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Mango Orchards: Canopy Management for Plant Protection

Several canopy measuring instruments like Convex Spherical Densiometer, Angular Densiometer, Canopy-scope, Moosehorn, etc., are used to estimate the canopy cover of trees. Most of these instruments do not directly display the readings of the canopy cover and also require some computational and technical skills to operate. These limitations restrict the use of such instruments by the orchardists in India. To overcome these bottlenecks, few software developers have developed mobile apps like Canopea, Canopy Cover, Canopy Capture, etc. for android platform which instantly process the image and display the reading of canopy cover in percentage. By using such apps, canopy of mango trees can be pruned to optimum for healthy tree and quality fruit production.

MANGO (*Mangifera indica* Linn.) is one of the most important tropical and subtropical fruits of the world. It is commercially grown between 23° North and 24.5° South latitudes. Due to the wide adaptability of mango trees, it is commercially cultivated in almost all parts of India except the temperate zone. The different edapho-climatic conditions of different regions lead to variation in the growth and development of trees and also lead to variation in the incidence and susceptibility to different types of insects, pests and diseases, for eg. Anthracnose can become a serious problem for mango cultivation in humid or high rainfall areas where fruits are exposed to the direct contact of pathogens which causes blackening of the peel and make the fruits less attractive. This is due to the high vegetative growth of the tree which causes poor light interception and air circulation in the lower parts of the canopy. The reduced air flow creates a microclimate that traps moisture in the orchard and increases the humidity, which is conducive to the rapid multiplication of insect-pests and diseases. Similarly, the trees having dense inflorescence and orchards with closer spacing are severely affected by hoppers (Reddy and Dinesh).

Mango mealybug (*Drosicha mangiferae*) is a polyphagous, dimorphic and notorious pest of mango orchard. The nymphs and females suck sap from tender leaves, shoots, panicles and fruit peduncles thereby affecting fruit set and causing premature fruit drop. Infested plants are also prone to sooty mould (*Capnodium mangiferae*), a fungal infection, due to which photosynthetic activity is affected. Similarly, dense canopy also favours fruit flies. Its damage is higher in high density orchards as flies have more chance to access a greater number of fruits per unit area. Mango shoot gall psylla (*Apsylla cistellata* Buckton) popularly known as *Ghundi rog* in Uttarakhand is recognised as the most noxious pest owing to its ability to transform reproductive and vegetative buds into galls results in poor to no fruit setting on affected plants. Since the last two-three years, major mango producing belts of the state (Almora, Nainital and Dehradun districts) have been facing severe incidents of shoot gall psylla. Several studies indicated that diseases like powdery mildew (*Oidium* sp.), anthracnose (*Colletotrichum gloeosporioides*) is also influenced by tree spacing and canopy orientation.

The disease reduction is directly by increased light intensity, which is altered by canopy architecture manipulation. The distribution of pests within tree canopy is heterogeneous. It is obvious that under higher planting density, plant canopies overlap into the rows, reducing light incidence on leaves, thereby making the tree canopy dense and compact which encourages more pest and disease incidence. Therefore, it is a well-established fact that the maintenance of optimum canopy cover by judicious removal of selected branches as well as the central opening of trees facilitates sunlight penetration throughout the canopy. This orchard management practice checks disease and pest infestation thus very important for harnessing production potential of mango trees with minimum application of pesticides.

Major disease and pests in dense canopies

A systematic survey was conducted in the uniformly managed orchards of ICAR-Indian Institute of Soil and Water Conservation Research Farm, Selaqui, Dehradun (Uttarakhand) during the year 2018 to record the incidence of disease and pests under various densities of tree canopies. Preliminary observations revealed that very dense canopies favour the development and multiplication of pests such as hoppers, mealy bug, mango psylla, fruit flies and diseases such as anthracnose and sooty mould

while thin canopies adversely affect fruit yield. Based on this observation, studies were conducted to minimise the incidence of these pests and diseases by standardizing tree canopy density so that economical, optimum and disease free production of mango fruit could be achieved.

Methods for the estimation of densities of tree canopies

Several specially designed instruments are used in forest studies to estimate canopy cover. Few of them are discussed below:

- **The convex spherical densiometer** is a pocket-sized instrument that uses a convex mirror with a grid of 24 squares. Canopy cover is calculated from the number of squares on the mirror filled with vegetation.
- **The angular densiometer** has a convex mirror, a compass, a bubble level, and a fixed eyesight. It produces a clearer image and a more exact estimation of canopy cover than the convex spherical densiometer.
- **The moosehorn** uses 25 dots on a 5 × 5 grid on a transparent screen; the dots covered by canopy are counted through a side aperture to give an estimate of the vertical projection on the canopy.
- **The canopy-scope** is an improvement on the moosehorn and uses the same principle of 25 dots on a 5 × 5 grid. This instrument is affordable, compact, and accurate. It has the advantage of being less prone to user error compared to other tools.
- **The vertical tube** is a 20 cm-long brass tube mounted in such a way that it hangs vertically. It is used to measure crown projection but requires many more points of observation within a given area compared to other methods.
- **Single-point and handheld light sensors** estimate the light that comes through the canopy cover. They do, however, need a reference measurement under an open and clear sky. The disadvantage of this method is that it measures only light transmittance.
- **Hemispherical photography (HP) and digital analysis** use the fisheye lens approach and produce the most accurate measurements. It can be used for estimating canopy cover, light transmittance, leaf area index and photosynthetically active radiation. It is suitable for tree level measurements of crown architecture dimensions, and density. These estimates are scalable, as they are related to stand level canopy cover.

It is clear from the above description that estimating canopy cover by these methods requires some operational and calculation skills and their readings are also not instant. This is a bottleneck which restricts the use of these techniques in the farmer's field. This problem has

Mango hopper under dense canopies of the orchard

Sooty mould under dense canopy of the orchard

Mealy bug on new growth under dense canopy

Shooty mould on fruits of Cv. Mallika under dense canopy

Anthracnose on new leaves under dense canopy

Severe infestation of shoot gall psylla under dense canopy of mango Cv. Mallika

already been addressed by various researchers and they have tried to develop mobile based various software like Canopea, Canopy Cover, Canopy Capture, etc., for instant processing of the canopy images and output in form of percent canopy cover. These software were thoroughly evaluated in the field conditions for the estimation of canopy density of mango trees. The software 'Canopy Capture' was found suitable for the study and used for the same.

Evaluation of optimum tree density for mango

A holistic approach to pest control by canopy management was evaluated in this study to obtain the potential yield of mango. The tree canopy is regularly monitored through Canopy Capture application installed on the android mobile.

Method to estimate canopy through Canopy Capture app

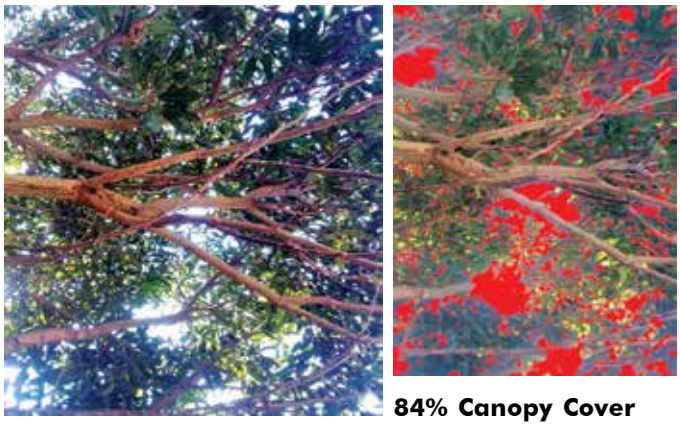
First of all, download the Canopy Capture app from Play Store and install it on Android phone. Open the app and go under the tree canopy see the image of canopy (whose cover percentage is to be extracted) in the screen and set the mobile screen according to the guiding arrows (appears in green colour). When all four sides of the mobile screen show green outline and the guiding arrow disappears, click photograph by tapping on screen. First it will display the image of canopy and then in the next step will show percentage canopy with photograph. Since this software is based on the quality of the photograph and the camera, there is a possibility of error in the reading due to a low quality photograph, which can be easily pointed out by comparing the canopy photograph and the reading photographs. In the processed image, the software displays the non-canopy portion in red and displays the canopy portion in canopy percentage in that particular photograph. It is recommended to record 2-3 readings to obtain the correct canopy cover so that errors, if any, can be double-checked and corrected.

Method for recording observation in respect of insect pests and diseases: Observations under different canopy percentage were recorded in respect of following pest and diseases which are prominent in the region.

Following canopy densities were maintained and the observations in respect to insects and pests infestation were recorded respectively.

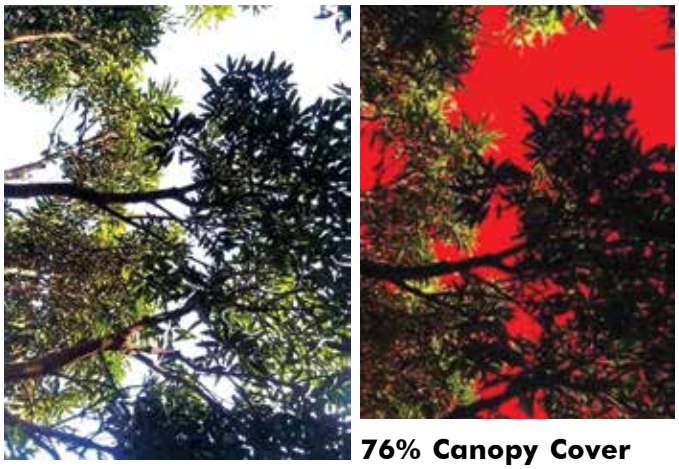
A. Control, no pruning operations > 80% canopy cover.
B. Trees pruned to obtain 76 to 80% canopy cover.
C. Trees pruned to obtain 70 to 75% canopy cover.

It is clear from the data mentioned in Table 1 and 2 that maintaining canopy cover between 76% to 80% by regular pruning of mango trees helps in controlling mango mealy bug 44.2%, mango leaf hoppers 85.02%, shoot gall psylla 66.1%, sooty mould 69.3% and mango malformation 74.3% in comparison to the control (no pruning- canopy cover above 80%) in the mango orchards of Doon Valley. Maintaining canopy cover between 76 to 80% also helps in improving fruit yield by 24.7, number of fruits per tree by 26.8% and average fruit weight by 11.1% over control. This significant control over pests and diseases is



84% Canopy Cover

Canopy cover reading recorded before pruning using Canopy Cover app



76% Canopy Cover

Canopy cover reading recorded after pruning using Canopy Cover app

attributed to the integrated effect of proper air ventilation in the orchard and sunlight exposure to the lower parts of the canopy, stem and orchard soil.

CONCLUSION

A canopy management practice in mango orchards is helpful in effective management of various insects, pests and diseases for sustained production of disease free quality fruit. Maintaining canopy cover between 76 to 80% is ideal for efficient light utilization for photosynthesis and elimination of parasitic leaves and branches. Judicious pruning of tree canopy helps in penetration of sunlight in the lower portion of the canopy, and orchard soil and facilitates circulation of air deep inside the orchard which ultimately reduces the formation of humid microclimate inside the canopy. Reduction in the severity of pests and diseases can eventually lead to reduction in the cost of cultivation and thus improve the socio-economic status of the orchardists.

Application of mobile app like 'Canopy Capture' is very helpful in pruning operations to maintain desired canopy cover. Some studies on the effect of canopy management on population dynamics of mango pests have been conducted by some investigators using various canopy measuring equipment which is time taking, needs operational skills and not practicable to implement in the farmers field. Using of mobile app for the estimation

Name of disease and pest	Procedure for observation
Mango mealy bugs	Counting number of mealy bugs infested shoots from each direction of the selected trees counted during season of infestation.
Mango leaf hoppers	Number of nymphs and adults were visually counted (by using photographs) on a single leaf from each direction of the selected trees.
Shoot gall psylla	Number of infested terminal shoots out of five shoots from each of the four directions of the selected tree.
Sooty mould	Infestation was recorded using following disease scoring scale. 0 : No infection on leaves 1 : 1 to 10% of leaf area covered 2 : 11 to 25% of leaf area covered 3 : 26 to 50% of leaf area covered 4 : > 50% of leaf area covered
Mango malformation	Count all the malformed shoots/twigs in a tree and record.

Observations

Table 1. Effect of canopy cover on the incidence of major diseases and pests in mango orchards

Incidence of pests (recorded in the month of March)	Canopy Percent				
	Control, No pruning Above 80%	Pruned to obtain 76-80% canopy cover	% reduction over control	Pruned to obtain 70-75% canopy cover	% reduction over control
Mango mealy bug	4.30	2.40	44.2%	0.75	82.6%
Mango leaf hoppers	71.75	10.60	85.2%	2.95	95.9%
Shoot gall psylla	3.10	1.05	66.1%	0.55	82.2%
Sooty mould	3.75	1.15	69.3%	0.95	74.7%
Mango malformation	13.05	3.35	74.3%	2.95	77.4%

*Significant reduction in pest and disease population under different pruning intensities is also due to the removal of infected portion of tree biomass.

Table 2. Effect of different percentage of canopy cover on fruit yield of mango

Yield attribute	Canopy Percent				
	Control No pruning Above 80%	Pruned to obtain 76-80% canopy cover	Percent increase or decrease over control	Pruned to obtain 70-75% canopy cover	Percent increase or decrease over control
Yield (Kg/tree)	83.4	104.0	+ 24.7	88.6	+ 3.8
Number of fruits/tree	182.8	231.8	+ 26.8	219.2	+ 19.9
Average fruit weight (g)	404	449	+ 11.1	456	+ 12.9

A well ventilated orchard with optimum canopy cover

Profuse flowering in Mango cv. Mallika, under optimum canopy cover

of canopy cover makes estimation of canopy very easy. Farmers can optimize the tree canopy of mango using this mobile app and may get a good yield of quality fruits.

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