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Canopy Management Guide for Citrus Mandarin in Bhutan
2019

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Food Security and Agriculture Productivity Project



Foreword

The Department of Agriculture is pleased to bring out this extension publication titled “Canopy Management Guide for Citrus Mandarin in Bhutan.”

This guide is intended to help our extensions and citrus growers in promoting and implementing canopy management technologies to improve the yield and overall sustainability of the citrus industry in Bhutan. The authors have put in their best efforts to keep the content simple and understandable. The Australian Council for International Agriculture Research and the Japan International Cooperation Agency funded projects have played a key role in taking forward citrus research and development in Bhutan. Capacity development being the integral part of the project has resulted in significant growth of expertise in citrus research and development. Our professionals are now more innovative, and regularly put together new technologies in response to the growing needs of our farmers.

Canopy management technology is one of the outcomes of years of regular observations, field experiences through practical engagement, and scientific innovations of the agriculture officers who were directly involved with these donor funded projects. The manual is also a culmination of extensive review of available literature, video guides and field guides published elsewhere by pioneers on the subject. The authors have also sought exhaustive consultation with relevant colleagues to make the guide technically reliable and relevant to the industry.

As a large proportion of citrus growers in the country are still not aware of canopy management technologies and other required management practices, we consider the publication of this guide as timely addition to the extensive technical information already generated over the years. Therefore, I commend the efforts put in by the authors in critically reviewing and coming out with this important guide. We at the department hope that our field colleagues and citrus growers find it useful. I also extend our sincere appreciation to the donors for their continued goodwill and funding support.

Tashi Delek



Kinlay Tshering (Ms)
DIRECTOR
Department of Agriculture

Acknowledgement

The preparation of this guide basically started much before its formal discussions through the gathering of information from field practices, observations, literature and documentary reviews. It also involved extension feedback from the citrus growers themselves. We thank the citrus growers and our field colleagues for their interests and in supporting us in developing this practical guide. We also deeply acknowledge all other sources of information without which many of the technical specifications and other contents in this publication would not have been adequately verified.

In response to a declining industry due to poor management practices and fast aging trees, numbers of directives were made from the department to devise appropriate canopy management technology guide to ensure farmers are able to implement management practices to sustain citrus production. An extensive deliberation on the development of guide was held in Tsirang in May 2019 amongst key experts with significant field experiences. This has to a large degree helped to finalize the documents with further improvement. We thank all the participants and the key technical experts in particular for their contribution. We also extend our gratitude to the department for regular guidance and support.

Lastly, we thank the Food Security and Agriculture Productivity Project (FSAPP) for fund support in organizing the workshop/write-shop to develop this guide, and for the support in printing this document. We welcome critical comments and suggestions if any, for further improvement of this edition of the guide.

General Concept

Importance of canopy management in citrus mandarin



Crowded and unproductive branches



Fast declining of the orchards if not pruned regularly



Too many fruits, but are small and of poor quality



Long ladders required to harvest and labour-intensive

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1 Background

Citrus is a genus of flowering trees and shrubs under Rutaceae family. The citrus mandarin (*Citrus reticulata* Blanco) is the main type of citrus cultivated in Bhutan, and it constitutes more than 95% of the total citrus production in the country.

The citrus mandarin is the major horticultural crop grown in 16 Dzongkhags by over 22,158 households. As of 2018, the area under citrus mandarin was about 16,407 acres with estimated production of 26,500MT. The average annual export and income generated over the last 11 years from citrus mandarin was about 21,000MT and Nu. 450 million, respectively.

However, the national average yield of 3.5 metric ton per acre is very low compared to the average yield of other citrus growing countries in the world. The low yield is attributed to inadequate and limited adoption of suitable orchard management practices. Citrus growers in Bhutan still continue with traditional system of orchard management, mostly leaving to the forces of the nature.

2 Canopy management

The citrus orchard management practices remained almost primitive in Bhutan until Australian Centre for International Agriculture Research (ACIAR) Project initiated and demonstrated citrus mandarin canopy management practices in selected orchards in 2010. At around the same time, JICA projects trained farmers and extensions in Eastern Bhutan on citrus management practices such as planting method, nutrient management, pruning & training including top working, fruit thinning and post harvest

management practices. Since then, citrus growers have been slowly adopting the management practices in their orchards. However, the citrus canopy management practices being still new to the citrus growers, the adoption rate is low; affecting the yield and quality. In addition to more labour required for orchard management and harvesting, water and nutrient use efficiency are also affected if the tree canopy is not managed properly. The low adoption rate of canopy management practices is also leading to rapid declining of citrus industry in the country.

3 Importance of canopy management

The importance of citrus mandarin canopy management is to:

- control tree height and width for ease of management practices
- rejuvenate fruit bearing woods on a regular basis
- improve light and air penetration into canopy
- remove dead and diseased branches, unwanted watershoots and unwanted growth
- manipulate crop load and reduce alternate bearing habit of the tree
- manipulate fruit size and improve fruit quality
- reduce the tree canopy area to reduce water and nutrient requirements
- increase the efficiency of labour at the time of harvesting

4 Important considerations for canopy management

While planning and implementing the canopy management practices, it is important to consider the following parameters:

- i. Adoption of appropriate pruning operations
 - a. Pruning techniques
 - b. Time of pruning
 - c. Pruning frequency

- ii. Tree structure and its type
- iii. Age of the tree
- iv. Use of appropriate tools/implement/equipment
- v. Use of disinfected/sterilized pruning tools, and their proper storage practices
- vi. Use of safety gears
- vii. Correct technique of preparation and application of Bordeaux paste/spray
- viii. Preparation of trench/basin for water and nutrient application
- ix. Appropriate application of nutrient and water
- x. Proper selection of shoots after re-growth
- xi. Use of other appropriate plant protection chemicals

5 Pruning tools

Citrus mandarin farmers in Bhutan hardly prune their trees because of the myth that trees will die if branches are removed or pruned. Even if they do pruning, they either use sickle, knife, dagger, or even axe. These types of tool damage the branches and leaves; the pruned branches get split apart and wounds over the time get aggravated. The split branches take long time to heal or do not heal at all and also the tree gets exposed to pests & diseases, impacting the overall health of the tree. In order to make clean cuts without damaging the branches and also to increase the efficiency and effectiveness of pruning operations, the following tools and accessories should be used;

- i. Pruning or horticulture saw
- ii. Secateurs
- iii. Budding knife
- iv. Loppers
- v. Top pruners
- vi. Power chain saw
- vii. Ladder (Wooden, bamboo or metal)



Figure 1: Tools for pruning

6 Disinfecting tools and equipment

The tools and equipment used for pruning operations should be cleaned and disinfected in order to prevent the spread of diseases from tree to tree and orchard to orchard. Cleaning, disinfecting, and lubricating will also help to increase working life of the tools and equipment. Following process of cleaning and sterilization should be followed:

- ✓ Clean the tools and equipment with boiled water added with salt
 - ✓ Wipe them and dry with clean cloth immediately after cleaning, or otherwise the tools will get rusted easily
- ✓ Ideally, disinfect the tools and equipment with ethanol (75%)
- ✓ Apply WD 40 (Mobil) or locally available oil after use and before storage

7 Safety gears

Farmers and field practitioners hardly or never use safety gears while performing pruning operations. This unhealthy, unprofessional and risky work habits can leave the farmers or operators wounded and even permanently disabled. The following safety gears should be worn during pruning operations to prevent physical injuries:

- i. Safety helmet
- ii. Safety work boots or gumboots
- iii. Safety goggles
- iv. Working gloves
- v. Mouth mask or aspirator
- vi. Ear plugs



Equipped with complete safety gear



Figure 2: Safety gears for pruning

8 Time of pruning

Citrus mandarin should be pruned right after harvest and before the bud break. However, dead woods and watershoots could be removed at any time of the year or seasons.

9 Types of pruning

There are three types of pruning:

- i. Training pruning
- i. Corrective pruning
- ii. Maintenance pruning

9.1 *Training pruning*

It is done right from the planting of seedlings/saplings. It is done to achieve the following objectives:

- ✓ To get a good shoot to root ratio
- ✓ To get a desired shape of a tree
- ✓ To minimize growth of undesirable or unwanted branches
- ✓ To optimize the use of available soil water and nutrient

9.2 *Corrective pruning*

It is done to bring standing or growing trees into a desirable shape and size. Corrective pruning is mainly required for trees which have not been trained through pruning operations on time after planting. Most of citrus mandarin trees in Bhutan require corrective pruning. The corrective pruning can be extreme to moderate depending on current shape and size of the trees. It is very important to make owners of unpruned or untrained trees to understand the necessity of varying degrees of pruning required in order to bring their trees to a desirable shape and size. It is also important to convince them by explaining the assured results such as yield improvement and fruit quality; production sustainability and to reduce the chances of early decline.

9.3 *Maintenance pruning*

It is done to remove watershoots, deadwoods, damaged branches and twigs, pests infested branches and twigs, crossing limbs or branches, acute angled

branches, and clustered branches. The watershoots and unwanted shoots at a very early age can be easily removed by brushing off with hands during the months of March, April and May.

10 Desirable shape of a citrus mandarin tree

A desirable shape and size of a citrus mandarin tree is highly variable depending on grower's choice, location, and most importantly from the operational health and safety concerns. In general, the desirable shape and size of mandarin trees should be:

- i. 2 to 5 meters tall in height of the canopy
- ii. 2 to 5 meters wide canopy
- iii. 4 to 6 number of primary (scaffold) branches
- iv. primary branches at atleast 1 meter above the ground level

However, the width of the mandarin tree canopy may be as wide as possible but should not touch or shade over the adjacent trees and must easily allow all kinds of management operations. The height of the scaffold branches can also be maintained based on the understory crop cultivation choices.



Figure 3: Rejuvenated orchards in Thangna and Kilkhorthang

11 Methods of pruning

11.1 What to prune?

Pruning is the removal of undesirable and unwanted stem, branches and twigs. In citrus mandarin, the pruning is done to remove:

- ✓ clustered branches which are often quite long
- ✓ dead branches due to pests or injury
- ✓ diseased and *Loranthus* infested branches
- ✓ branches damaged during the harvesting operations or due to heavy fruiting or by windstorms
- ✓ crossing branches which may be of different sizes
- ✓ acute angled branches that go straight up or that are horizontally spread
- ✓ over grown water shoots which have not been removed in time
- ✓ stumps greater than 2.5cm left during pruning operations
- ✓ previous season's fruit bearing twigs
- ✓ main trunk or stem if there are more than one and clustered
- ✓ aged and declining trunk or branches to stimulate the re-growth for complete rejuvenation

11.2 How to prune?

Farmers are very reluctant to prune any fruit trees including citrus mandarin trees. The myth that pruning unwanted branches would cause the whole tree to die or reduce fruit production still prevails among the farmers. On the contrary, pruning undesirable stem, branches, and twigs will not only improve fruit quality, but will also help to sustain the production for a longer period. Therefore, the farmers should not hesitate to prune fruit trees as long

as they prune them technically correct and with utmost care to minimize all sort of stress that might be induced at the time of pruning operations.

At the time of pruning, the following pruning process and techniques should be followed:

- i. Use appropriate and disinfected tools and equipment
- ii. Use right tools and equipment for right operations
- iii. Use safety gears in order to prevent accidents and ensure personal health safety
- iv. Prepare mental maps of branches to be pruned before climbing on to trees or pruning off the branches
- v. Use ladders, bamboo poles, or wooden poles to climb trees if necessary
- vi. Cut long secondary branches to about 50cm to 60cm back to scaffolds branches to '*regenerate new shoots and branches*' and ultimately to reduce the heights of the trees
- vii. Irrespective of tools or equipment used for pruning, always cut off the branch, especially the heavier ones at 30-50cm above the final removal point in order to reduce its weight and prevent the splitting of branches or stem at the time of cutting off. In order to avoid the splitting of branches:
 - Use overcut and undercut methods
 - Use three-point system to remove branches
 - Make one overcut above 30-50cm from the final cut point; one undercut about 25-45cm from the final cut point; and then finally cut off the branch (Fig. 4)
- viii. Remove or prune branches as close to collar region as possible
- ix. The stump remaining after pruning should not be longer than 2.5cm.

- x. Make slanting cuts (45°) as far as possible to prevent water stagnation and disease infection
- xi. Branches bigger than 2.5cm should be removed by using pruning saw while smaller ones could be removed by secateurs or loppers
- xii. Use top pruner to headback branches which are way up in the canopy
- xiii. Cut wounds greater than 2.5cm diameter should be treated with wound sealant or must be applied with Bordeaux paste

The wound healing becomes difficult if the stump left after pruning is longer than 2.5cm. Always ensure that stump is cut as close to collar region as possible.



Figure 4: Methods of pruning a heavy branch using three-point system



Figure 5: Collar region



Figure 6: Dead stump at collar region



Figure 7: Improper removal of stump base



Figure 8: Dead stump after pruning



Figure 9: Flat cut, water stagnation and fungal infection



Figure 10: Healing with free of diseases infection on cut surface

12 Preparation of Bordeaux paste

The following materials⁵ are required to prepare Bordeaux (Bordo) paste:

- Copper sulphate (pentahydrate) or blue crystals
- Slaked lime or hydrated lime
- Water
- Plastic or wooden buckets or earthen pitcher
- Bamboo or wooden sticks
- Polished nail or any polished iron surfaced tool

12.1 Bordeaux Paste preparation procedures

- Dissolve 500 grams of Copper Sulphate (bluestones) in 2.5 liters of preferably warm water in a plastic or wooden barrel or earthen pitcher
- Mix/dissolve 500 grams of quicklime in 2.5 liters of water in a separate plastic or wooden bucket or earthen pitcher
- Pour the Copper Sulphate solution to lime mixture with constant stirring (not the other way)
- Dip a polished or bright metal surface into the solution for 2-3 minutes to test the presence of free copper in the mixture
- Add more lime powder if copper deposits are observed on the polished metal surface
- Add some sugar (100-150 grams) to keep the hydrogel mixture more stable and delay formation of crystalloid
- Bordeaux paste is more effective when used fresh

It is always recommended to prepare a fresh paste for every use. At present, Bordo paste is prepared and used to dress cut wounds and paint one meter of a citrus tree trunk from the ground level.

⁵ *Never use aluminum or metallic bucket*



Figure 11: Preparation of Bordeaux paste



Figure 12: Bordeaux paste application on tree trunk

“Some literature prescribes preparation of Bordeaux paint with 1kg Copper sulphate, 2kgs of quick lime and homogenize in 3 liters of boiled linseed oil before adding 30 liters of water.”

12.2 Bordeaux mixture preparation

- Dissolve 500 grams of copper sulphate in 2.5 liters of preferably warm water in a plastic or wooden barrel or earthen pitcher
- Mix/dissolve 500 grams of quick lime in 2.5 liters of water in a separate plastic or wooden bucket or earthen pitcher
- Pour the copper sulphate solution to lime mixture with constant stirring (not the other way)
- Dip a polished or bright metal surface into the solution for 2-3 minutes to test the presence of free copper in the mixture
- Add more lime powder if copper deposits are observed on the polished metal surface
- Add some sugar (100-150grams) to keep the hydrogel mixture more stable and delay formation of crystalloid
- Add 45 liters of water to the above mixture to prepare Bordeaux mixture.

13 Preparation of trenches for irrigation and fertiliser application

The technique to dig a trench to irrigate and create soil water reservoir for each tree depends on the site situations and the location of the orchards. Digging a trench to increase soil moisture is a widely adopted practice in permaculture.

The following steps should be followed while preparing the trench and applying fertilizer:

- The trench should be dug during or after harvests season and before bud break of citrus mandarin trees
- Prepare a trench of 45cm width and 45cm depth. It should be one meter away from the tree trunk and must be on the upper side of the slope
- The trench should be prepared along the direction of the natural flow of surface run-off water down the tree trunk
- The length should be as long as the drip line of the tree
- Roots encountered when digging the trench must be properly pruned using secateurs or pruning saw
- Add manure and fertilizers in the trench. The manures and fertilizers should be added based on soil test result⁶
- Apply 300-600 grams of Suphala per bearing tree in January-February. Supplement the required amount of NPK through use of straight fertilizers. Generally, citrus perform well with 2:1:1 NPK contents. Apply 100-150 grams of urea per bearing tree in May-June, and August-September
- Add water till the trench is filled as mandarin trees prefer deep and long irrigation water regime

⁶ This is based on the soil test results of Dagana and Tsirang Dzongkhags.

- Add locally available mulching materials such as paddy straw, grass and weed clippings, crop stubbles, and dry leaves. Add water as and when soil in the trench cannot be formed into a ball shape

“The above steps should be repeated every year”



Figure 13: Trenches for manure/fertilizer and water storage



Figure 14: Water harvesting pond and drip lines for irrigation

14 Shoot selection in the following years

Citrus canopy management is incomplete without the proper selection of new shoots in the next two years after removal of undesirable stems and branches. Leaving all the new shoots without selection is a major mistake in the citrus canopy management.

The following steps of shoots selection must be followed:

- Remove all new shoots sprouting at the base of the removed or pruned branches
- Remove all new shoots sprouting at the base of removed trunk(s)
- Remove all new shoots sprouting on surfaces of primary and secondary branches
- Remove all new shoots sprouting on internal surfaces of branches pruned for regeneration purpose
- Remove undesirable shoots from the outer surfaces of pruned branches leaving three to four in the first year depending on number of new sprouts
- Remove undesirable shoots from the outer surfaces of pruned branches leaving two to three in the second year depending on health of the shoots
- Remove undesirable shoots from the outer surfaces of pruned branches leaving one to two in the third year depending on health of the shoots

14.1 Managing shoots

- Remove water shoots which sprout in the months of May, June, July and August
- Unwanted new shoots can be removed by brushing off with hands in March, April, and May when the shoots have just sprouted or when it is tender and soft
- New shoots which are not removed when young should be cut off by secateurs
- The shoot selection must be followed every year



Figure 15: Management of new shoots growth after pruning

15 Height Reduction

Mandarin trees can grow up to 8 meters or slightly even taller. Tall trees pose serious challenges for production management and harvesting operations. The canopy management, spraying, and harvesting become difficult if the height of a tree is very tall. Apart from more labour requirement for the management and harvesting, the efficiency of nutrient and water are also affected.

The existing citrus mandarin trees have many branches which are not differentiated and maintained as primary, secondary, tertiary and fruiting branches. Some branches are single, bifurcated, and with more than two secondary branches. Preferably, the height of citrus mandarin tree should be maintained at 2-5 meters above the ground. The following practices are recommended while reducing the tree height:

- Target those branches which are bifurcated or have more than two branches
- Head back one of the branches to 50-60cm and allow it to regenerate
- Manage the regenerated shoots so that two or three strong shoots are

selected, pruned, and trained

- Once the selected branches come to full bearing in two to three years, head back the other branches in such a way that new shoot growths will not become crowded with the existing shoots
- The tree should be monitored regularly and its height maintained to ease cultural operations and the harvesting



Figure 16: New flushes and heading back points

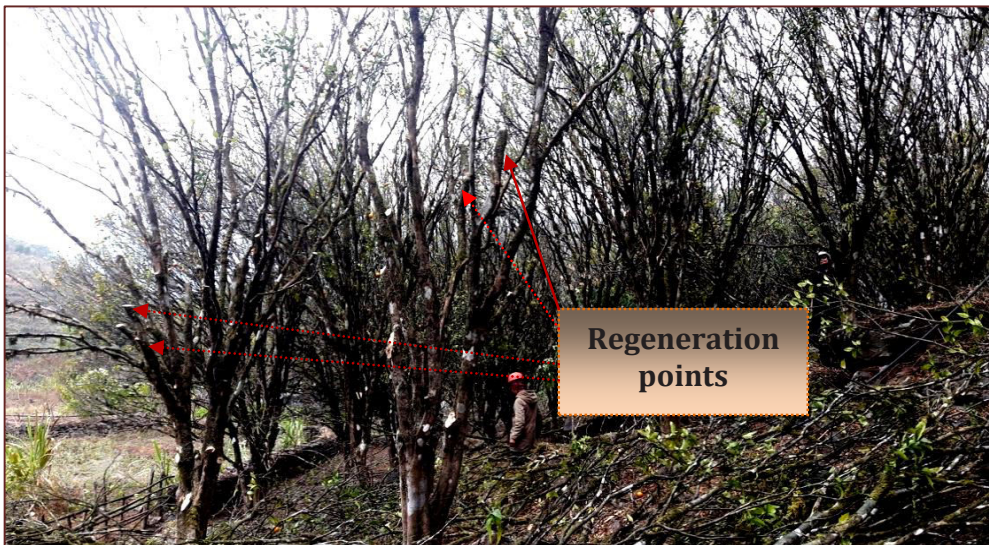


Figure 17: Pruning for rejuvenation



Figure 18: Fruiting after canopy management in Drukgyalgang

16 Pruning and training of a young tree

The following steps should be followed while pruning a young tree:

- Head back half of the previous seasons' shoot growth while planting
- The tree should be pruned and trained after allowing its growth for 3-4 years
- Select 3-4 primary branches and maintain them at the crotch angle of 45°
- Remove water shoots in time by brushing off with hands when it's tender or remove latter with help of secateurs
- Remove dead, diseased, damaged and dysfunctional branches
- Prune crossed limbs, clustered branches, and almost vertically growing branches
- Remove about 15-20% of the canopy every year to maintain a desirable tree structure and also to produce quality fruits

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