



AVRDC  
World Vegetable Center

# International Cooperators' Guide

October 2005  
AVRDC pub # 05-642

## ***Suggested Cultural Practices for Heading Chinese Cabbage***

*Tom Kalb and Lien-Chung Chang<sup>1</sup>*

### ***Introduction***

Chinese cabbage is a delicious vegetable that has been used extensively in Asian cooking for centuries. The crisp leaves are an excellent source of calcium, potassium, vitamin A, and folate.

Chinese cabbage refers to two groups, one heading and the other non-heading. This publication will discuss the production of the heading group, *Brassica campestris* L. (Pekinensis group) (Fig. 1). Commonly used names for this group include pe-tsai, celery cabbage, Chinese white cabbage, Peking cabbage, won bok, napa, hakusai, pao and bow sum. Within this heading group there are chihili types that grow erect and develop cylindrical heads, and che-foo types that form compact round heads of green-bladed, white-petioled leaves.

The other group, *B. campestris* L. (Chinensis group), is non-heading. This group includes pak choy, bok choy, Chinese mustard, celery mustard, chongee, and pe-tsai (overlapping with the previous group). This group is characterized by several thick white petioles and glossy green leaf blades that form a celery-like bunch. For information on growing this vegetable, read *Suggested Cultural Practices for Non-heading Chinese Cabbage*.

Heading Chinese cabbage is a cool season, annual vegetable. It grows best under temperatures of 15–20°C degrees. In the tropics, the production of this vegetable is typically limited to highland areas. When grown in the lowland tropics, crops easily succumb to diseases and may fail to form heads. AVRDC has developed heat-tolerant lines and samples of these lines are available upon request.



*Fig. 1. Heading Chinese cabbage*

### ***Treating seed***

To minimize damping-off and other seed-borne diseases, soak the seeds in 50°C hot water for 25 minutes and then in 1% sodium hypochlorite (80% water, 20% household bleach) solution for 10 minutes (sometimes this treatment is already done by the seed supplier). Seeds may also be coated with Thiram and Benlate to protect seedlings from fungi. Read the seed label carefully and follow the manufacturer's instructions.

<sup>1</sup>Information and Training Officer and Olericulturist, respectively.

## Growing transplants

Transplants are usually used to establish a uniform stand of plants. Transplants grown in cells or containers are ideal because they allow field planting without disturbing the root system.

Plug trays or containers are filled with a sowing medium. The medium should be disease-free and have a proper water-holding capacity. Adequate amounts of nutrients must be available for seedling growth. At AVRDC, we prepare a mixture of soil, sand, completely decomposed sugar cane compost and rice hulls with a ratio of 3:1:1:1 by volume. Add NPK fertilizers to supplement nutritional components in the medium. The amounts should be adjusted upon the available nutrient component of the soil and compost. At AVRDC, 500 g of ammonium sulfate, 500 g of superphosphate and 170 g of potassium chloride are used per one ton of soil.

Plug seedlings are raised under greenhouse conditions. Sow 2–3 seeds per pot at a depth of 0.5–1.0 cm. Optimum temperature for germination is 20–25°C. It takes 3–5 days for seeds to emerge. Thin the seedlings to one vigorous seedling per pot, when plants have two to three true leaves. After thinning, fertilize with a water-soluble fertilizer. Plug seedlings will be ready to transplant in the field three weeks after sowing.

Seeds may also be sown in seedbeds. The seedbeds should be fertile and well drained. The bed area can be incorporated with fertilizers at 40 g/m<sup>2</sup> ammonium sulfate, 50 g/m<sup>2</sup> superphosphate, 30 g/m<sup>2</sup> potassium chloride, and 2 kg/m<sup>2</sup> compost. Prepare seedbeds that are approximately 15 cm high and 1.0 m wide, and sow the seed in rows spaced 6 cm apart and 0.5 cm deep. Apply a thin layer of compost on the bed before mulching with rice straw and cover them with a mesh screen net. Thin seedlings at the first true leaf stage. They will be ready for transplanting in three weeks after sowing.

Cover seedlings with a fine-mesh nylon netting to protect them from heavy rain, hot sun, and virus-transmitting insects (Figs. 2, 3). If such netting is not available, construct a simple protective shed with cleft bamboo or similar materials, which allows adequate sunlight to reach the seedlings.

About five days before transplanting to the field, reduce water supply to the seedlings and expose them to strong sunlight to harden them. This will decrease transplanting shock. If transplanting must be delayed for some reason, a more intensive hard-



Figs. 2,3. Seedlings are protected with mesh netting

ening procedure is suggested to curb overgrowth of the seedlings. Just before transplanting, however, water the seedlings until the growing medium is thoroughly wet, or else the root system will be easily damaged when dislodged from pots.

## Selecting and preparing the field

Chinese cabbage grows well in fertile loam soils with a pH range of 5.5 to 7.5. Choose a site with good drainage and access to irrigation water. Rotate cabbage production with unrelated crops to prevent a build-up of pests and diseases. Whenever possible, green manure crops and paddy rice should be included in the rotation to improve fertility of the soil.

Form the bed with a plow by opening furrows to a depth of 20 cm during the dry season or at least 30 cm during the wet season. The distance between centers of two adjacent furrows is about 150 cm.

## Fertilizing

A combination of organic and inorganic fertilizers is recommended. Organic fertilizers improve soil structure, provide micronutrients, and improve the efficiency of nutrient uptake in the soil. Inorganic fertilizers provide major nutrients to plants in a form that is quickly available.

At AVRDC, we apply 10,000 kg/ha of compost before planting spring and winter crops. This is broadcasted on the bed and mixed in the top 10 cm of soil. No matter the season, an application of 60N–90P<sub>2</sub>O<sub>5</sub>–60K<sub>2</sub>O is done before planting. Do not apply too much basal nitrogen as it may increase internal head rot during the hot season.

Chinese cabbage develops most of its mass during the final third of its production period. Sidedressings at 10 and 20 days after sowing can increase yields. At AVRDC, we sidedress with 30N–

30P<sub>2</sub>O<sub>5</sub>–30K<sub>2</sub>O in spring and winter, but use lighter applications of 30N–7.5P<sub>2</sub>O<sub>5</sub>–15K<sub>2</sub>O in summer and fall. These recommendations are applicable to AVRDC soils where 120, 45, and 70 kg of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O are normally taken up to produce 45 t/ha of yield. Proper adjustments elsewhere should be made according to local soil conditions.

### Transplanting

Seedlings are ready to be transplanted after three weeks. The ideal transplant is 5–6 leaved, well hardened, vigorous and free from diseases (Fig. 4). Transplant in the late afternoon to reduce shock caused by heat and sunlight.



Fig. 4. Healthy transplant

Plants are planted in twin rows on raised beds. Space plants approximately 50 cm apart in rows (Fig. 5). A soil insecticide, such as diazinon, may be applied to prevent root damage caused by root maggots and cutworms (Fig. 6). Water the plants and then irrigate the field after planting is completed.

Irrigate each hill slightly using a small watering can so that the root system will adhere to the field soil immediately after transplanting, and then furrow-irrigate the field. If transplanting and top irrigation were done in the later afternoon, furrow irrigation can be postponed until the next morning.



Figs. 5,6. Holes are dug for transplanting and insecticide is applied to prevent root damage

### Irrigating

Chinese cabbage requires an ample water supply especially just after transplanting and at heading stage. Wide or rapid fluctuation in soil moisture of-

ten induces abnormal growth and brings about serious physiological disorders.

At AVRDC, furrow irrigation is practiced once every 10 days during the dry-cool season and once a week during the hot-dry season (Fig. 7). As a rule, the plants are irrigated if wilting occurs in the mid-day or early afternoon. Whenever irrigating, supply an adequate amount of water to saturate all the cultivated soil. Frequent but insufficient irrigation should be avoided.

Chinese cabbage is vulnerable to even a brief period of flooding. In the rainy season, excellent drainage is essential to plant survival and growth. Raised beds, cleanly weeded furrows, and clean, large drainage canals help to quickly drain off excessive water after heavy rain.



Fig. 7. Furrow irrigation

### Controlling weeds

Apply a pre-emergence herbicide just prior to transplanting. Choose the proper herbicide recommended by local extension specialists, and follow manufacturer's instructions on the label carefully. Frequent weeding is necessary in furrows. Weeds in furrows sometimes become unmanageable especially during the rainy season. In this case, a non-selective, post-emergence herbicide such as Roundup can be applied. Confine the spray strictly on furrows and avoid contact with plants. Spraying on a calm day using a sprayer with a nozzle shield may minimize herbicide damage to plants.

### Mulching

Rice straw is recommended for all seasons. Mulch provides partial weed control no matter the season. In the dry season, mulch also conserves and stabilizes soil moisture conditions. During the rainy season, mulch hastens the establishment of transplants by promoting root development in the upper stratum of soil. Mulch is also good for preserving the structure of the plant bed during the monsoon season. Apply straw perpendicularly to the rows at a rate of 5 t/ha (Fig. 8). Mulching should be done within a few days after transplanting.



Fig. 8. Mulched plants on raised bed

### Controlling insect pests

Insect pests must be controlled to ensure good yields of marketable heads. If applying insecticides, carefully follow the instructions on the label. Do not spray while leaves are wet. Most insecticides are poisonous so care should be taken during and after the spray. Consultation with local extension specialists is recommended to control insects using Integrated Pest Management (IPM) techniques.

#### Diamondback moth (*Plutella xylostella*)

This is the most serious pest of cabbage in the tropics and subtropics. Larvae of diamondback moth (DBM) eat nearly every part of cabbage plants at any stage of growth. Damage is most serious in the dry season. After emerging from eggs, DBM larvae feed on the underside of outer leaves, chewing out small holes between veins (Figs. 9–11). On young plants, the growing tips are eaten and seedlings appear stunted.

The control of DBM is very difficult since it is resistant to many insecticides. You can reduce DBM populations by regularly cultivating weeds and removing plant debris from the field. Regularly scout the field. If DBM populations rise, use natural insecticides such as neem or *Bacillus thuringiensis*. These pest-specific insecticides will not harm the valuable natural parasites of DBM. In fact in some temperate and tropical highland regions, parasites *Diadegma semiclausum* and *Diadromus collaris* effectively control DBM with minimal or no use of pesticides. In the lowlands, parasites *Cotesia plutellae* and *Trichogrammatoidea bactrae* are useful but less effective. These parasites need to be conserved by reducing the use of broad spectrum insecticides.

Seedlings may be protected using a nylon mesh net or plastic sheet covering. This method will post-

pone DBM infestation, reduce the need for control measures early in the season, and help to conserve natural enemies. In peri-urban areas where farm size is small, barrier nets can be used to exclude DBM. Use a 2-m high barrier net (32-mesh). At the top of the net, an additional 30–40 cm of netting should be stretched outwards and then down to make an angle of 80° against the net wall.



Figs. 9–11. Diamondback moth larvae feeding on leaves causing severe damage; adults are easily identified by their silver diamond pattern on back.

#### Aphids (*Myzus persicae*, *Hyadaphis erysimi*, *Brevicoryne brassicae*)

Aphids are most serious during the cool-dry season at AVRDC. The small, soft-bodied insects (Fig. 12) pierce leaves and suck the sap inside. This causes leaves to turn curl and yellow. Aphids create a sticky substance that can lead to a sooty mold to develop on leaves (Fig. 13). The pests prefer to feed on the underside of the leaves (Fig. 14), therefore, insecticides should be applied on the underside for effective control.



Fig. 12. Aphids



Figs. 13,14. Sooty mold damage; aphids feeding on leaf underside'

### Cabbage webworm (*Hellula undalis*)

This pest causes serious damage during the hot-rainy season. A single larvae that feeds on the growing point of the plant can make the plant unmarketable. Once damage is seen, it may be too late to take action. Spray three days after transplanting and once a week thereafter for 3–4 weeks.



Figs. 15,16. Cabbage webworm and its damage

### Striped flea beetle (*Phyllotreta striolata*)

Small, shiny black beetles feed on the undersides of leaves, creating numerous round "shot-holes" (Figs. 17,18). Seedlings can be killed if severe damage occurs. Generally, damage is more severe in the dry season. During dry summers, larvae attack the roots of plants and cause irreversible wilting.



Figs. 17,18. Striped flea beetles create holes in leaves

For quick control of large populations attacking seedlings, use insecticide sprays. Longer-term strategies include effective weed control, protecting seedlings with floating row covers or fine mesh netting, plowing fields after harvest to expose larvae, and introducing parasitoids *Microtonus epitricis*, *M. punctulatae*, *M. vittatae* or *Townesilitus psyllioidis*.

## Controlling diseases

### Downy mildew (*Peronospora parasitica*)

This fungus creates leaf spots that enlarge to form yellow areas on the upperside and mildew on the

lower side of the leaves (Fig. 19). A fluffy white growth appears on lesion surfaces (Fig. 20). Spots may appear on leaves, stems, seed pods and flowers. On leaves, spots are often confined by the leaf veins. Extended periods of leaf wetness caused by fog, rain, or dew are ideal for disease development. Downy mildew develops most rapidly when night temperatures are between 10 and 15°C. When night temperatures exceed 24°C, disease development is greatly restricted.



Figs. 19,20. Yellow spotting and close-up of white fungal growth on leaves

To control, avoid planting in wet, foggy areas. Select well-drained, well-aerated sites for planting. Remove debris from previous crucifer crops. Use fungicides if the disease is present and weather conditions favor the disease.

### Soft rot (*Erwinia carotovora*)

Infection occurs through wounds caused by leaf scars, insects or mechanical injury. The disease usually starts on the underside of the lower leaves near the soil surface (Fig. 21). Water-soaked spots appear, followed by brown or black discoloration of the vascular system. Soon, the entire plant rapidly rots with a creamy-white color and a strong smell. This disease usually becomes serious at the heading stage and is favored by rainfall and high temperatures.



Fig. 21. Soft rot symptoms

Chemicals cannot control this disease. Recommended practices to prevent infection include using raised beds, mulching with straw, removing crop debris, allowing crop residues to decompose before planting a second crop, rotating Chinese cabbage with cereals or other non-susceptible crops, spacing plants properly to allow ventilation, cultivating carefully to avoid wounding, and using rain shelters.

## Turnip mosaic virus (TuMV)

TuMV symptoms include mosaic and mottling, ring spot, malformation, discoloration and/or stunted growth (Fig. 22). The virus is spread by aphids. To control, protect seedlings in the nursery from aphids by using fine mesh net covers. Reflective mulches and insecticides are useful in field production. Resistant and/or tolerant cultivars are available and recommended.



Fig. 22. TuMV symptoms

## Controlling physiological disorders

### Tipburn

Tipburn is a calcium-related disorder. It causes browning along the margins of outer wrapper leaves (Fig. 23) or internal rot (Fig. 24). The development of a healthy root system during the early stages of growth will minimize this disorder. Avoid using excessive amounts of basal nitrogen since this leads to excessive initial top growth and marginal rotting. Use nitrate sources of nitrogen instead of ammonium sources. Mulch plantings with straw.

Spraying with calcium citrate is effective on internal rot. Dilute 25 g of calcium citrate to 100 liters of water and spray twice a week from four weeks after transplanting or from the beginning of heading stage at a rate of 1500 liters of solution per ha. Where soil calcium content and pH are low, liming is generally recommended to adjust the soil pH and meet the large calcium needs of cabbage crops.



Figs. 23,24. Calcium deficiency can create marginal browning and internal rotting

## Boron deficiency

This disorder causes brown streaks and corking of midribs (Fig. 25). To prevent in the future, apply borax or boric sulfate in the basal fertilizer. Borax contains about 10% boron. Apply 10–12 kg/ha and 20–45 kg/ha in mineral soil and muck soil, respectively. In acidic soils that have been heavily limed recently, double the rates.



Fig. 25. Boron deficiency symptoms

## Harvesting

Harvest heads when they are firm and compact. Prematurely harvested heads lack development of young, tender leaves and are light. On the other hand, over-matured heads may burst in the field.

To harvest, cut the entire plant just above the soil line (Fig. 26). Remove any ragged outer leaves. For heading types, keep two to three non-heading outer leaves around the head for protection during transport. ☞



Fig. 26. Harvesting

## References

This publication is a revision of :

Yoon, J.Y., R.T. Opena, and L.C. Chang. 1987. Cultural practices for Chinese cabbage at AVRDC. Shanhua, Tainan, Taiwan. Publication no. 76-272.

Additional references include:

Black, L.L. Vegetable diseases: a practical guide. AVRDC training guide.

Parker, B.L., N.S. Talekar, and M. Skinner. 1995. Field guide: Insect pests of selected vegetables in tropical and subtropical Asia. AVRDC, Shanhua, Tainan, Taiwan. Publication no. 94-127.

Stephens, J.M. 1994. Cabbage, Chinese -- *Brassica campestris* L. (Pekinensis group), *Brassica campestris* L. (Chinensis group). Univ. of Florida, Gainesville, FL, USA. Fact Sheet HS-569.