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A Users Manual For the Cultivation of Commercially Important Edible Aquatic Plants in and around 4 Cities in SE Asia.

PAPUSSA

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A Users Manual For the Cultivation of Commercially Important Edible Aquatic Plants in and around 4 Cities in SE Asia.

An output from the EC funded Papussa (Production in Aquatic Peri- Systems in SE Asia).

Contents

Introduction

The considerable quantities and value of edible aquatic plants cultivated in SE Asian cities is not measured or included in annual FAO statistics for aquaculture production. This is despite creating income and employment for a significant number of peri-urban households, in many cases recycling and treating urban waste water, whilst also producing a green and nutritious foodstuff which is consumed on a daily basis by millions of urban dwellers in these cities.
This manual is an output from the EC funded Papussa (Production in Aquatic Peri-urban Systems in SE Asia) project and was conceived and put together after finding there was little if any technical support or information for the many existing aquatic plant growers or those who might wish to begin cultivating them on a commercial basis.

The manual was put together by Papussa staff in Bangkok, Hanoi, Ho Chi Minh City and Phnom Penh after three years of working with aquatic plants farmers in these cities. Information was collected and verified as the result of many interviews, participatory workshops, questionnaires, observations, and simply spending time with aquatic plant farmers during different periods and seasons of the year. Since there are a number of differences between the cultivation methods of the most common aquatic plants between our study cities the manual is divided up into sections on the cultivation of these species within and around each city. The booklet is also produced in conjunction with a 25 minute DVD video entitled " The Hidden Harvest" – The cultivation of Aquatic plants in cities in SE Asia - which can be obtained by visiting the Papussa website www.papussa.org.

The four most commonly cultivated aquatic plants described in this manual are:

Morning Glory – also known as water spinach	*Ipomoea aquatica*
Water Mimosa	*Neptunia oleracea*
Water Dropwort	*Oenanthe stolonifera*
Water Cress	*Rorippa nasturtium-aquaticum*

Duckweed (*Lemna and Wolffia spp.)* is also cultivated together with water mimosa

Growing Techniques for Aquatic Plants Cultivation in and around Bangkok, Thailand

By

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A Guideline for Morning Glory (Water Spinach) Cultivation In and Around Bangkok

Introduction

Morning glory is one of the most locally important aquatic vegetables which has been well recognized by the people since it is inexpensive, high in fibre and vitamin A and easy to digest.

Since it can be cultivated relatively straightforwardly, the total annual production in Thailand in 2004 was estimated to be 58,245 tons from the cultivated areas of approximately 63,485 rai (10,157 ha.).

Over 80% of total production is currently produced in the central plain areas around Bangkok (Dept. of Agricultural Extension, 2005).

It has been ranked as the most popular aquatic vegetable for people's consumption because all parts of morning glory such as the stem, leaves and especially the young apex, can be consumed.

It can be cooked in many ways including by boiling, pan-frying and making soup. As well as eaten raw with Thai papaya salad, minced meat and chili paste.

Morning glory has been recognized as a good cash crop with simple growing and maintenance techniques.

It can be grown year round in both lowland and upland areas. However, a flat plain area or paddy-field with no slope is the most preferable for intensive farming.

Soil type is also very important for root attachment and providing essential mineral substances.

However, morning glory can be grown in a variety of soil types such as loam, loamy sand and clay.

Most paddy-field grown morning glory is cultivated in square shaped fields with a wide range of cultivation areas depending on land availability.

Branches of small water supply canals located nearby to the fields are the main sources of water which is pumped directly into the field by diesel pumps. Generally, the water supply canal is used as both water inlet and water outlet.

Note 1 rai = 1600m²

Techniques for growing aquatic morning glory intensively in such field based systems in peri-urban Bangkok are described below:

1. Field preparation

(1 Hectare = 6.25 Rai 1 US$ = 40 baht)

Field preparation is very important before morning glory cultivation. After the last crop is harvested, all remnants of morning glory left and bottom soils are ploughed together with the water level of 5-10 cm using a diesel engine truck (Figure 1) and then left for one week.
This ploughing of soil is repeated again one day before transplantation of morning glory stems.

Figure 1 Diesel engine truck used for preparation of the cultivation field.

2. Cultivation method

2.1 Germ stem preparation

The young apex of morning glory of around 50 cm long is used for germ stem cultivation.

They are prepared by scattering them in a dry well ventilated indoor or outdoor place, with no direct effect of sunlight, then covering with fertilizer bags to incubate for a period of 3-4 days without any water supply.

During this period, the new roots at the node of germ stem begin to emerge and are then ready for plantation.

2.2 Growing

Bundles of two to three germ stems are planted in the field within rows.

Around 20-30 cm. is allowed between bundles of germ stems each other with the width between each row set at around 2 metres (Figure 2).

The early morning is the best time for planting. Hired labourers are needed for this activity in the case of large plot areas of growing.

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Figure 2 The characteristics of morning glory cultivation in the paddy field.

2.3 Fertilization and Management

The water is discharged from the field one day after plantation and then herbicide (betachor) is sprayed using a benzene-engine sprayer to control weeds (Figure 3).

The field is allowed to dry for at least 3 weeks and lime should be broadcasted at 100 kg/rai (625kg per hectare) during this period (Figure 4).

After that water is pumped into the field to maintain a depth of around 30cm. (Figure 5).

A variety of chemical fertilizers (25-7-7 or 16-20-0) are then first applied at a rate of 50 kg/rai (312kg per hectare) after the first harvest, with this rate decreased into half after the fifth time of harvesting onwards. The frequency of fertilization and chemicals used is regularly practiced the day after each harvesting time which is estimated at one week intervals.

A benzene engine with a capacity of 12-20 liters of chemical solution is an important sprayer (Figure 6). Generally, hired labourers or farm's owners can carry out these activities however they should use protective clothing/equipment particularly when spraying herbicides. Sock cloth worn on the feet is found to be the protective material for prevention of injury from snails during spraying herbicides. The spraying is regularly practiced in early morning for the most effective results. Typically chemicals are used to control insects, weeds, and diseases as is shown in Figure 7.

Figure 3 Farmer wearing sock cloth is spraying herbicide after discharge of water.

Figure 4 Field is left drying for at least 3 weeks.

Figure 5 Water is pumped into the field after drying.

Figure 6 Farmer pouring the chemical solution into a benzene-engine sprayer.

Figure 7 Typical chemicals used for insects, weed and diseases control.

2.4 Harvesting and Packaging

The total growing period of morning glory is around 90-105 days.

During this period, the crop can be harvested 12-15 times (Figure 8). Hired labourers are needed to harvest the morning glory at this time.

Early morning is the appropriate time for starting harvesting until at midday.

A small metallic boat is used for carrying the harvested products. Normally the apex of the stem around 40-60 cm below the top of the plant is cut using a knife.

A set of 6-7 stems is put into a small bundle with a wooden stalk (Figure 9).

Around 25 of these small bundles are packed into one pile which is then wrapped with a clear plastic packaging sheet making an average weight of 5.5 kg per pile (Figure 10).

Total gross yield is estimated to 8,000-10,000 kg/rai or around 50.0- 62.5 tons/ha/crop.

Figure 8 Harvesting of morning glory from the paddy field using small metallic boat.

Figure 9 The wooden stalks used for tying together a small set of morning glory bundles.

Figure 10 Hygienic packaging of morning glory into piles with plastic sheet/bag wrapping.

Transportation

Most of the middlemen collect morning glory products directly from one or more farmers, and transport them to market by four wheel pick-up truck (Figure 11), but some farmers sell their farm products to market directly using their own trucks.

A capacity of around 1.0-1.5 tons morning glory can be carried per trip. Transportation starts in the afternoon and most of products are taken to and sold at the big wholesale markets.

Figure 11 A typical four wheel pick-up truck is usually used for transportation of morning glory products to the wholesale market.

Market

Morning glory is delivered in large amounts everyday to the wholesale market, starting in the late afternoon from about three in the afternoon to midnight (Figure 12).

One function of the wholesale market is the centre for further distribution of any kinds of agricultural products to various retail markets, supermarkets, food shops and directly to the consumers.

Over 20% of the wholesale market for aquatic vegetables is now going to Bangkok supermarkets, a trend which is increasing.

Figure 12 A pile of packaged morning glory products being sold at the wholesale market.

Problems

The major problems of morning glory cultivation are insect damage and disease outbreaks. Examples of insects and diseases mostly affecting the crop are as follows:

1. Death's Head Moth

This is caused by one species of insect namely *Acherontia lachesis* (Sphingidae).

It is at its full size 10–12 cm a green worm with a yellow stripe and blue border on both sides can easily be noticed (Figure 13).
They can lay green eggs on leaves. These eggs require approximately 5 days to hatch.

During this worm stage which takes approximately 3 weeks, they will feed on morning glory leaves. Then they will turn into a chrysalis stage in the ground for approximately 2 weeks. The mature death's head moth will have a brown color.

Figure 13 An example of Death's head Moth *(Acherontia lachesis)* (Sphingidae)

A variety of chemical pesticides are used to control and eliminate the insects such as "Abamectin" (30 cc./20 liters of water), "Cypermethyl" (50 cc./20 liters of water) and "Methomyl" (20-35 g/20 liters of water) .

These pesticides can be mixed together or used alone following the guidelines on the bottles.

Generally the farmers spray these pesticides at weekly intervals or after the day of harvesting to control and eliminate the insects.

2. Aphids

This is caused by one species of insect namely *Aphis gossypii* (Aphidiae).

A juvenile aphid can have many colours with the most common color being dark green to black.

Smaller than 1 mm sized faded yellow to white juveniles can be found under dense groups of leaves normally at warmer temperatures.

In the tropical zone, instead of laying eggs, an aphid can directly produce its juveniles. They can be found on leaves and flowers.

These juveniles can reach their mature stage within 4-20 days depending on temperature.

During their mature stage, they can produce 20-140 new juveniles for every 2–9 days. They feed on the water content of morning glory.

The treatment recommended is the same as mentioned above.

3. White Rust

White rust is caused by a species of fungi namely *Albugo ipomoea-aquaticae* (Sawada).
Faded yellow spots can be observed on leaves with small nodes (1-2 mm.) underneath. Some knotty stem and stalks can be found.

Outbreaks mainly occur in the winter season.

During a spread of infection, the chemical "Zeneb" at a concentration of 30-40 g/20 liters of water can be sprayed at weekly intervals.

4. Leaf blight

Leaf blight is commonly found during the dry season and caused by the bacteria *Xanthomonas compestris pv.* (Pathovar).

Small clear nodes can be found underneath the leaves. Later, these small clear nodes expand and turn a brown to black color, then fade to yellow, wilt and fall off the plant.

Collecting all infected plants and eliminating them by burning is recommended after disease outbreak.

However, the prevention of this disease can be achieved by either the preparation of a paddy field by mixing lime (500 kg per rai, 3125kg per hectare) with soil and leaving them for at least a month or using a crop rotation with other types of vegetables.

5. Others

5.1 Outbreaks of Golden Apple Cherry Snail

The Golden Apple Cherry Snails lay their eggs attached to the stems of morning glory.

This causes damaged and fouled stems of morning glory resulting in the low price of products.

Tea seed cake is the preferred treatment actually used by farmers to eliminate the snails during outbreaks. It is broadcasted at a dose of 20-30 kg/rai (125 -185kg/hectare) over the paddy-field after discharge of water for the most efficient treatment.

5.2 Slow growth

The problem of slow growth of morning glory occurs during the winter season.

This causes the decline of production per unit area and adversely affects the high capital cost although the marketability of farm gate price is higher.

However, some farmers use growth hormone solution as a stimulant over this period of culture.

5.3 Using SO_2

Using Sulphur dioxide solution (SO_2) to clean the products after harvesting is generally practiced by farmers.

However this is a toxic substance to humans and in Thailand it is presently prohibited to use this substance.

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A Guideline for Water Mimosa Cultivation in and around Bangkok

Introduction

Water mimosa is one of the most important Thai native vegetables or aquatic plants which have been involved with Thai people lives from the past.

The taste of this aquatic vegetable is good and it can readily be cultivated in rice paddy fields and irrigation canals.

Therefore current production can be supplied into Bangkok markets for all seasons throughout the year.

The price of this aquatic vegetable fluctuates from 60-300 Baht, 1.5 – 7.5 US$/pile – (12-15 kg overall weight, dressed weight after removing floating bubbles surrounding stem is around 7-8 kg) depending on the production and seasons. The highest price is during the winter season (220-300 Baht, 5.50 -7.50 US$/ pile) but the normal price is 100 Baht, 2.50US$ per pile.

The main production system used for mimosa in peri-urban Bangkok is intensive with the heavy use of chemical fertilizers and pesticides.

The preference of Bangkok consumers for this aquatic native vegetable as a popular part of their diets is increasing as shown by its increasing demand.

Water mimosa is normally grown in square or rectangular shaped plots with a wide range of cultivation areas depending on the available land.

A small ditch of around 1-2 m width is designed surrounding the paddy-field at a depth of 30 cm.

A water supply canal located adjacent to the field is the main source of water over the period of cultivation. Generally, the water supply canal is used as both water inlet and water outlet.

Techniques used for growing water mimosa intensively in peri-urban Bangkok are described below:

1. Field preparation

The technique applied for land preparation is similar to the technique used in rice paddy fields.

After the previous crop has been harvested, the field is sun-dried for at least 7 days.

Then the soil is ploughed and broken up into smaller particles.

Water is then pumped or fed by gravity into the field up to a water level of 5-10 cm.

After around 5-6 days, the field is again ploughed for one day then the water is discharged.

Transplantation of young water mimosa is recommended on the following day (Figure 1).

Figure 1 Preparation of the paddy field showing the rows of water mimosa stems in bundles after transplantation.

2. Cultivation method

A bundle of the young stems (top portion of the plant) of water mimosa (3-5 tops) of 1 metre in length is transplanted into the soil at a depth of 6-7 cm.

The distance between bundles and rows should be 2 x 2 m^2. A straight line pattern is preferable.

The soil attached to the bottom part should be pressed down adequately.

On the following day after planting water is then pumped into the field using a diesel engine (Figure 2) to a depth of 10-15 cm. allowing the top portions of stems to float on the water surface.

Figure 2 Diesel engine used for pumping water in and out the paddy-field.

2.3 Fertilization and Management

A formula of 25-7-7, 16-20-0 or 18-12-6 chemical fertilizers with the application rate of 50 kg per rai (312kg/hectare) can then be applied weekly the day after each harvesting usually in the early morning. It is broadcasted by the farm's owner or labourers in the case of larger areas of cultivation. In case of enhancing the growth of the top portion, urea fertilizer can be broadcasted more with the rate of 3–5 kg per rai (19- 30kg/hectare) weekly.

The frequency of fertilization and chemicals used is regularly practiced after each harvesting day which is estimated at one week intervals.

Chemicals are also used to control insects, and diseases.

Adding or discharging water can be gradually increased weekly until it reaches 60 cm within 1-1.5 months and this is then maintained at this level until the harvest.
During the period of cultivation, floating duckweed is allowed to grow up densely covering the water surface (Figure 3).

The remnants of duckweed attached to the original stems of water mimosa for transplantation and some duckweed left during the previous crop are the main source of the duckweed bloom over the period of cultivation.

This is a benefit to water mimosa in the helping of whitening the stems of the plant which is preferred by consumers.

Figure 3 Water mimosa growing together with duckweed during the period of cultivation.

2.4 Harvesting and Packaging

Water mimosa can be first harvested after the third week from transplantation and then harvested regularly once a week in the following period (Figure 4).

The total growing period of water mimosa is around 75-90 days.

During this period, due to rapid re-growth of the stems the plants can be harvested 11-12 times.

For harvesting it is recommended to cut the stems with a knife at approximately 1 metre from the apex (tip) of the plant.

Total gross yield is estimated to 6,000-7,500 kg/rai or 37.50-46.87* tons/ha. throughout the whole cropping period or 112.5-140.6 ton/ha/year.
Following cutting, a set of 10 harvested stems is put into a small bundle. Around 25 of these small bundles are packed into a larger bundle (12-15 kg) and then wrapped with a plastic sheet (Figures 5 and 6).

In some production areas it is recommended to dip clean water mimosa bundles in alum solution (2-5 kg/100 liters of water) before packaging (Figure 7).

Figure 4 A group of farmers harvesting water mimosa from the paddy field.

Figure 5 Farmers packaging the water mimosa into a bundle.

Figure 6 An example of packaging of water mimosa; 1 pile is around 12-15 kg.

Figure 7 The alum solution is used to clean water mimosa stems before packaging.

Transportation

Harvested water mimosa is usually brought to market using a four wheel pick-up or a six wheel truck (Figure 8).

Most of the middlemen purchase the mimosa directly from one or more farmers but some farmers who have their own four wheel pick-up can sell their farm products directly.

A capacity of around 1,000-2,500 kg water mimosa can be loaded per a trip by a four wheel pick-up. Transportation starts in the afternoon and most of products are sold at the big wholesale markets.

Figure 8 Transportation of water mimosa products by four wheel pick-up.

Market

Water mimosa is delivered all year-round in large amounts to the wholesale market (Figure 9) where it is the centre for further distribution of any agricultural products to various retail markets, supermarkets, food shops and directly to the consumers.

Figure 9 A pile of packaged water mimosa being sold at a Bangkok wholesale market.

Problems

The major problems of water mimosa cultivation are insects and disease outbreaks. Examples of insects and diseases mostly affecting the crop are as follows:-.

1 Aphid, leafhopper and chilli thrips

These insects can suck water from a leaf or tip during the new tip emerging, as a result, the tip can soon be destroyed.

2. Cutworm and diamondback

These worms can pierce through a spongy part of water mimosa and cause a rot problem.

3. Leaf eating beetle

A juvenile stage (a worm) which feeds on the water mimosa roots and the adult beetle which feeds on leaves producing damage for the plant's growth.

4. Downy mildew disease

Yellow spots on leaves, falling leaves, destroyed apex (tip) and lean brown spongy stem can be noticed.

5. Others

Slow growth

The problem of slow growth of water mimosa occurs during the winter season.

This causes decline of production per unit area and adversely affects the high capital cost although the marketability and farm gate price of water mimosa is higher at this time.

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Aquatic plants cultivation in and around Ho Chi Minh City (HCMC), Vietnam

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Introduction

In some peri-urban areas of HCMC where flooding always affects rice fields and causes losses in the rainy season, edible aquatic plants have been chosen by farmers as alternative species to adapt with the critical natural conditions. Morning glory and water mimosa are the two most commonly cultured aquatic plants in peri-urban lowland areas of HCMC. These species have shown their important roles in the livelihood of involved farmers as they can help farmers to generate relatively high incomes thus can provide stable livelihoods for farmers. The advantages of these systems can be relatively low investment and simple cultivation techniques that make them applicable to almost every farmer who wants to practice. This booklet is aimed at providing basic culture techniques that are required to initiate and operate either morning glory or water mimosa culture systems.

Water Morning Glory Cultivation in Peri-urban HCMC

1. Selection of plants for propagation

Seedling plants can be chosen based on following criteria:

- Good appearance, strong and good shape stems with an average length of 30 – 40 cm.
- Goodness and high density of leaves. Rich in number of roots. Seedling plants should not be too young.
- No sign of disease

2. Pond preparation

- Pond size varies dependent on the capability of the growers but 1000 – 2000 m^2 is the best size for management
- Culture pond should be located so as water can be exchanged easily
- Water source should be available year round and no salt water intrusion allowed during the dry season
- Pond soil has to be ploughed and raked carefully before transplanting to ensure good conditions for best growth of the plants.
- Water should be fully exchanged 4 – 5 times in the pond before transplanting morning glory
- Pesticides should be applied and predators have to be removed from the culture pond before transplantation takes place.

- Organic fertilizers such as animal manures can be used to make the pond more fertile before transplanting.

3. Transplanting

- Water level should be about 20 cm. Morning glory seedlings are transplanted into the pond with the depth of root about 5cm. The remaining parts are left on the ground. Seedling plants should be planted 30 cm apart.
- The average density is about 1,500 morning glory stems per 1000m^2 (about 500 bundles of seedling plants)
- Water should be kept at the level of 20 – 30 cm. Daily water exchange (if possible) will give the best growth of morning glory.

4. Maintaining and management

- Pond water quality should be maintained by regular water exchange.
- Grass should be regularly removed from morning glory culture pond. The yellow snail is a predator of morning glory which must be prevented by the early removal of its eggs which are reddish in colour.
- Fertilizers are usually applied 10 days after transplantation. The average application rates for 1000 m^2 morning glory pond are:

  Urea: 7 kg
  DAP: 5 kg
  Phosphate: 5 kg

  Fertilizers are only applied twice per crop (35 – 38kg/crop)

  Insecticide application: leaf eating worms, brown cockchafer, white cockchafer, red spider, etc. are the most harmful insects.

  Common insecticides used for morning glory ponds are: Bifoliar, Applaud 10 WP, Actolik. Dose of usage varies according the situation and can be calculated based on the instructions of the respective insecticides.

Picture 6: Some insecticides used for morning glory

In addition, some other issues have to have taken into the management program: salt water may cause morning glory death; strong sunshine may increase water acidity causing leaching out from the soil; heavy rain can also cause death to morning glory due to rotting of roots.

Regular observations are recommended to recognize in time any abnormality of the morning glory plants so that appropriate measures can be taken.

Picture 7: Disease of rolling leaf worms on morning glory

Picture 8: Fatality of Morning glory plants due to salt water

5. Labour requirement

With an area of 1000 m^2, morning glory culture requires 1 labourer working 1 – 2 hours/day, 20 days/ month. During 10 days of harvesting of the month, there is a need for one labourer to work 3 – 6 hours/day

Morning glory culture requires less labour in comparison to other systems, however the labour is intensively used during harvesting time.

6. Farm equipment

Similar to water mimosa, equipment for morning glory cultivation is also standard: insecticide sprayer, bucket for fertilizer carrying, gloves, mask, hoe, and knife for harvesting.

A motorbike is commonly used for transportation of morning glory to market or for sale to collectors.

Picture 9: Morning glory is transported by motorbike

7. Harvesting method

After 35 – 38 days following transplanting, the first harvest can be conducted. Small knifes are common means of harvesting. Morning glory stems have to be completely cut. No stem should be left on the pond bottom.

Morning glory is then bundled up, with the weight of 1.2 kg/bundle. There are two choices for farmers to sell their morning glory: the whole plant or the stem only. For the stem only product, farmers usually hire labour to remove the leaves which can then be used for pig or giant gourami culture or can be sold to other fish farms with the price of 5000 VND, 0.33US$/package (25kg).

Picture 10: Good growth of morning glory

Picture11: Harvesting morning glory

Picture 12: Removing Leaves and bundling up morning glory for sale

Seasonal factors: due to low growth rate of morning glory in the dry season (Jan – May), it should be harvested 30 bundles/1000 m^2/day with 10 days per crop. In the rainy season when morning glory grows very well, the daily harvest can be up to 60 bundles/1000 m^2 with 15 days per crop.

Storage: After harvesting and before sale, plants have to be kept in a cool place (avoid sunshine). To maintain the freshness of the plants, water must be used for wetting them because losing water will reduce quality and thus the price.

Renewal of seeding plants: The cultured morning glory plants have to be renewed after 1 – 1.5 year of harvesting in order to ensure good production continues. Production of cultured plants decreases when the plants get older.

Price: The seasonal price of morning glory is more stable than that of water mimosa. Average prices are in the range of 1,200 – 1,500 VND, 0.08-0.10 US$,/bundle (1.2 kg). However similar to mimosa the price usually goes up in the dry season due to limited production caused by salt water intrusion. The price in dry season varies from 1,700 to 2,500 VND, 0.11–0.16 US$/bundle (1.2 kg)

8. Water morning glory diseases

Rolling leaves worms, brown cockchafer, white cockchafer, red spider, golden snail are the most common diseases for morning glory. Different from water mimosa, disease prevention measures and treatments are provided regularly by the Extension Station, Plant Protection Agency and some insecticide manufacturing companies.

Some common morning glory diseases and treatment methods (Source: Tran Thi Thien An, Department of Plant Protection, Faculty of Agronomy, Nong Lam University of Ho Chi Minh City)

a. White rust

Disease symptoms

- Causes infection on buds, stem and leaf stalks.
- Causes leaf deformities such as curling up of the leaves.
- At an early stage, morning glory leaves are covered by bulging white rust.
- If not treated, the single white rust will aggregate into a larger lesion which can seriously damage the infected leaves.

Picture 13: White rust disease in morning glory

Prevention and treatment

- Good management of morning glory pond.
- Pond should be well tilled and dried during preparation
- Use organic fertilizer instead of inorganic fertilizer, especially for nitrogen.
- Regularly spraying morning glory pond using Mexyl MZ 72WP, Zineb 80WP.
- To prevent the spread of disease,

Alpine 80WP, Curzate M-8 50W are recommended when primary symptoms recognized.

b. Leaf spot disease

Disease symptoms

- Affects all development stages of morning glory but old leaves are infected first.
- When getting infection, morning glory leaves contain circular or oval spots of 2-3mm or even 1cm in diameter.
- A serious infection usually causes sunken gray or reddish brown spots.
- The infected leaves may be broken at the spots and eventually die.
- Disease often starts on the lower leaves and spreads out to the upper ones.

Picture 14: Leaf spot disease in morning glory

Prevention and treatment

- Dead infected leaves should be removed from cultivation ponds and burned
- Using Zineb 80WP, Rovral 50WP, Funguran OH 70WP at the dose of 0.2% to spray to prevent the disease.

10. Problems faced

- The most important problem is the increasing numbers of harmful insects
- Uncontrollable impacts of climate changes
- Water pollution causing death or low growth rate of morning glory
- Over application of insecticide of which residue may have adverse affect on human health

11. Protection measures: rubber gloves, boots, mask, nylon coat for insecticide spraying.

12 Economic benefit of the system

With the average culture area of 2,500 m^2 and 4 family labourers, the morning culture system can help farmers to generate a net income of 31,000,000 VND, 1,960 US$/year. With this income, the daily remuneration of family labour is about 22,000 VND or 1.40US$ per day. In addition, the total cost for this system is rather low, only 1,230,000 VND, 78US$/year for the afore-mentioned area.

13 Beneficiaries of morning glory culture:

Morning glory is the most preferred vegetable for people in Vietnam because it can be used to cook different dishes. Thus morning glory culture is an important source of fresh vegetables for HCMC people's daily consumption.

With high income generation, morning glory is the main occupation of a large group of farmers. Morning glory also utilizes effectively the available local labour for the pre-processing step of removing morning glory leaves.

Water Mimosa Cultivation in Peri-urban HCMC

1. Selection of plants for propagation

The successful growth of water mimosa is dependent mostly on the quality of seedling plants. Thus they have to be chosen very carefully, according to following criteria:

- Big stem and homogenous size of floating components.
- The suitable average length of the stem should be in the range of 0.4 – 0.6m.
- Good appearance of leaves. Good set of roots, young roots are best. Don't choose plant with old roots for seedlings.
- Seedling plants must have no signs of disease, especially the floating components and leaves. Leaves must be fresh, without yellow colouration.

Figure 1: Newly transplanted water mimosa

2. Pond preparation

- Pond size varies dependent on the capability of the growers.
- Culture pond should be located so as water can be exchanged easily
- Water source should be available year round and no salt water intrusion allowed during the dry season. Fresh and clean water supply can be a decisive factor of water mimosa culture system. Further, the ability of water exchange is another requirement for the good growth of the plant.
- Pond soil has to be ploughed and raked carefully before transplanting to ensure good conditions for the best growth of the plant.
- The pond banks should be checked and repaired after every crop. Flooding prevention measures should be built (eg higher pond dikes) if ponds are located in a flood threatened area.
- Application of pesticide and sun drying pond bottoms for 2-3 days before supplying of water.
- Water should be stored (water conditioning) 4 – 7 days before water mimosa transplanting. Therefore new farmers thinking of going into mimosa production should strongly think about how and where they will store their water for 2-3 days prior to letting it into the pond.

- During water conditioning, organic fertilizer can be used to provide a nutrient source for the cultured plants. Pig, cattle or chicken manure can be used at the rate of 50kg/1000m^2.

3. Transplanting

There are 2 methods for transplanting water mimosa applied in different places in HCMC

- **Method 1:** the plants are divided into groups of 3 – 4 stems which are then tied onto many stakes and fixed onto the pond bottom. Each group of plants should be 1.5 – 2m away from each other. In this way, most part of the stem is immersed in the water and thus relatively less production is produced.
- **Method 2**: the seedling plants are fixed into many parallel wires or strings which are set up as transplanting rows. These rows are located at suitable height to the water surface so that water mimosa stem can be floated on the water. Transplanting wires are 0.5 m away from each other to ensure enough space for water mimosa growth.

For both methods, pond water depth should be kept about 1m or a little deeper. Shallow water will cause high water temperatures that may impact on growth of the plant. Water mimosa will perform better growth in ponds with higher water exchange rates.

Water mimosa is always stocked in combination with duckweed. The purpose of duckweed stocking is to shadow the water column to avoid plankton growth which will utilize nutrient and thus would reduce water mimosa production. Because duckweed grows very fast, it can be harvested daily. This by product of water mimosa culture can be used to feed herbivorous fish and sold to fish farms.

4. Maintenance and management

- Water quality should be maintained well by regular water exchange. Due to recent problems with water pollution, water exchange for the water mimosa pond should be done at least twice a month. The time for water exchange should also be chosen carefully to avoid polluted water. It is best to choose high tide days of the tidal cycle.
- Grass should be removed from culture pond. Duckweed growth also has to be monitored by harvesting regularly because if duckweed grows to a high density the plants will easily be infected by different worms such as *Nymphula enixalis* and *Pyralis sp.* which can be a threat for water mimosa production. However, duckweed density should be maintained properly – this can be learned by experience. It is completely harmful for water mimosa if no duckweed is kept in the culture pond.

Figure 2: Maintaining water mimosa in pond after harvesting – note floating duckweed.

Duckweed is a by product of water mimosa culture system which can sold for fish feed or as terrestrial plants fertilizers. Thus it is an extra income source for water mimosa growers.

Fertilizer application: for 1000 m^2 pond: the following rates of different fertilizers should be applied every 3 days during March to August; or every day during September to February the next year.

- Urea: 3 – 5 kg/time. Dissolve the fertilizer in water with recommended dose and bail out over the entire pond
- Phosphate: 7 – 10 kg/time. Dissolve the fertilizer in water with recommended dose and bail out over the entire pond.
- DAP: 3 – 5 kg/time- Dissolve the fertilizer in water with recommended dose and bail out over the entire pond.
- Green fodders: 0.3 – 0.5 kg/time. Use composted form of green plants leaves or grass.

Insecticide application: following doses guide from the manufacturer. Importantly, insecticide should only be used when plants are found to be attacked by pestilent insects such as leaf eating worm or worms attacking floating components of the plants. All insecticides should be sprayed over the plants.

Cultured plants have to be monitored carefully on a daily basis so that disease can be recognized early to apply appropriate treatments. This measure can help prevent disease spreading out to the whole pond or to other ponds which can cause complete loss. If infection is not identified and treated within 2-3 days, the whole pond may be infected and lost.

Some common insecticides used for water mimosa culture: Wofatox 50ND, Furadan, Basudin 10H, Sevin 50BHN, DDT 30ND. However, there is no defined dose for farmers to apply thus the dose varies very much dependent on the level of infection.

5. Labour requirement

The average water mimosa area of one household is 2000 m^2. With this land area, water mimosa culture requires 2 labourers working 6 – 7 hours/day.

In comparison to other aquaculture systems, water mimosa requires more labourers as the maintaining and harvesting activities are time consuming, especially for harvesting. Therefore, water mimosa households usually have no chance to be involved in any extra or auxiliary occupations.

6. Farm equipment

Because water mimosa culture can be considered as small scale production system, farm equipment required is very simple and does not account for much investment. Common equipment for water mimosa culture farm includes: insecticide sprayer, hoe, and motorbike or bicycle for product transportation.

7. Harvesting method

Water mimosa is ready for first harvest about 15 – 20 days after transplanting. At this time, each group of transplanted water mimosa consists of 3 – 4 stems out of which 1 – 2 stems can be harvested. Stems with a length of 0.5 – 1m are suitable for sale and thus should be harvested.

The harvesting interval is different from season to season as the growth rate of water mimosa varies seasonally. In the dry season, due to slow growth, it should only be harvested once a week. In contrast, water mimosa can be harvested daily in the rainy season as it can perform very high growth rate at this time.

Figure 3: Harvesting water mimosa

Preparing the plant ready for sale: Before bundling up the plants for sale, some pre-processing steps have to be taken including: removing the roots, bad/rotten leaves, floating parts. The water mimosa plants are then bundled up. Each bundle consists of 10 – 20 stems dependent on the size so that they can get to a weight of 5kg/bundle. This is the stage for transportation for sale.

Figure 4: Removing of floating part and bad leaves before sale

Storage: After harvesting and before sale, plants have to be kept in cool places (avoid sunshine). To maintain the freshness of the plants, water must be used for wetting them because loosing water will reduce quality and thus the price.

Renewal of seedling plants: Water mimosa plants have to be renewed every year in order to ensure the maintenance of good production. Production of cultured plants decreases when the plants get older.

Selling products: water mimosa is usually sold during night time at wholesale markets. Farmers can sell their products to collectors, wholesalers or retailers at markets. They can also transport to nearby collectors' houses for sale to avoid long distance of transportation.
Price: the price of water mimosa is usually unstable dependent on quantity of vegetables imported into local markets. Therefore, the price of water mimosa is often higher in the dry season than in the rainy season because of low production in dry season. The price in the dry season is about three times that in the rainy season.

8. Water mimosa diseases

There is no formal technical reference for prevention measures and treatments of water mimosa diseases. Therefore farmers are using treatments for terrestrial vegetables to treat water mimosa diseases.

Figure 5: Atrophy of floating part in water mimosa

9. Problems faced

- Lacking in disease prevention measure and treatments
- Bad weather (e.g. hoarfrost) causes water mimosa death that reduces productivity.
- Lack of proper techniques for water mimosa culture.
- Industrial wastewater pollutes water source making more difficulties for farmers
- Unstable prices in the markets

10. Human Health protection measures

Very simple protection measures can be used to avoid human health impact, including: rubber gloves, boots, and mask. However, very few farmers are aware of the importance of protection measures.

11. Economic benefit of the system

With an average area of 2000 m^2 and 2 family labourers working permanently, a household can generate a gross income of 21,000,000 VND, 1329 US$/year which provides a net income of 15,000,000 VND, 949 US$/year.

12. Beneficiaries of water mimosa culture

Water mimosa culture is not only a means of income generation for stakeholders but it is also an important food source for the city. Furthermore, this helps to maximize agricultural land use in peri-urban areas of HCMC where flooding prevents any other types of agriculture and aquaculture being practiced. Despite this, the system is threatened from many problems including water pollution and lacking of formal technical guidelines which have both led to increasing difficulties for water mimosa farmers.

Growing Techniques for Aquatic Plants/Vegetables in peri-urban Hanoi

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Introduction

Aquatic plants are a very popular constituent of our daily meals, supplying vitamins and minerals for people. Peri urban areas can offer good conditions to develop aquatic plant production. The different field locations (lowland, upland, source of water supply etc) are suitable for cultivating various kinds of aquatic vegetables. Morning glory can grow on upland or lowland areas and can be harvested 9 months of the year except during Hanoi's winter (December – February) when production is low. Whereas water dropwort and water mimosa grow best in lowland areas requiring frequent daily water exchange, water mimosa is harvested from March – July, and water dropwort from October – March the following year.

Growing techniques are relatively simple, with low levels of inputs compared to fish culture and the possibility of using household labour. Aquatic plant cultivation can contribute a significant part to the incomes of households in suburban areas.

Morning glory cultivation in Peri-urban Ha Noi

In Hanoi morning glory is a very important vegetable which is eaten by people every day and is cultivated widely throughout the city mainly using urban waste water.

There are 2 techniques used for growing morning glory in Hanoi:

I. Floating morning glory cultivation technique

In Hanoi people normally begin growing floating morning glory at the beginning of May, and can begin harvesting this by the end of this month through to September (harvesting about 20 days per crop). Therefore the farmer can produce up to 5- 7 crops per growing cycle.

1. Field/Canal preparation:

- Floating morning glory can be cultivated in large canals, converted lowland rice fields, and fish ponds. The area for cultivation varies dependent on the capability of the farmer, but fields of between 300 - 400m^2 are best for management.
- There should be a water inlet and water outlet at opposite ends of the field.
- Do not use fertilizer at this time.

2. Cultivation method:

Using older morning glory plants that have been grown in the field for about 30-40 days, cut and put all plants together into 1 pile (as shown in Figure 1) and leave for 5 -7 days. By this time, most leaves are falling off, and the germ brand begins to develop at the base of the plant. (As shown in Fig 2). The plants are then spread over the water (100-150kg plant/150m^2). Wooden stakes are then used to keep the floating morning glory in the same area as shown in Figure 3 below.

Figure 1: Cut and put all plants together into 1 pile

Figure 2: New germ brand developing at base of plant

Figure 3: The plants are then spread over the water

3. Management and fertilization

- 5-7 days after planting, spread Urea 2-3kg/ 360m²/crop.

- Maintain water level in morning glory field between 40-50cm, supplement water 1-2 times/week.

- For the 2nd and 3rd crops, 5-7 days after 1st harvest, spread urea 5kg/360m²/crop and then 7 days before harvest, spread 5kg/360m²/crop urea.

4. Pesticides which are used in Hanoi:

Monitor

Ingredient: Dimethylacetin phosphoramidothioate 40%. Spray 1 time/crop, when plant begins to develop at 3-5cm.

5. Harvesting

Floating morning glory crop can be long in harvesting from 17-20 days. If the water is too deep, the farmer can use a boat. It is best to cut the plants by hand (not using knife) 35 cm from their tops leaving about 5cm stem to the root. After cutting firstly remove any old leaves and make into bundles (800-900g/ bundle), some harvests can reach 400-500 bundles/360m^2. Morning glory is normally harvested at between 3 - 5 am so that the farmer can take their crop fresh to the market by 6 am to get the best price.

After the 3rd harvest (60 days after first planting), remove all the plants, and begin cultivation again with new plants.

II. Non - floating Water morning glory cultivation technique in fields

This technique is used in fields where water is added once or twice per week similar to irrigated vegetable production.

1. Field preparation

Morning glory can be cultivated in fields in lowland or highland areas. The area for cultivation varies dependent on the capability of the farmer, but fields of between 300-500m^2 are best for management.

- There should be a water inlet and water outlet at opposite ends of the field.
- First plough the soil and level field surface.
- Fertilizer: apply 10kg phosphate/ 360m^2

2. Cultivation method

Water morning glory can be grown from March, and then harvested from April to December. Therefore the farmer can produce up to 10-13 crops per growing cycle, using this method. 2-3 plants are cultivated together in one cluster, each cluster is spaced 15 cm apart in rows and each row is 20 cm apart.

Maintain water level in morning glory field between 3-5 cm if possible.

3 Management and fertilization

There are 2 seasons:

In the summer (April – August): spread 5 kg urea /360m^2 /crop and 10kg phosphate/360m^2 /crop when plants reach 5-7 cm. Then 7 - 10 days before harvesting, spread 5 kg urea /360m^2/crop.

In the winter (September – February) when the new growth begins to develop spread 10-15kg photphate/360m^2 or 20 kg NPK/360m^2. When the plants reach 5-7 cm spread 3 kg urea/360m^2. If the weather is too cold, you should not irrigate using wastewater on the plants as it will cause them to die.

During December to February apply phosphate (10-15kg/360m^2) to help the plants during the cold weather, keep the soil wet. Do not use waste water or urea. At this time some farmers can keep plants from this winter crop to use as seedlings for next years first crop in March.

4. Pesticides

Should spray pesticides when new plants reach 5-7 cm or spray pesticides when insects appear. Some pesticides which are commonly used include:

- Monitor

Ingredient: Dimethylacetin phosphoramidothioate 40%. Spray 1 time/crop, when plants begin to develop at 3-5cm.

- 90 SP (Dich bach trung)

Ingredient :Trichlorfor 90%

Adjuvant: 10%

Figure 4: Spraying pesticide for morning glory

4. Harvesting

The Morning glory crop can be long in harvesting from 20-25 days, as you should cut each plant by hand one by one. Cutting the plants by hand is better than by using knife because it encourages the remaining plant to grow more quickly. Make into bundles (700-900g/bundle). In

the summer harvesting can reach 700-800 bundles/ 360m²/, in the winter 400 bundles /360m². The farmer can produce up to 10-11 crops per year. Productivity can reach 4.5 – 5.5 ton/360m^2/year.

Figure 5: Collector buying fresh morning glory to transport to market

5. Notes to remember

- Remove grass and weeds from the field in order to limit insects
- Limit use pesticides
- After 4-5 crops, should remove old plants completely and introduce new plants to increase productivity.
- Do not use waste water and urea in the winter.

Water mimosa cultivation techniques in peri-urban Ha Noi

1. Field preparation

- First plough the soil and then dry for 5 to 7 days
- Plough again, level field surface
- And then fill with water maintaining a water level of 50-60cm in the field
- A 300-400m^2 area is the best area for management and cultivation with the height of the banks being 50-60cm. There should be a water inlet and outlet at opposite ends of the field. **Do not use fertilizer at this the time.**

2. Cultivation methods

Water mimosa cultivation usually begins in April with farmers planting seed stock in smaller size fields (Mimosa seedlings are expensive in Hanoi). After 15 days they then transplant the growing plants into a larger field.

Seed selection: Choose strong, healthy plants, with red roots, and long, white floating stems.

***Cultivation method (in water)*:**

- Most farmers in Hanoi use this method.
- Once filled with water divide the pond using string tied between wooden stakes, each line being 1.3 – 1.5 metres apart.
- The stem of each plant is then attached to the strings with each plant being 40-50cm apart (as shown below in Figure 11)

Figure 11: Newly transplanted Water mimosa

After growing for 10-15 days, the plant length should reach 80cm - 1m, at this time cut the top off each plant (at around 60cm) to allow multiplication and new vegetative growth. This then normally takes about 1 month.

3. **Management and fertilization**

- After transplantation, add duckweed (40kg/360m²).
- **Do not add too much duckweed, as it will reduce plant growth.**
- After harvesting remove some of the duckweed (160kg/360m^2), it can be used as a good feed source for fish fingerling production..
- Maintain the water level in the fields at a minimum of 50cm with some farmers using up to 1m depth for deeper ponds.
- After every 3-4 days farmers must straighten each plant by hand so that they optimize space and therefore increase growth of the crop.
- If using wastewater spread 1-3kg urea/ 360m^2/crop
- If not using waste water, increase this to 10kg urea/ 360m^2)/crop.

Figure 12: Removing duckweed from water mimosa pond – used to feed fish

4. Harvesting

When the main stem of the plant reaches 100 -120cm cut by hand about 70cm from the bottom of the plant and remove the roots to sell（as shown in Figure 13a). Normally farmers put 4-5 stems together into 1 bundle.

- After three harvests onwards the farmers replace old plants with new cuttings with 4-6 small side branches in order to maintain high production levels.
- The next day the farmers again cut off each of the side branches branch (as shown in Figure 13b)
- Then re-attached 2-3 side branches are cultivated together in one cluster to line for new plants. (as shown in Figure 13c).

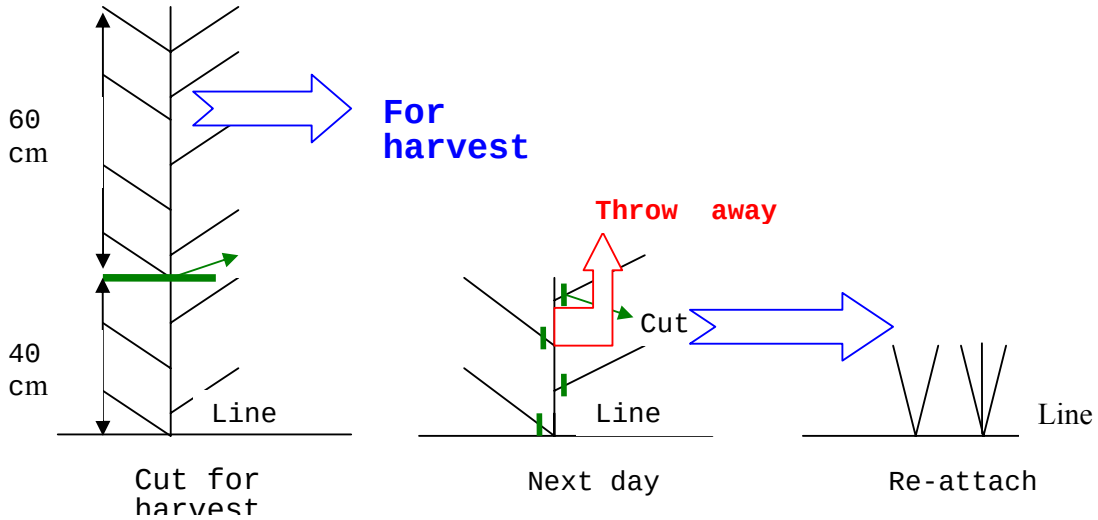

Figure 13a: Cut about 60cm to sell **Fig 13b**: cut off each of the side branches branch

Fig 13c: Then re-attach side branches to line for new plants.

Figure 14: Harvesting water mimosa in bundles

Maintain seedlings:

- Keep a small area (20-30m^2) of the vegetable field for supplying seedlings for the following year - keep watering with fresh water if available (**do not use waste water for this).**

- It is very difficult to maintain water mimosa seedling plants and takes many years of experience, hence the high price. The farmers usually buy seedlings plants from Hai Duong province 60km from Ha Noi.

5. Notes to remember:

- Pesticides should not be used for growing water mimosa
- If the waste water is too polluted, the plants leaves will turn a yellow colour.
- Diseases of the water mimosa plants tend to appear at the beginning of the season (April – May).

Water dropwort cultivation techniques in peri-urban Hanoi

1. Field preparation

Should choose field with soil of a high silt level, (pH 6 -7). The area for cultivation from 300-400m^2 is best for management and the height of banks from 50-60cm. There should be an inlet and outlet for water at opposite ends of the field.

Crop 1: Plough the soil and dry for 5 to 7 days and then plough again, level field surface.

- *Liming*: Spread 20 - 25kg/360m^2 in order to improve soil and destroy moss and algae. After 1 –2 days fill the field with water and then discharge the water straight away to remove unwanted moss and algae.
- *Organic fertilizer*: Different strategies:

1. Add between 30 - 50kg broken horn (bone meal)/ 360m^2/crop, and then fill water into the field up to 2 –3cm depth.
2. Or use about 100kg per 360m^2 broken horn (this is enough for 2-3 crops).
3. Or use manure eg pig manure: 300kg/360m^2/crop.
4. Or use a combination of broken horn (20kg/360m^2) and (30kg/360m^2) chicken manure per crop.

After harvest of 2nd Crop:: plough the soil and dry for 5 to 7 days. If the soil is hard, it should be ploughed again, if the soil is soft, remove weeds, and supplement with broken horn using 20kg/360m^2. If the field has moss, you can use lime (20-25kg/360m^2).

2. Cultivation method

Some farmers begin growing water dropwort at the beginning of July however the best time for growing water dropwort is from December to January the following year.

Seed selection Should choose mature and strong vegetable seedlings.

Cultivation method: divide 360m^2 field into 5-6 blocks, (2m wide for each block), with 25-30cm spaces between blocks, so it is easy to take care of.

Grow stock seedlings in lines (1 plant/cluster), the space between the lines being 7 - 10cm and between plants 5 - 7cm.

Figure 6: Newly transplanted water dropwort (2-3days)

3. Management and fertilization

Maintain water level of 3-5cm in the field (as shown in Figure 6) . Do not maintain the water level too high as this will restrict the young plants from producing new growth. The best temperature range for the plants to grow is between 15-20^{0}C.

1st fertilization: 10-15 days after transplantation (plants at 10 -15cm), apply 2 kg Urea and 20kg NPK/360m^2. After 2-3 days following 1st application of fertilizer, spray pesticide to destroy insects.
2nd fertilization: After 7-10 days following 1st fertilization, apply 5kg phosphate and 1.5kg urea/ 360m^2.
In terms of using wastewater, add once per week together with chicken manure, do not use chemical fertilizer (urea). Ideally it would be better if the farmer can allow inflowing wastewater daily into the field.

3rd fertilization: After growing for 1 month, apply wood and rice stem ash (20kg/360m^2), after which leave for 10 days and then harvest.
Manuring method: Spread fertilizer in late afternoon of a day when it is not raining. At this time the leaves are dry, and it is easier for the fertilizer to go straight to the roots, so that the leaf is not damaged.

Figure 7: Spreading fertilizer

Chemical fertilizer

Farmers can use chemical fertilisers once per week that make the leaves develop. Apply using concentration and dose given in the instructions on the packet

Figure 8: Some different kinds of fertilizer

- **TS 96**
  - Ingredient : $K_2O \geq 1,5\%$, Cu $\geq 0.05\%$;Zn $\geq 0,5\%$;Mn $\geq 0.05\%$;Bo $\geq 0.02\%$
  - mineral , acidamin.

- **HQ 909**
  - Ingredient : N 10%, P_2O_5 : 5%, K_2O : 5%
  - Ca, Mg, Cu, Zn, Fe, Bo, Co...>1000ppm
  - Acidamin, vitamin, non toxic

- **PHITO**

  §a lîng : N, K_2O, P_2O_5

  Vi lîng : Fe, Cu, Zn, MO, Mn, Mg...

Chemicals used against condensation/ dew on plants

Condensation or dew in the early morning can cause disease on the plants. Farmers can use chemicals against dew 2 to 3 times per week in the first crop, because the weather is unsuitable at this time. Never use this chemical 7 – 10 days before the crop is harvested.
Chemicals that are used for this purpose (all trade names):

- **TIL** (Supap) or **FORO** (Thuþ sü).

Pesticides

Used to kill insects and pests

Spray pesticide 2 – 3 times per crop. When insects appear, use pesticide immediately.

Pesticides used:

- **Cyperkill**

  Active ingredient : Cypermethrin 100g/lit

- **Sherpa Super 550EC**

  Active ingredient : Chlorpyrifos ethyl 50%
  Cypermethrin 5%
  Adjuvant: 45%

- **90 SP (Dich bach trung)**

  Active ingredient : Trichlorfor 90%
  Adjuvant: 10%

- **Score**

  Active ingredient : Difenoconazole/L

- **Red spider** (China) or Ortus 5SC from Nohyaku. (Japan)

Figure 9: Some different kinds of pesticides used

4. Harvesting

7 days before harvesting, do not add further water into the fields, since this may cause fall down of the plants. It is considered best to harvest on days when there is no north-easterly wind to prevent fall down of the plants.

Cut the plants at stump level by knife, clean with water, remove old leaves and roots, and then make into bundles (700-800g/bundle). Harvesting water dropwort is quick, but can also be hard work.

After harvesting, plough the field and remove all of the old roots then re-plant. Using these methods there is the possibility of 3-4 crops of water dropwort per year. Productivity can reach between 2.5 - 3.0 ton/360m^2/cycle.

The first crop is long at 2.5 months from July – mid September. If the weather is good, the vegetables will grow well, and reach a productivity of around 2000 bundles (over 1000kg) per 360m².

The second crop onward is about 1.5 months duration from mid September- November. The weather is not so good at this time for new plant growth, so productivity only reaches 1600 bundles (over 800kg)/360m².

Figure 10: Cleaning aquatic plants with water before sale

Maintain seedlings: Farmers can keep and maintain a small area of field (100-200m^2) for supplying seedlings for next year which they should water occasionally. There is no need to use fertilizer or pesticides. Some households specialize in this and make money supplying other farmers.

5. Notes to remember:

- The production fields should be surrounded on their edge by nylon netting in order to prevent destruction by mice.
- Do not use pesticide for the second crop onwards. Add inflowing water to the fields and keep for at least one hour, and then remove water, insects will dye.
- Do not use too much fertilize (urea) as the plants will become weak and fall down)
- 10 days after transplantation you should spray with pesticide - look for leaf change colour, the leaves should not be too bright in colour.

Watercress Cultivation Techniques in Peri-urban Ha Noi

1. Field preparation

Should choose lowland, muddy area, first plough the soil and dry for 5 to 7 days and then plough again, level field surface. The area for cultivation should be between 300-400m^2 for good management with the height of the banks between 50-60cm. There should be a water inlet and outlet at opposite ends of the field.

- Liming: apply 15kg/360m^2
- Fertilizer: apply phosphate 10kg/360m^2,

From the second crop onward do not use lime again, fill water up to a depth of 3–5cm and then cultivate immediately or begin cultivating after 1-2 days.

2. Cultivation method

In Hanoi people normally begin growing watercress in September, and depending on the weather can begin harvesting by October and continue up to March the following year. Therefore the farmer can produce up to 5 crops per growing cycle.

Seed selection: Farmers should choose old/mature and strong vegetable plants.

Cultivation method: 2-3 plants are cultivated together in one cluster, each cluster is spaced 10 - 15 cm apart, each line is spaced 10cm apart.

3. Management and fertilization

Maintain water level in watercress fields between 3-5cm and also always remove weeds on the banks.

1st fertilization: After growing 10 days, normally in the afternoon when there is no rain spread urea granules (3kg/360m^2) and then after 1-2 days spray with pesticide to destroy insects.

2nd fertilization: After 7-10 days following 1st fertilization, spread 2kg urea /360m^2 and spread 9-10kg phosphate/360m^2. **If using waste water, you should not use urea at this time.**

Pesticides

There can be small insects in watercress fields, so use pesticides at the beginning of the growing cycle.

Some pesticides which are commonly used include:

- **Cyperkill**

  Active ingredient: Cypermethrin 100g/lit

- **Sherpa Super 550EC**

  Active ingredient : Chlorpyrifos ethyl 50%
  Cypermethrin 5%
  Adjuvant: 45%

- **90 SP (Dich bach trung)**

  Active ingredient : Trichlorfor 90%
  Adjuvant: 10%

- **Red spider** (China) or **Ortus 5SC** (Nohyaku from Japan).

4. Harvesting

Water cress crop can be long in harvesting, from 25 - 40 days depending on the weather. Cut vegetables with a knife, clean with water, remove old leaves and make into bundles (750-850g/bundles). **Always transplant with new plants again after harvesting,** if you don't the old plant will carry on growing and productivity will only be 50% of the previous harvest. Some farmers keep a small area of field (3-5m^2), where they grow mature plants to use as seedlings for the next crop.

5. Notes to remember

- Maintain water level of 3-5cm in the field.
- Do not use too much urea
- Should use NPK
- 10 days before harvesting use rice straw ash.
- Do not use pesticide on the main crop (2nd or 3rd crop) or when there is a dry and cold wind.

Summary

This booklet is based on information collected from Bang B village, Hoang Liet commune and Tran Phu commune, both in Thanh Tri district, Ha Noi in the period 3/2004 – 1/2005

Please note that we are not recommending or endorsing any particular company's chemicals, pesticides, fertilizers etc which are mentioned in this manual. We do however recommend that people working in and with waste water should be wearing suitable protective clothing for at least their feet, legs, arms and legs ie those areas which regularly come into contact with waste water. Similarly we also strongly recommend that the appropriate protective clothing should be worn during spraying operations including face mask, gloves and where applicable protection for the feet and legs.

Some information was also collected from Vegetable Manual (Duong Hong Dat, 2002).

Aquatic Plants Cultivation in Peri-urban Phnom Penh, Cambodia

By

Mr. Khov Kuong, Ms. Sok Daream, and Mr. Sok Seyha from the Faculty of Fisheries, Royal University of Agriculture (RUA), Phnom Penh.

Introduction

This booklet has been compiled and written referring to the experience of farmers in and around Phnom Penh who have been involved in aquatic plants cultivation (Morning glory and Mimosa) for many years as well as being combined with some scientific technical concepts of the PAPUSSA project working team. In collaboration with farmers, national and international working teams and support from the EC (European Commission), the booklet is published with its purpose to share simple aquatic plant growing techniques for farmers who may wish to start aquatic plants cultivation or develop their own existing aquatic plant cultivation techniques. The booklet is also expected to contribute to the livelihood improvement of farmers whose living already depends on waste water aquatic plant production, as well as to share basic information for scientists and policy makers.

For the development and production of this booklet itself, the PAPUSSA team in Phnom Penh feels a deep sense of gratitude:
- to the aquatic plant producers in Beung Cheung Ek lake for their valuable time, tolerance and patience in sharing the knowledge and experience of growing aquatic plants.
- to the artists for their professional competence in drawing those admirable illustrated pictures in the booklet.
- to our colleagues in the Asian Institute of Technology (AIT) Bangkok and the University of Stirling, UK for their constant support, especially to Mr. William Leschen for sharing his ideas and suggestions, his encouragement to the working team and his invaluable editing for this booklet.

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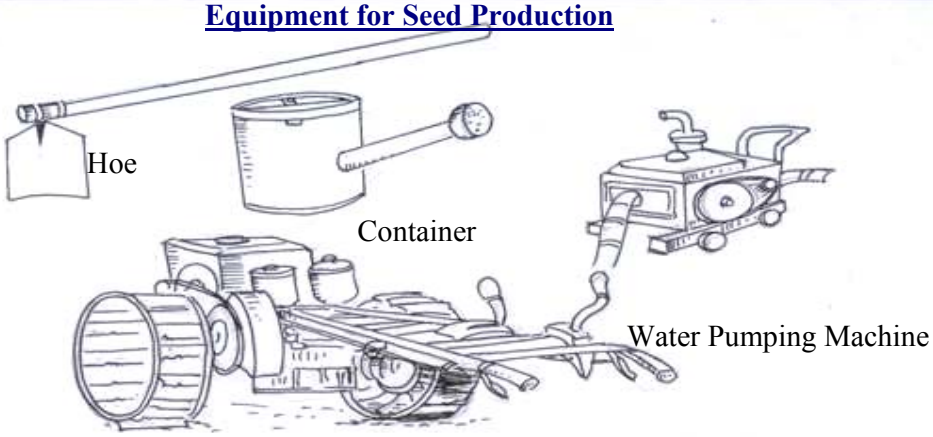
Cultivation of Morning Glory In Boeung Cheung Ek Lake, Phnom Penh

Introduction

Morning glory is a popular aquatic plant cultivated in Phnom Penh which is eaten both cooked and uncooked. It requires a relatively easy growing technique with lower labour costs compared to other cultivated plants. Furthermore, morning glory products can be harvested every day for both sale and home consumption

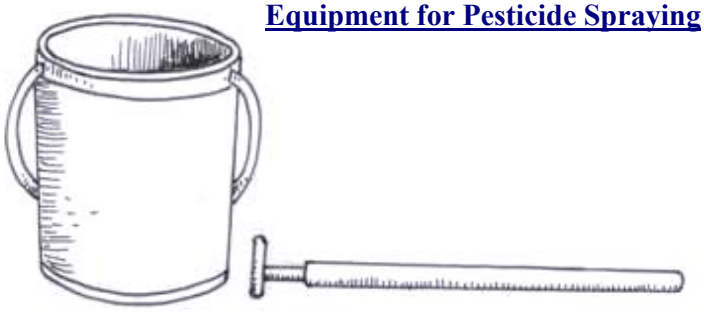
1. Required Equipment

Equipment for Seed Production



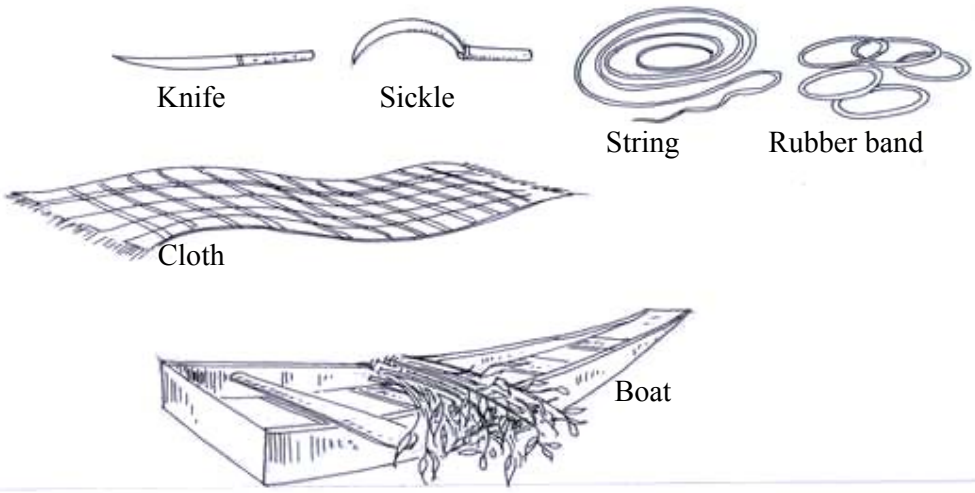
Tractor

Equipment for Pesticide Spraying



Container Spraying Pump

Equipment for Harvesting



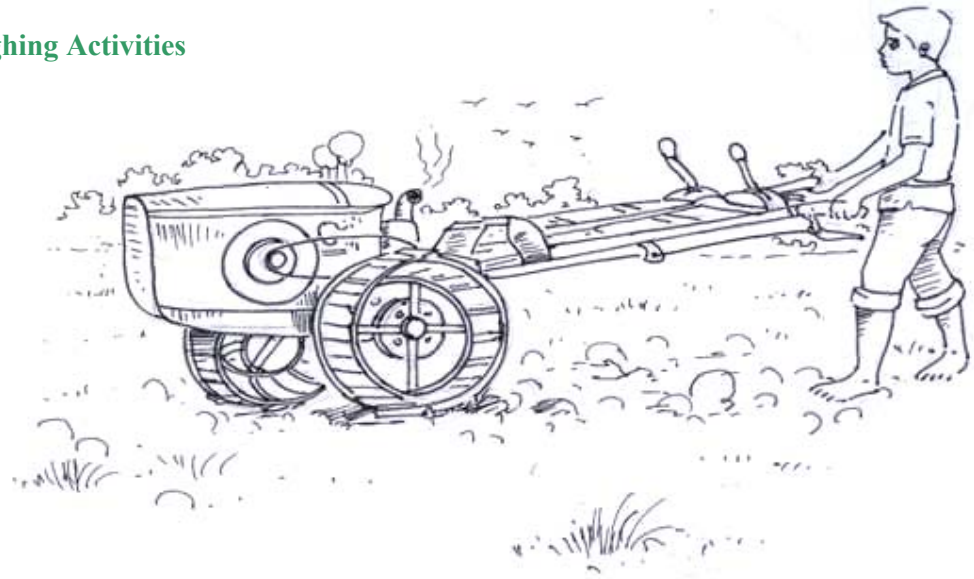
2. Cultivation Methods

2.1 Seedling Preparation

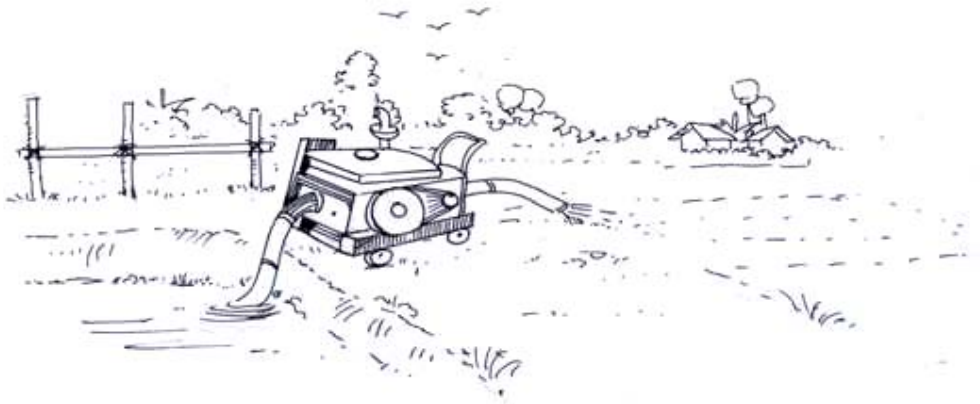
- **Field Preparation for seedlings**

  - Select the area which is close to a water body or lake
  - Prepare the field by air drying the soil
  - Moisten soil with waste water before seed planting

Ploughing Activities



Water Pumping Activities



- **Seed Propagation**

The selected seedlings have to be propagated in a previously prepared area of land. Morning glory stems are folded into a small piece and buried into a hole in the soil of depth 20 cm width and 10 cm depth, with two sides of the stems exposed to the air. The seedlings should be planted in rows with 30 -50 cm between each seedling.

Planting the morning glory seedlings

Note: Morning glory seedlings are taken from the previous years crop and seedlings should be selected with big white stems of 8 angle shaped and green, healthy leaves.

- **Taking care of morning glory seedlings**

The planted seedlings should be regularly taken care of by removing any weeds from the field and applying pesticides in order to allow them to grow well. 7 days after planting the seedlings the plants buds should start growing. At this point the farmer then applies bud fertilizer and pesticide. If there is no rain during seed propagation, then the farmer should often sprinkle the morning glory plants with water once every 2 or 3 days.
After 3-4 weeks the seedlings can be transferred to grow in floating rafts in a lake – in the case of Phnom Penh this is the large waste water fed Beung Cheung Ek lake where most of the city's morning glory is grown.

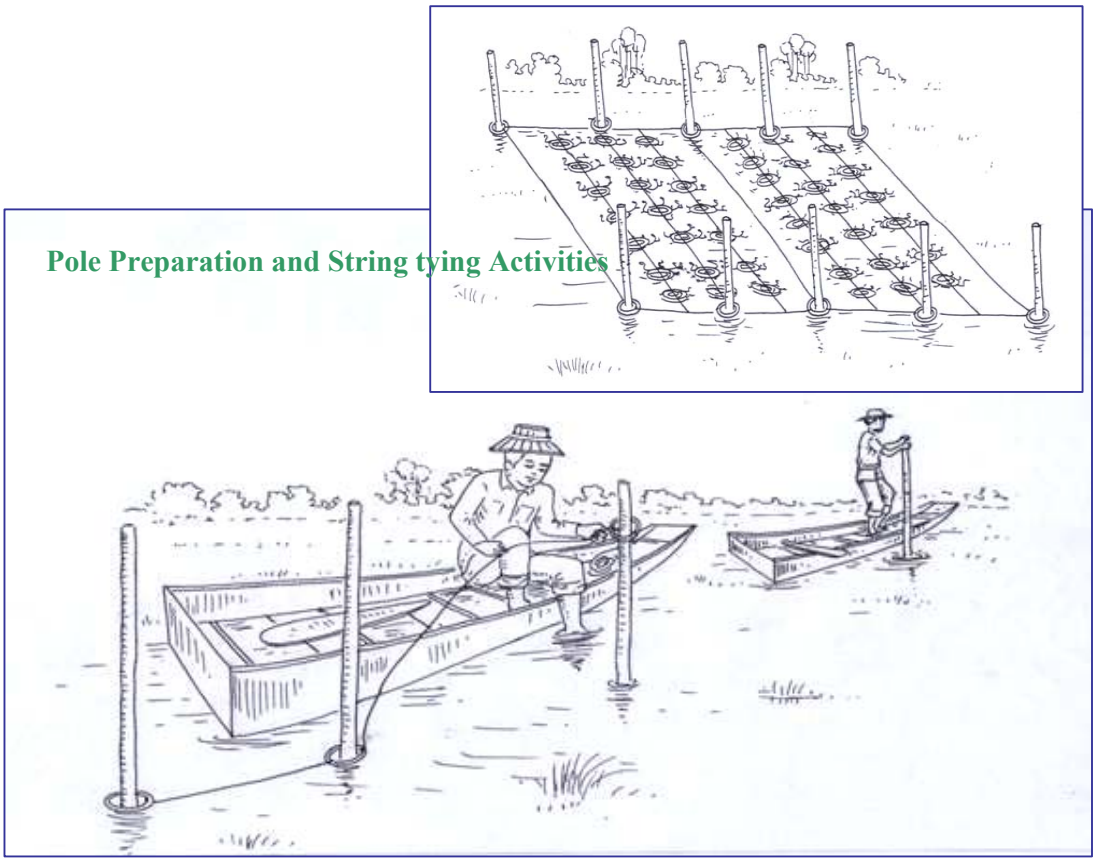
Seedling Maintenance Activities

2.2 Transferring morning glory seedlings to the water

Morning glory planted in water should be in a raft floating on the surface of water, thus propagated seed have to be bound with string tied up to the poles which are already prepared in the lake.

- **Pole Preparation**

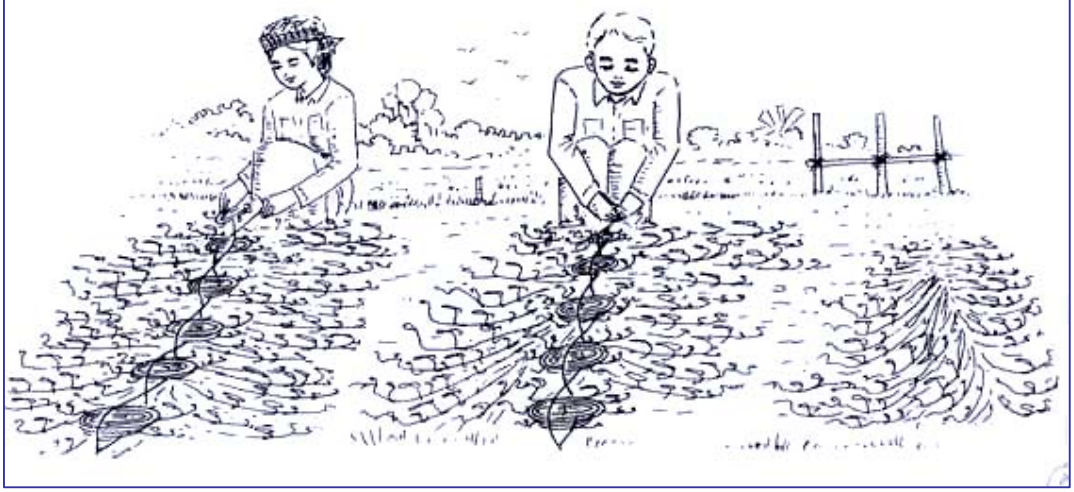
Poles should be prepared in a long rectangle shape of 30 meters long per each plot and each pole should be 3 to 4 meters apart from each other along the width of the plot, and then connected from one pole to another by rope in the manner that they can be floated on the water surface. Poles should be prepared before braiding morning glory seed.



- **Morning glory Seedling braiding**

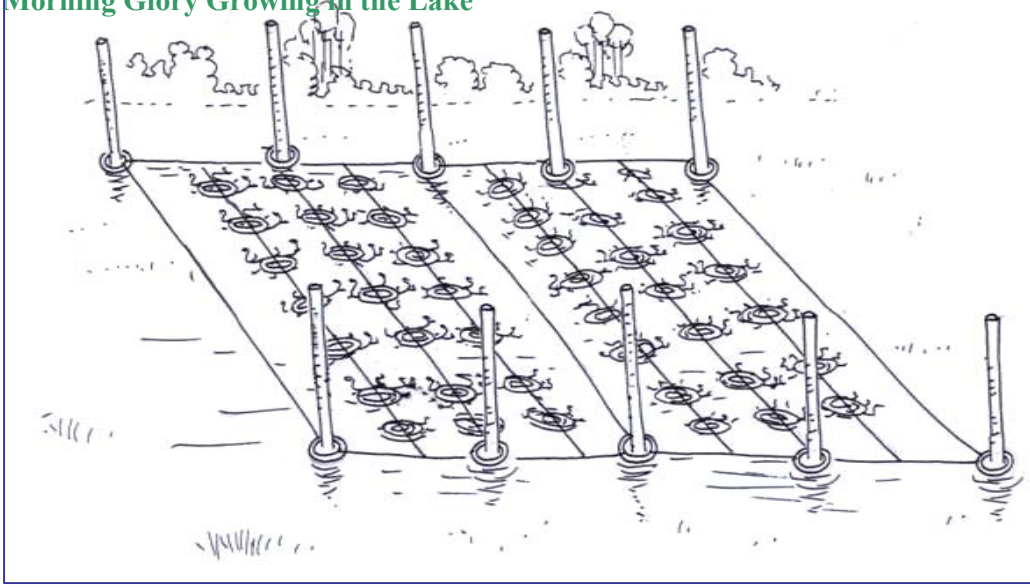
Morning glory seedlings are folded as a forearm-size plant and braided with string, with 10 cm between each plant on the string as shown below:.

Morning Glory Seedling braiding Activities



* Morning glory seedlings which have already been braided have to be transferred immediately to the raft in the water. They can be kept no longer than one night like this before being transferred. As an estimation, an area of 3 m² can support 10 metres of braided morning glory seedlings.
If there are not enough seedlings for planting, further seedlings can be bought from other farmers.

Morning Glory Growing in the Lake



- **Method of Plant Maintenance**

In order to make morning glory grow well, the farmer should regularly:

- Keep the floating morning glory bed/raft clean by removing water hyacinth and water lettuce
- Monitor morning glory braided strings, ropes and poles
- Sprinkle the morning glory leaves with water when they become dried up in the dry season
- When the morning glory's new bud has just appeared, pesticide and fertilizer should be applied.

Sprinkle water on morning glory row

MG maintenance Activities in the Lake

Chemicals and pesticides commonly used:

- **DDVP -50** made in Thailand (Called by farmer as Holding-Hand Brand) used for prevention of worms and white rust lesions (Kra).
  Active Ingredients: 2, 2-dichlorovinyl dimethyl phosphate 50%W/V EC

- **Visher 25 ND** made in Viet Nam (known by farmer as One-Worm Logo) used for prevention of worms, grasshoppers and white rust lesions.

- **V 80** (known as Carrying-Pumpkin Brand) made in Thailand, used for prevention of white rust lesions (Kra) and conditioning plant bud.
  Active Ingredients: Zine ethylenebis (dithiocarbamate) (polymeric) 80% W.P

- **BIOBIT 32B FC** made in Viet Nam (One worm logo powder) used as pesticides and for bud conditioning
- Chemical to soften morning glory stems (Use when their stems are getting hard).

- **Chemical (Bao 30)** with golden comb brand from Thailand, used to stimulate new d growth of buds.

Farmers like to use these chemicals and pesticides for spraying on morning glory when buds are just newly grown and when the insects or diseases first appear on the plants.

Normally, farmers mix many kinds of these chemicals and pesticides together in one container and spray just once but this is not recommended. They should apply using concentration and dose given in the instructions on the bottle and packets

Note: This booklet is not trying to recommend or promote the use of those chemicals and pesticides but sharing experiences from the farmers

Note: After applying chemicals and pesticides, morning glory should be left at least one week before harvesting.

Pesticide Spraying Activities

Warning: Please be aware that all kind of the above chemicals and pesticides can strongly affect human health, so before spraying, the sprayer should dress up your whole body with cloth and mask, and they should spray following the wind direction.

3. Harvesting

- Morning glory can be partially harvested after 3 to 4 weeks following planting. During harvesting, farmers should tidy up their morning glory by arranging the stems into a well-disciplined bed – see below, as this allows the plants to continue to grow well and avoid blocking access for the boats between each row.

Morning Glory Harvesting Activities

- Morning glory should be harvested as much as possible each time in order to give chance for the plants to produce their new buds for the next time of harvesting.

- A boat is often used wherever the water is deep.

In general, farmers spray pesticide and fertilizer on the morning glory 2 to 3 days after the appearance of the new buds.

- For harvest collect only good quality morning glory and remove the leaves from the main stems. Bind them in a bunch of about 20 stems of 50 centimeters length of Morning Glory with a rubber band.

Note: In case the morning glory quality is not good, they may be harvested for pig food.
In the case of the whole rows of morning glory deteriorating in quality due to disease or poor water quality, the farmer should remove and replace them with new healthy plants.

4. Difficulties

Some difficulties which are often faced are as follows:

- Human health affected following application of chemicals.
- Waste water quality (contamination with industrial effluents) affecting morning glory growth.
- Storm surge, raft destruction by water hyacinth movement, hot weather.
- Skin problems of farmers due to exposure to waste water.

5. Remedy in using chemicals and pesticides

- Avoid spraying chemicals and pesticides during reversing wind direction
- Avoid spraying chemicals and pesticides when other people are closeby because poisons in wind could infiltrate into human body through skin and respiratory airways.
- Avoid smoking when spraying chemicals or pesticides because poisons could be absorbed inside body through smoking.
- Avoid fishing or collecting food within morning glory farm as poison could be transferred to human by those foods.
- Avoid washing or disposing of chemicals or pesticides wastes into water body
- Avoid eating or smoking before washing your hands after spraying chemicals or pesticides
- Children and pregnant women should not be allowed to be involved in spraying chemicals and pesticides.
- Avoid reuse of chemical and pesticide containers
- Chemicals and pesticide should always be labeled and kept in a safe, secure place out of reach of children and away from food.

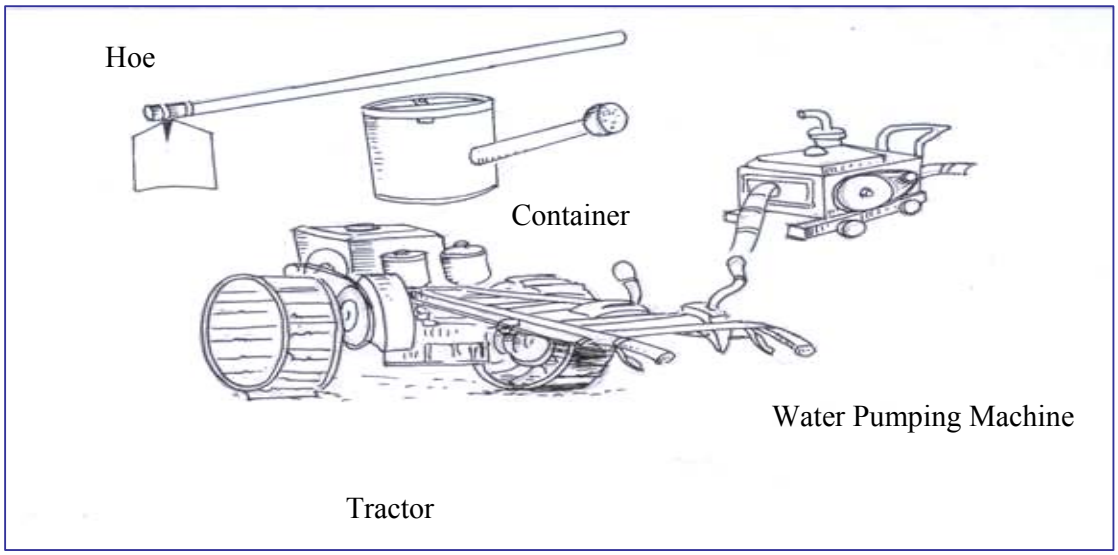
Water Mimosa Cultivation In Boeung Cheung Ek Lake, Phnom Penh,

Introduction

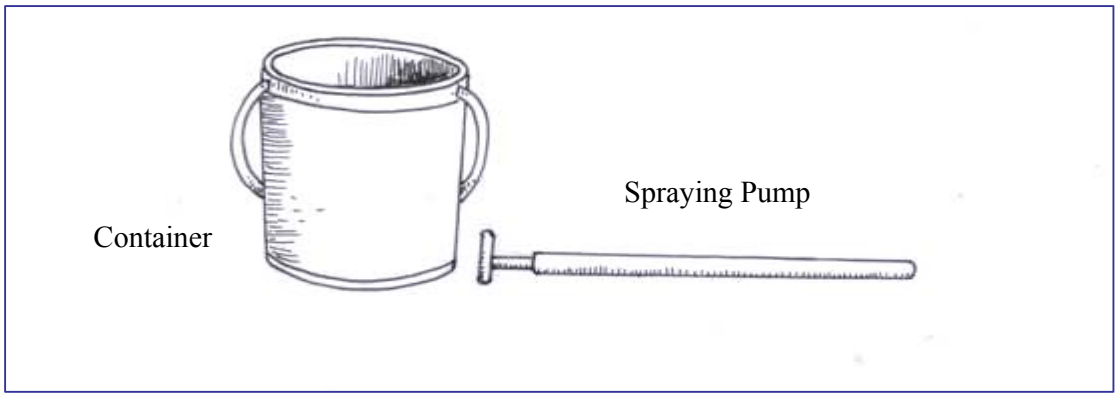
Water Mimosa is a popular aquatic plant cultivated in Phnom Penh which is eaten both cooked and uncooked. Water Mimosa requires a relatively easy growing technique with lower labor costs compared to other cultivated plants but it requires an area with water movement. Furthermore, Water Mimosa products can be harvested every day for both sale and home consumption.

1. Required Equipment

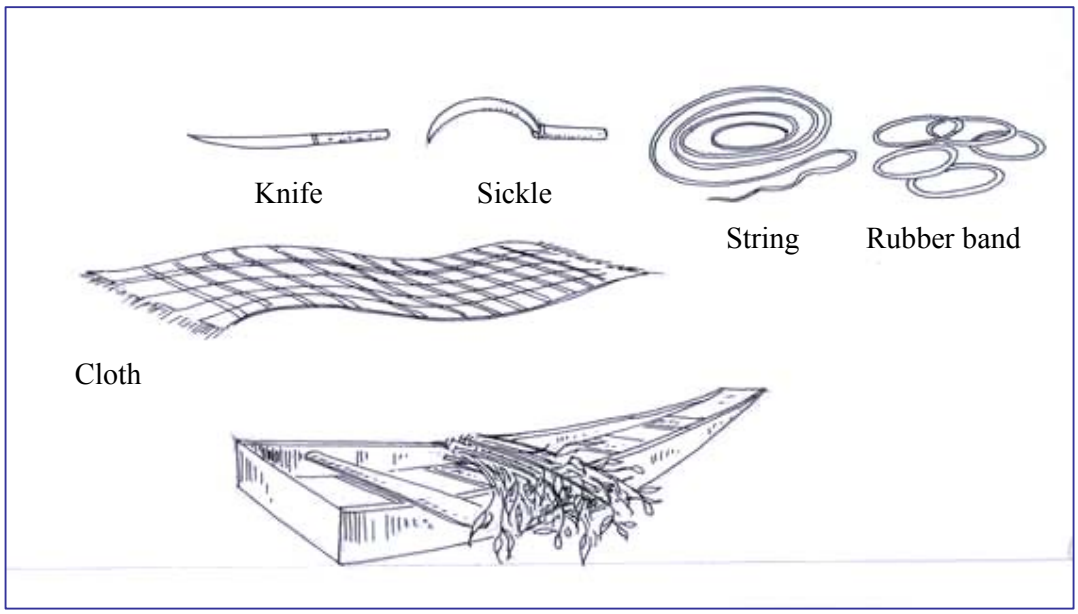
Equipment for Seedling Production



Equipment for Pesticide Spraying



Equipment for Harvesting



Boat

2. Cultivation Method

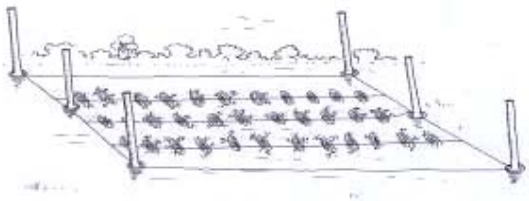
- Water mimosa is usually cultivated in peri-urban areas of Phnom Penh using the technique of being planted in a raft floating in rectangular/square shaped ponds. Thus the raft should be already prepared before the transferring the mimosa seedlings to the water.
- A pond area of 30 by 40 metres is the best for management and cultivation. There should be a water inlet and outlet which permits new water exchange through the cultivated area.

2.1. Pole preparation

Rafts should be prepared using wooden poles in a long rectangle shape of 40 metres long per each plot and each pole should be 3 to 4 metres apart from each other along the width of the plot, and then connected from one pole to another by ropes in the manner that they can be floated on the water surface. Poles should be prepared before braiding Water Mimosa seedlings.

Pole Preparing and String tying Activities

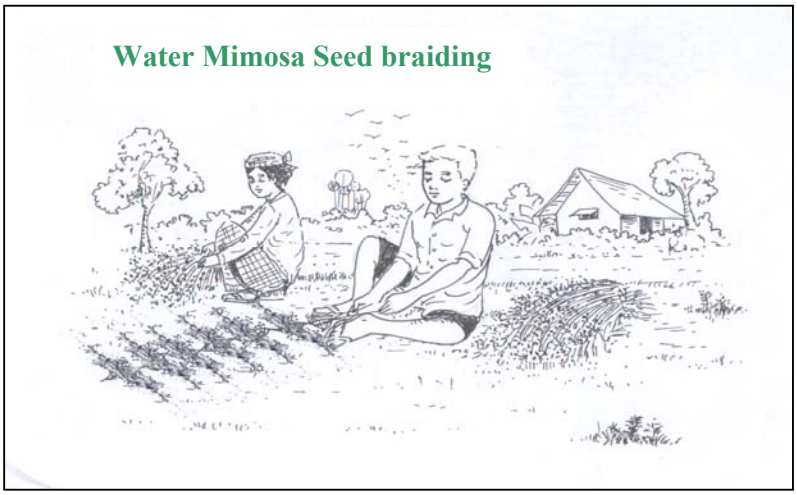
Water Mimosa Growing in the Lake



2.2. Water Mimosa Seedling braiding

The seedlings should be selected from another mimosa crop. Each should be 3 to 5 metres long with a big trunk and many stems twisted around by big white floating sponges.

Two selected seedling plants are put together facing opposite directions and braided with string in 20 to 30 cm between each knots. Once the braiding is finished, they should be attached to the poles which are already prepared in the water and another floating aquatic plant, duckweed, should be applied among the mimosa spaces on the water surface.



2.3 Mimosa Maintenance

In order to make water mimosa grow well, the farmer should regularly:

- Keep the floating mimosa bed/raft filled with in a suitable amount of duckweed to cover the open water surface
- Remove some duckweed when it is growing too thickly.
- Remove any weeds such as water hyacinth and snails as it is a prey of mimosa
- Keep monitoring Mimosa braided strings, ropes and poles
- When the mimosa's new growth buds have just appeared, pesticide and fertilizer should be applied.

Water Mimosa maintenance Activities in the Lake

2.4 Chemicals and pesticides commonly used

- **DDVP -50** made in Thailand (Called by farmer as Holding-Hand Brand) used for prevention of worms and white rust lesions (Kra).
  Active Ingredients: 2,2-dichlorovinyl dimethyl phosphate 50%W/V EC

- **Visher 25 ND** made in Viet Nam (known by farmer as One-Worm Logo) used for prevention of worms and grasshopper and white rust lesions.

- **V 80** (known as Carrying-Pumpkin Brand) made in Thailand, used for prevention of white rust lesions (Kra) and conditioning plant bud.
  Active Ingredients: Zine ethylenebis (dithiocarbamate) (polymeric) 80% W.P

- **Vicarben 50hp** used to stimulate new bud growing.

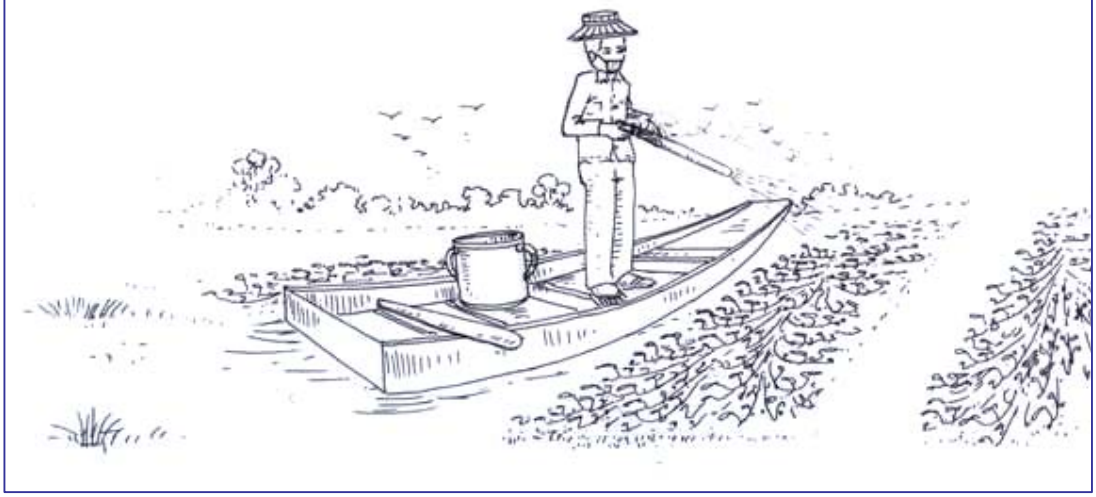
Farmers like to use these chemicals and pesticides for spraying on mimosa when buds are just newly grown and when the insects or diseases appear on the plants.

Normally farmers mix many kinds of these chemicals and pesticides together in one container and spray just once but this is not a recommended way. They should apply using concentration and dose given in the instructions on the bottle and packets.

Note: This booklet is not trying to promote the use of those chemicals and pesticides but sharing experiences from the farmers

Note: After applying chemicals and pesticides, mimosa should be left at least one week before harvesting.

Pesticide Spraying Activities



Warning: Please be aware that all kind of the above chemicals and pesticides can strongly affect human health, so before spraying, the sprayer should dress up your whole body with cloth and mask, and they should spray following the wind direction.

3. Harvesting

- Mimosa can be partially harvested after one month following planting. The plant stems should be harvested as much as possible each time in order to give chance for the plants to produce their new buds for the next time of harvesting.
- For harvesting, use the knife or sickle to cut the stems from both sides of the middle knots, and leave the stems 20 cm interval from knots in order to let the plant grow for later harvest.
- A boat is often used wherever the water is deep.
- After harvesting the mimosa their floating sponges will be removed and the stems bound into a bunch of about 10 pieces of 50 centimeters length with a rubber ring. The small branches can be separated from the main stems to sell by weight in plastic bags.

Notes: Mimosa can be harvested only during 3 to 4 month periods depending on water quality. The old plants should be replaced with new mimosa plants once they start providing a lesser product or deteriorating in quality due to disease or poor water quality

4. Difficulties

Some difficulties which are often faced are as follows:

- Human health affected following application of chemicals – insufficient wearing of safety equipment – masks, gloves etc.
- Waste water quality (contamination with industrial effluents) affecting mimosa growth
- Storm surge, raft destruction by water hyacinth movement, hot weather
- Skin problems of farmers due to exposure to waste water.

Overall Conclusions

It is hoped that the lack of technical guidelines and information on the commercially important cultivation of edible aquatic plants in Bangkok, HCMC, Ha Noi and Phnom Penh has to some extent been addressed in this Users Manual. However we would welcome any of our readers to contact us on the addresses, emails or telephone numbers below if they have further information on the cultivation of water mimosa, morning glory, water cress and water dropwort. We recognize that other aquatic plants/vegetables are cultivated in and around cities in the region and would also welcome our readers experiences and knowledge on how they are cultivated so that we will be able to incorporate this information into a second more comprehensive edition of the manual.

In response to consumers increasing concerns over food safety and eating healthier food the Papussa project has also been involved in trials of growing morning glory in peri-urban Bangkok in pond based production systems integrated with fish culture and without the use of chemicals. Results from these trials will be available from the project website www.papussa.org or through the contact person listed below in each city.

Meanwhile we would like to acknowledge and thank the considerable numbers of aquatic plant growers in the four cities who contributed towards making this manual possible, as well as helping to recycle waste water and maintain green and pleasant environments amongst the development and urbanization of their growing cities.

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