CULTURE OF CHINESE WATERCHESTNUTS IN THE SOUTHEASTERN UNITED STATES

ROBERT B. McGEACHIN, Department of Wildlife and Fisheries Science, Texas A&M University, College Station, TX 77843

ROBERT R. STICKNEY, Department of Wildlife and Fisheries Science, Texas A&M University, College Station, TX 77843

Abstract: Two .05 ha ponds were planted with water chestnut (*Eleocharis dulcis*) corms in March 1978. After the waterchestnuts had sprouted the ponds were flooded in late March to an average depth of 15 cm, and remained flooded until mid-October 1978. The ponds were drained and left dry until February 1979 when they were harvested. One pond had excellent production throughout, leading to an extrapolated level of 13,600 kg/ha. The other pond had good production only along the sides and in the shallow end due to high turbidity and unfavorably low soil pH. Production in the second pond was at the rate of 13,200 kg/ha. Production figures for intensive culture in China range from 17,000 to 34,500 kg/ha. The Chinese waterchestnut grows well in the southeastern United States and the necessary technology for mechanical harvesting and peeling have recently been developed. The only constraint on large scale production is the need for the imported market price to rise above the economic break-even point for domestic production. It may be possible in the future to raise waterchestnusts in polyculture with extensive and/or intensive finfish production systems.

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The Chinese waterchestnut is a tropical sedge native to southeastern Asia. It has been widely cultivated in the temperate regions of China and is known world-wide for its use in Chinese cooking (Hodge and Bisset 1955). The Chinese waterchestnut is a tall reedy plant that produces tuber-like corms which represent the edible portion. The scientific name means "the sweet delight of the marsh". In Cantonese it is nown as "matai" meaning "horse's hoof" referring to the round discoid shape and black or brown color of the corms (Hodge 1956).

Chinese waterchestnuts are cultivated in paddies and in China are rotated or grown along with rice (*Oryz sativa*), Old World arrowhead (*Sagittaria sagittifolia*), Oriental lotus (*Nelumbo nucifera*), and sweet flag (*Acorus calamus*) (Hodge 1956). There are 2 varieties of waterchestnuts grown in China. "Hon matai" is the more highly valued cultigen that produces large brown skinned corms that are sweet and juicy and either eaten raw (whole and peeled) like apples or sliced in cooked dishes. The other variety is "Sui matai", the wild strain that is cultivated for its smaller black skinned, drier textured corms that are mostly processed into starch. Since the Old World does not cultivate corn it is waterchestnut starch that is used in the batter of the tempura dishes for which oriental cooking is noted.

Chinese waterchestnuts were first successfully introduced into the United States (they should not be confused with *Trapa natans*) in August of 1934 at the USDA Barbour Lathrop Plant Introduction Garden in Savannah, Georgia as PI numer 106274. This station has remained the center for corm production and distribution (Groff 1950). There was some commercial production of Chinese waterchestnuts in the southeastern coastal plains of South Carolina, Georgia, and Florida in the 1950's (Groff 1950; Hodge 1956), but economic factors such as the need for hand cultivation due to a lack of mechanical planters or harvesters, and the lack of a mechanical peeler, led to the decline of domestic production in recent years. Only small scale production continues at present in Georgia, Florida, Texas, Louisiana, California, and Mexico.

Most Chinese waterchestnuts available on a regular basis are canned imports from Taiwan. United States Department of Agriculture (1978) statistical figures on Chinese waterchestnut importation by the United States for 1977 were approximately 14,250,000 kg, worth $10,824,000. USDA statistics also show that imports have been steadily increasing in recent years.

The development of a mechanical means of peeling (Leeper and Williams 1976) and modification to potato digging machinery (A.K. Williams, personal communication) have once again made large scale domestic production economically and technologically feasible if the imported market price is high enough (above about $1.10/kg). Rising labor costs in Taiwan and reduced acreage in production had raised the market price to about $1.65/kg and at least 1 large U.S. firm was planning to initiate large scale domestic production. But the recent establishment of trade with the People's Republic of China has sent the market price back down to a break-even level.

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CULTURE METHODS

The following description of waterchestnut cultivation as it has been practiced in China for centuries was adapted from Hodge (1956) based on field observations by Dorsett, McClure, and Meyer of the USDA Plant Introduction Section. After any danger of the last frost has passed in late March or early April the paddies are plowed, harrowed, and initially fertilized with about 17,000 kg/ha cow manure and 400 to 850 kg/ha of lime. A small part of each paddy is set apart as a seed bed and rows of corms are planted about 3 cm deep and 3 cm apart. The seed bed is fertilized with dilute human night soil and kept moist until the plants have sprouted. When culm sprouts are about 20 cm tall the plants are carefully transplanted by hand into the rest of the paddy and spaced about 75 cm apart. The paddy is then flooded to a depth of about 10 cm. Abouth 2 weeks after permanent planting human night soil is applied at a rate of 4300 kg/ha. Later, when the plants are beginning to produce lateral rhizomes, peanut cake at 1300 kg/ha, hog manure at 5200 to 6900 kg/ha, and plant ash at 2600 hg/ka are applied to the paddies. About 2 months later, when corm production is starting, another 133 kg/ha of peanut cake and 400 to 850 kg/ha of lime are applied. Hon matai are said to prefer sandy soil where Sui matai do best in mucky clays.

Waterchestnuts require a 220 day frost-free growing period to grow and mature. Any time after the first killing frost they can be harvested, but often Hon matai are left in the ground until just before spring as they initially have a high starch content which is gradually converted into sugar over the course of the winter, giving them their sweet taste (Hodge 1956; DeRigo and Winters 1964). Following the first killing frost Hon matai paddies are drained, the culms harvested for animal feed, and the corms dug from the dry ground at the end of winter. Sui matai, on the other hand, are harvested in the fall from muddy, water filled paddys by workers bending over and grubbing the corms out of the mud by hand. Typical yields from these cultivation methods in China range from about 17,250 to 34,500 kg/ha (Hodge 1956).

After harvesting, Hon matai are air dried for a few days and stored in large crocks in cool places (Hodge 1956), whereas Sui matai are ground and processed into starch.

Cultivation methods in the U.S. were described by Hodge and Bisset (1955) and are very similar to those in China except that inorganic fertilizers at the rate of abut 220 kg/ha are used instead of animal manures. Two applications are made, one during soil preparation and the other (using only one-fourth of the total amount) at the time seconary plant growth starts. Other details of culture include water dpeth of 10 to 15 cm, maintance of soil pH from 6.9 to 7.3 with the use of lime to correct for acid soils, and the practice of starting seedlings indoors in more northern areas (Virginia) with shorter growing seasons or in southern areas (South Carolina, Georgia) when direct planting in permanent possitions in the fields (10 cm deep 75 cm apart in a row and with rows 75 cm apart) is practised (Hodge and Bisset 1955). Because the corms develop at the ends of lateral rhizomes sent out from the culms, once they have sprouted and started to spread over the field there should be no further walking on or use of equipment in the field to avoid injurying developing young rhizomes.

Only a few experimental studies on cultural requirements have been conducted with waterchestnuts. Experiments using different combinations of inorganic fertilizers in Savannah, Georgia soil (DeRigo and Winters 1968) demonstrated highest production with 228 kg/ha nitrogen, 112 kg/ha phosphorus and 170 kg/ha potassium (although these rates are probably lower than optimum). That study also found that nitrogen and calcium become limiting before potassium, phosphorus, or magnesium. Experiments by Twigg, et al. (1957) showed that water depth of at least 10 cm is required for maximum waterchestnut production. Fertiliztion at the relatively low rate of 112 kg/ha nitrogen, phosphorus, and potassium produced no differences from fertilization at a rate of 22 kg/ha. In contrast to the recommendations of Hodge and Bisset (1955), Twigg et al. (1957) found no difference in growth in soil adjusted to a pH to 7.0 as compared to unadjusted soil of unknown pH.

There is and has been some interest by fish culturists in the possible use of water chestnuts in the removal of nitrogenous waste products of fish in recirculating or static water systems. The waterchestnuts would utilize the available nitrates and at the same time produce a secondary crop. The only published study on such a system (Loyacano and Grosvenor 1973) showed no statistically significant increase in production, food conversion ratio, or percent survival between control channel catfish and those reared in pools containing floating rafts of waterchestnuts. Waterchestnut production in that study was 3178 kg/ha.

EXPERIMENTAL METHODS AND CONDITIONS

Two 0.05 ha earthern ponds at the Aquaculture Research Center of the Texas Agricultural Experiment Station were used in a growth trial of *Eleocharis dulcis* var. Hon in 1978. The previous summer the 2 ponds, designated 10A and 11A, had been utilized for tilapia culture and had received the waste from 200 and 150 laying hens, respecitvely for about 5 months (Burns 1978). The previous experiment was terminated in October of 1977 and the ponds were dry from that time until planted with waterchestnuts in March 1978. On 1 March 1978 the pH of the soil in the two ponds was determined from a mixture of pond soil and distilled water (1:1 v/v). The soil pH of pond 10A was 5.2 and that of pond 11A was 5.8.

On 2 March the ponds were disced. Pond 11A was planted by hand with 243 waterchestnut corms on March 14. The corms were planted about 10 cm deep, spike side up, in nine rows and 27 columns spaced about 75 cm, apart. The pond was flooded overnight to settle the soil and then drained the next day. Pond 10A was planted on 15 March in the same manner with a total of 270 corms in 10 rows by 27 columns. The corms planted in pond 11A came from a local backyard garden (originally the stock was purchased from a nursery in Los Angeles, Ca.). The corms planted in pond 10A came from the United States Department of Agriculture Plant Introduction Station in Savannah, GA. (PI No. 106274). The corms were stored moist in a refrigerator at 3 C prior to planting.

Pond soil was kept moist by daily hand watering or by rainfall. On 6 April, 23 days after planting, sprouts first appeared in both ponds. Some manual weeding was necessary to prevent encroachment along the sides of the plots before final flooding.

The sprouts in both ponds had reached a height of about 20 cm by 22 April at which time both ponds were flooded for the remainder of the growing season. Because the ponds are used primarily for fish culture, the bottoms are sloped from the sides toward the center and from the shallow end toward the drain such that there is about a 25 cm difference in elevation from the sides to the middle and from the shallow to the deep ends. In order to flood all of the pond bottoms to at least 5 cm, the water depth at the standpipe in pond 10a was maintained at about 35 cm, and in pond 11A at about 39 cm. When flooded and thereafter, the water in pond 10A became very turbid, whereas in pond 11A it remained clear.

On 10 October, 210 days after planting, both ponds were drained. The ponds were left dry until harvest in late Febraruy, 1979. During harvest the pond bottoms were dug to a depth of about 15 cm and the soil worked by hand to seperate out the corms. The harvested corms were washed and final production figures calculated.

RESULTS AND DISCUSSION

Waterchestnut survival in pond 10A was poor. At the time of flooding there were sprouts covering the entire plot but by the end of about a month the only remaining plants were along 1 side and in the shallow end of the pond. The survivng plants developed normally, with each initial sprig of culms spreading into a clump about 30 to 40 cm in diameter around the original site and to a height of about 100 to 150 cm. A fairly dense mass of culms covering about one-third of the original area planted was formed in the shallow end of the pond. There was some encroachment of vascular weeds and Johnson grass (*Sorghum halepense*) around the edges of the pond and in the shallow end, and eventually scattered clumps of *Chara* formed in the bare deep end. Production of waterchestnuts in pond 10A was estimated to be 13,200 kg/ha in areas of heavy growth.

In pond 11A waterchestnut survival appeared to be excellent. A dense mass of culms covered the entire planted area by the end of the growing season. There was some growth of Johnson grass among the waterchestnuts at the shallow end of the pond and growth of *Chara* in the deep end. Production of waterchestnuts in pond 11A was 13,600 kg/ha.

Two possible reasons for the drastic reduction in overall growth in pond 10A as compared with pond 11A have been proposed. The lower pH in pond 10A could have inhibited growth. Hodge and Bisset (1955) stated that waterchestnuts do not grow well in acid soil. The high turbidity in pond 10A may also have been a factor by shading out newly emerging culms in the deeper end of the pond. The fact that the seed stock in pond 11A had been grown in the local climate for several seasons and may have become somewhat better adapted ot it than the seed stock from Georgia in pond 10A was probably not a factor as growth and production in the shallow end of pond 11A was equal to that in pond 10A.

The overall production of waterchestnut corms in this study was slightly low compared to production using traditional Chinese methods but in light of the probable low level of fertilization that was residually available from the chicken manure (at most 6000 kg/ha) and acid pond soil conditions this was not surprising. The climates of east and south Texas do seem suitable for waterchestnut cultivation. Small scale backyard production is feasible and if the market price rises sufficiently, larger commercial production will also be feasible in the southeastern states. Areas of potential importance to commercial culture include development of systems of rotation with rice and polyculture with finfish in either extensively or intensively stocked ponds. Waterchestnuts are also potentially usable in conjunction with closed recirculating water systems.

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