un-infested areas when collecting and transporting azolla

must grow in water or wet mud, and it dies within a few hours under dry conditions. Azolla can survive a water pH range of 3.5–10, but optimum growth occurs when the water is between pH 4.5 and 7. The optimum temperature for azolla is between 64 and 82°F (18–28°C). The growth rate gradually declines as salinity increases. Azolla grows in full to partial shade (100–50% sunlight), with growth decreasing quickly under heavy shade.

Establishment

Azolla is established by vegetative propagation. Nursery ponds are generally used to supply a large enough volume to a wetland field to ensure quick coverage.

Azolla sources

A. filiculoides is commonly found in ditches, ponds, and slow moving streams, where it can be collected with a net. Azolla is a preferred food of apple snail, a serious pest of taro in Hawaii. Check azolla carefully for apple snails or their eggs before transferring azolla to a taro patch.

Nursery ponds

Use an unplanted *lo'i* as a nursery to provide a reliable, pest-free source of azolla. Azolla requires abundant phosphorus (P) to grow rapidly (about 20 parts per million P in the water is optimal). For a pond 6–10 inches deep, apply 4 oz of P_2O_5 per 100 square feet of surface area. For a pond nursery with a depth of 3–5 inches, use half that amount. With P levels of 20 ppm, and if other nutrients and environmental factors are not limiting, azolla weight can double every 24 hours. Add P fertilizer every 8–10 days to maximize growth.

Inoculation rate

Use 100 lb of azolla for every 1000 sq ft of taro *lo'i* (field pond) surface area. Apply P to maximize azolla growth and to get quick coverage and weed suppression.

Taro planting

Plant the *huli* after the azolla forms a complete mat over the water of the *lo'i*. The water should be no deeper than 1 inch to prevent wind from blowing the azolla against the newly planted *huli*, loosening or submerging them.

P deficiency

Symptoms of phosphorus deficiency include red-colored fronds, decreased growth, and curled roots. Add more P if these symptoms become apparent.

Weed control during establishment

Some hand-weeding may be necessary, particularly if perennial weeds have not been controlled prior to establishing the azolla.

Incorporation

When using azolla as a green manure, drain the taro *lo'i* and roto-till it into the soil.

Uses

Organic N source

Use azolla to add organic nitrogen (N) to the *lo'i* system. Estimates of how much N azolla can fix vary widely. Values reported in the literature range from 53 to 1000 kg/ha N fixed, with dry matter production between 39 and 390 tons/ha, in crop cycles of 40–365 days. Perhaps because of a high lignin content (20%), azolla N is initially released slowly, with about two-thirds released on the first 6 weeks after application. Under flooded conditions, 40–60% of the available N is released after 20 days, and 55–90% is released by 40 days after application. In addition, azolla contains other plant nutrients (such as 0.38–0.43% phosphorus, 2.5% potassium, 1.0% calcium, and 1.2% magnesium), which will become available to the next taro crop. Tissue N levels in azolla range from 2 to 6.5%, and the C:N ratio is about 10.

Soil improvement and nutrient availability

Azolla (*A. filiculoides*) produces about 1.8–3 tons/ha dry matter per crop. Adding organic matter improves soil quality and diversifies the soil “food web.” When green manures such as azolla are incorporated into the soil and decay, they provide nutrients for the following crop.

Weed suppression

Azolla’s ability to create a light-proof mat that suppresses other weeds has been used for centuries in rice production to save the expensive labor costs of weeding. Hawaii’s taro growers and CTAHR researchers are working to refine an azolla-taro production system for Hawaii conditions.

Feed options

On a diversified farm, azolla can be used as a feed source for pigs, ducks, chickens, and fish.

Ducks for snail control

Cayuga black ducks can help control the apple snail. Although recent regulatory changes have made the importation of these ducks into Hawaii illegal, it is possible that other ducks found in Hawaii can be taught to eat apple snails. Ducks will roam the *lo'i* and eat small

to medium sized snails and crayfish. For larger snails or crayfish, another pest control method, such as hand-picking, will be necessary. Care should be taken to protect ducks from dogs and duck eggs and ducklings from mongoose.

Management considerations

Water temperatures are reduced when using azolla in taro production. This can slow taro growth rates. However, savings that result from the reduced weeding and fertilizer costs may compensate for the longer duration of the crop cycle when azolla is grown. Also, lower water temperatures may help to reduce the incidence and spread of root diseases like *Pythium*.

Water management is critical, especially for year-round azolla production. Wind and turbulent water can fragment and kill azolla. Maintaining low water levels and rough plowing can protect azolla from wind. Alternatively, protect azolla temporarily by establishing bunds or wooden floats.

Pest problems

Azolla is a preferred food of apple snails, a serious pest of taro. Care must be taken when transferring azolla from one location to another to ensure that apple snails and their eggs are not present. As indicated above, ducks may be helpful in snail control. A weevil (probably *Stemopelmus* spp.) and larvae of the moth *Agrotis ipsilon* have also been reported on azolla in Hawaii. Azolla can become weedy in slow moving waterways. It has become a noxious weed in waterways of Europe, Africa, and New Zealand.

For assistance:

Contact your nearest Cooperative Extension Service office for additional assistance in selecting appropriate cover crops and green manures for your farm and cropping situation. Help can also be obtained from the USDA Natural Resources Conservation Service field offices located on each island.

Visit CTAHR's Sustainable Agriculture for Hawaii Program Website at <<http://www.ctahr.hawaii.edu/sustainag>> to find additional information about green manure and cover crops. The site also includes references and links to other useful on-line resources.



Sustainable Agriculture in Hawaii . . .

. . . integrates three main goals—environmental health, economic profitability, and social and economic equity. Sustainable farms differ from conventional ones in that they rely more on management practices such as crop diversification and crop rotation, agroforestry, integrated pest management, rotational grazing, and innovative marketing strategies. For further information on Sustainable Agriculture in Hawaii, contact:

Dr. Richard Bowen,
Hawaii SARE Program Coordinator
phone (808) 956-8708
e-mail: <rbowen@hawaii.edu>
<<http://www.ctahr.hawaii.edu/sustainag/>>