Crop Cut Manual
for
Field and Horticulture Crops

DoA

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Foreword

Determination of crop yield and production is a vital information for policy formulations and planning related to food security and also to assess the performance of the Agriculture sector over the period of time. The yield estimation in Bhutan is carried out in two different ways; famers' recall method and crop cut by Extension officials. The yield data obtained is the average of the two methods. However, recall method for yield estimation is not effective as farmers do not keep record of the production except for few important crops like paddy and potato and the information obtained is not accurate. Presently, Gewog Agriculture Extension Supervisors had been conducting crop cut of major crops using the old crop cut manuals published by the department. The existing manual is outdated and exists in bits and pieces for different crops.

Hence, department is pleased to bring out this Crop Cut Manual on Field and Horticulture Crops. This manual consists of comprehensive crop cut procedure for all the major crops cultivated in Bhutan. The step by step procedure mentioned in the document will guide our Agriculture Extension officials in carrying out crop cut in a scientifically accepted process. Consequently, it is expected that biasness and errors can be significantly reduced and a reliable yield estimation data can be made available for all crops.

The department would like to request our field colleagues, who will be the main users of this manual to make best use of it. It is important to note that if the process laid down in the document is followed through, we will be able to generate quality yield data, which has direct impact on all level of plans and policies.

I acknowledge the contributions of Commodity Coordinators, Commodity Focals and all others involved in shaping this document and being able to publish it.

Kinlay Tshering
DIRECTOR

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1. Background

Monitoring crop yield is not only basic but also a fundamental piece of information. Crop yields vary with seasons, inputs and location and therefore regular monitoring is important. Normally, yield monitoring is done through crop cuts. Crop cut is a technique used to estimate crop yields from a unit area. The methodology for taking crop cuts varies with the type of crop. The primary objective of the crop cut is to measure the crop yield in that season.

The yield estimation in Bhutan for crops are done in two ways; famers' recall method and crop cutting by Gewog Agriculture Extension Agents. The yield recorded is adjusted data of the two methods to get the best yield estimate of a crop in the particular area. The experience over the years had shown that recall method is effective only for few important crops like paddy, maize, wheat, potato and chilli, which are grown in large scale. For the rest of the crops like fruits and other vegetables, the farmers do not keep record of the yield.

So, crop cut gives the basis for yield determination of the major crops grown in the particular area and also serves as an important basis for strategizing developmental policies and plans. Consequently, it is imperative to have a standard crop cut method suited for each crop so as to reduce error and be scientifically correct for yield analysis.

Hence, this comprehensive manual is developed to standardize the crop cut procedures of cereals, oil seed, grain legumes, vegetables, potatoes, fruits and MAPS. It consists of step by step process for conducting crop cut, starting from sampling procedure to yield estimation. This manual will guide our Agriculture Extension Agents in the field in conducting crop cut.

2. Objectives

1) Serve as a standard crop cut guide for all the crops
2) Guide Agriculture Extension Agents and researchers in conducting crop cuts
3) Generate realistic annual crop production data at gewog, district and the national level

3. Sampling procedure

Crop cut data collected should be representative. Thus, purposive stratified random sampling method is recommended. To start with, from the list of villages under the Gewog, list down villages that grows the given crop and then randomly select 3 villages. Then from each village, randomly select one farmer each for collecting data through crop cut as illustrated in the Figure1 below.

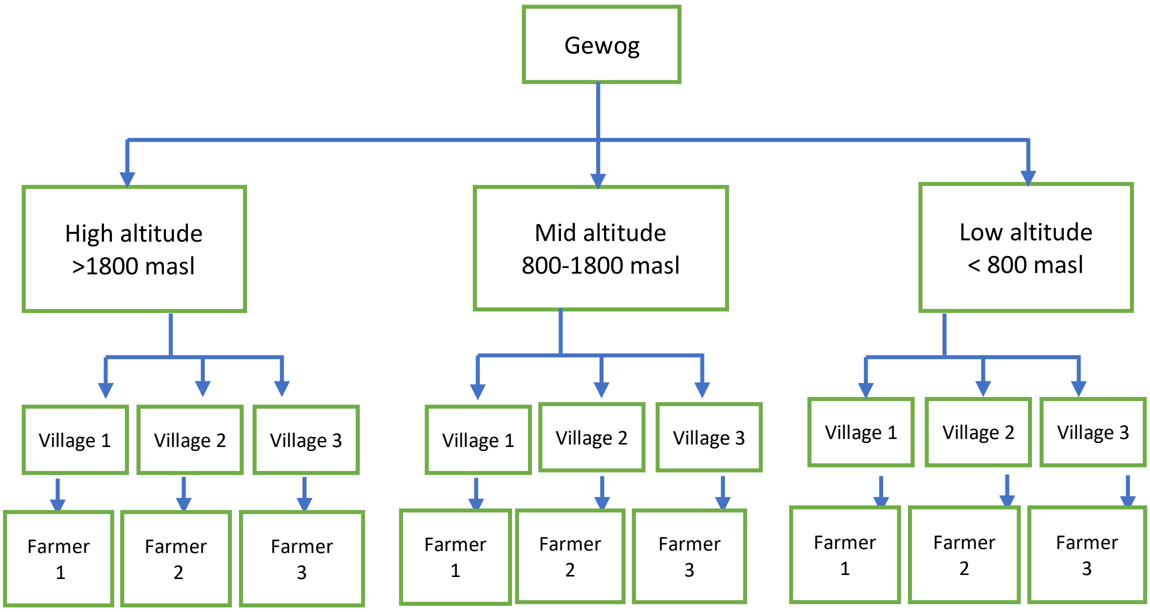

Figure 1. Sampling procedure for field and horticulture crops

3.1 Locating and marking of plot

Three sample plots need to be taken from one farmer for all the crops except for vegetables, fruits and nuts. For these two crops, only one sample plot is taken from a farmer and the procedure to locate the sample plot has been given under the respective crops. Locating of sample plot in a scientifically accepted method is critical to reduce sampling error. Thus, following steps has to be followed for locating the sample plots (Figure 2).

a. Once the crop is ready for harvest, identify a representative plot. Stand on the south-west corner of the field.
b. Take 4 steps across the field along the edge of the field and then take another 4 steps into the field.
c. Fix the wooden peg closest to the plant marking it as the plot 1. Measure the dimension of the plot area as recommended for each crop.
d. For locating the second plot, from the centre of plot 1, take 8 steps towards the centre of the field (use 4 steps if the field is too small).
e. Fix another wooden peg marking it as plot 2. Measure the same dimension as that of plot 1.
f. Similarly, for plot 3, take another 8 steps from centre of plot 2 towards the corner of the field.
g. Fix a wooden peg and mark it as plot 3. Measure the same dimension as that of plot 2.

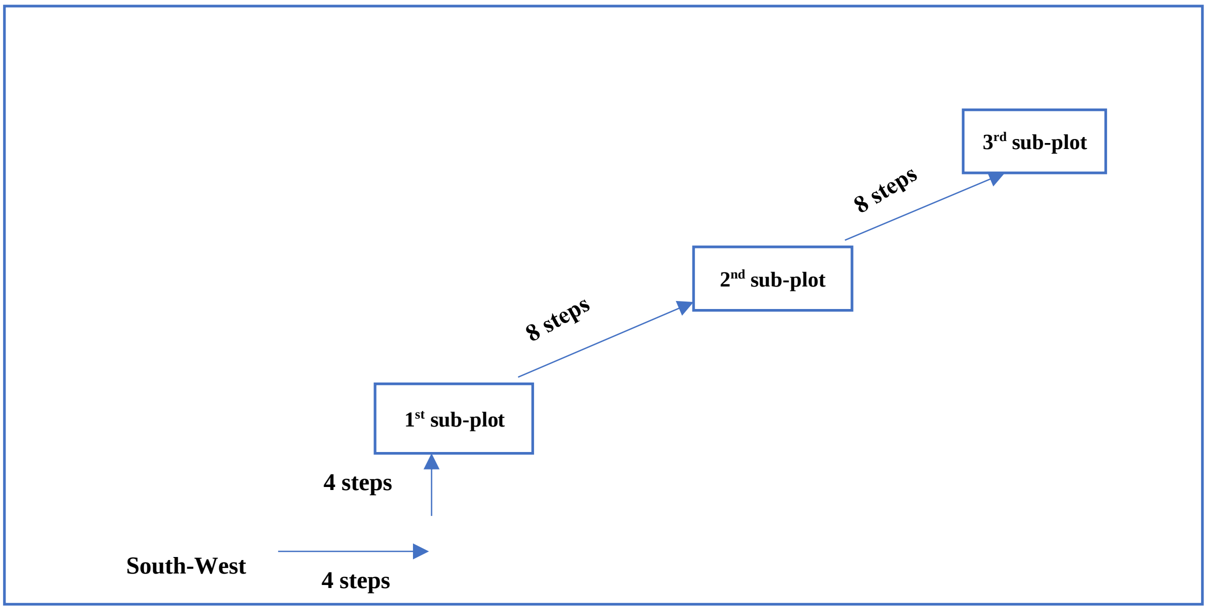

Figure 2. Locating and marking of sample plots

4. Materials

The materials required for crop cut applies to all the crops as listed below:

1) Measuring tape
2) Weighing balance
3) Moisture meter
4) Rope
5) Wooden pegs
6) Basket
7) Container
8) Sacks
9) Winnower
10) Tarpaulin
11) Pen
12) Data recording sheet
13) Altimeter
14) Compass
15) Labelling tags (for fruits and nuts)
16) Ladder (for fruits and nuts)
17) Marker pen (for fruits and nuts)
18) Harvester (for fruits and nuts)
19) Pick axe/crowbar

5. Crop cut method for field and horticulture crops

5.1 Field crops

The crop cut area and method for cereals (except for maize), oil seeds and grain legumes are almost same.

5.1.1 Rice

i. Maturity indices

- 80 % of panicle turn straw colour
- Grains become hard and turns yellow

ii. Crop cut method

a. Once the sample plots had been located and marked, with the help of wooden pegs and measuring tape, measure an area of 6 m^2 (3 m x 2 m) as shown in Figure 3.

b. Demarcate the area with wooden pegs and tie a rope to each end of the peg.

c. Harvest the crop that falls inside the demarcated area.

d. Thresh and clean the grains by removing husks, chaff, damaged and unfilled grains.

e. Record the weight of the grain with a weighing balance.

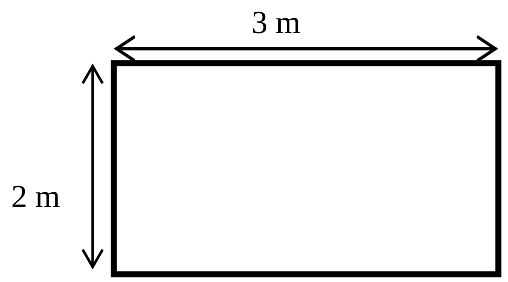

Figure 3. Sample plot area

f. Record the moisture content using a moisture meter.

g. Record the yield in the crop cut data recording format (Annexure I).

h. Use this data to compute the yield in kg/ac *iii. Yield Estimation*

In order to calculate the yield, first we need to find the adjusted moisture content as follows:

$$Adjusted\ Moisture\ Content\ (MC_{(adj)}) = \frac{(100 - actual\ moisture)}{(100 - desired\ moisture\ content)}$$

$$Yield\left(\frac{kg}{ac}\right) = \frac{Average\ yield\ from\ all\ plots(kg)\ x\ 4000\ m^2\ x\ MC_{(adj)}}{6\ m^2}$$

5.1.2 Maize

i. Maturity indices

- 75% of kernels have a black layer formation at the base of the kernels OR
- the kernel milk line is no more visible

ii. Crop cut procedure

Unlike other cereals, maize being a tall crop, the area and method of crop cutting is slightly different from other cereals. The crop cutting should be carried out in a circular fashion where the radius of the circle is kept 1.5 m with an overall crop cut area of 7 m^2.

Sample area (m^2) = 3.14 m x (1.5 m)^2 = 7m^2

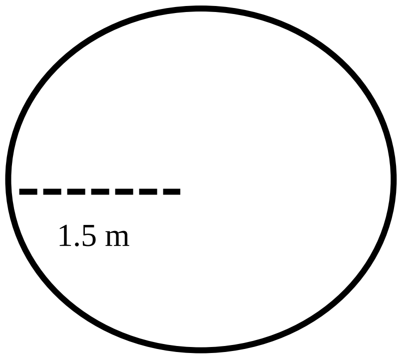

Figure 4. Crop cut sample area for maize

Crop cut method

a. Once the sample plots have been located and marked, tie a rope on the peg and make a sliding knot. The length of the rope from the centre of the peg to the other end (radius) should measure 1.5 m (Figure 4).
b. Take the end of the rope and walk in circular motion in the field.
c. Cut and pile all the plants that fall inside the string length as you walk.
d. Remove and de-husk the cobs, and record the fresh weight of the cobs using a weighing balance.
e. Measure and record moisture content of the freshly shelled cobs.
f. Record the data (Annexure I) shown below and compute the grain yield (kg/ac) using the formula given under Yield Estimation.

Shelling recovery percentage

Shelling recovery in maize is the total shelled kernels obtained from cobs which is expressed in percentage using the given formula.

iii. Yield Estimation

$$Shelling\ percentage = \frac{seed\ weight}{cob\ weight}\ x\ 100\%$$

$$Adjusted\ Moisture\ Content\ \left(MC_{\ (adj)}\right) = \frac{(100 - actual\ moisture)}{(100 - desired\ moisture\ content)}$$

$$Yield\left(\frac{kg}{ac}\right) = \frac{Average\ yield\ from\ all\ plots(kg)\ x\ 4000\ m^2\ x\ MC_{(adj)}}{7\ m^2}$$

5.1.3 Quinoa

i. Maturity Indices

- Plants dry and turn pale yellow or brownish depending upon variety
- Seeds thresh easily by hand

ii. Crop cut procedure

a. Once the sample plots have been located and marked, with the help of wooden pegs and measuring tape, measure an area of 6 m^2 (3 m x 2 m) as shown in Figure 3.

b. Demarcate the area with wooden pegs and tie a rope to each end of the peg.

c. Harvest the crop that falls inside the demarcated area.

d. Thresh and clean the grains by removing husks, chaff, damaged and unfilled grains.

e. Record the weight of the grain with a weighing balance.

f. Record the moisture content using a moisture meter.

g. Record the yield in the crop cut data format (Annexure I).

h. Use this data to compute the yield in kg/ac

iii. Yield Estimation

$$Adjusted\ Moisture\ Content\ \left(MC_{adj}\right) = \frac{(100 - actual\ moisture)}{(100 - desired\ moisture\ content)}$$

$$Yield\left(\frac{kg}{ac}\right) = \frac{Average\ yield\ from\ all\ plots(kg)\ x\ 4000\ m^2\ x\ MC_{(adj)}}{6\ m^2}$$

5.1.4 Wheat and other cereals

i. Maturity Indices

Table 1: Maturity indices for wheat and other cereals

Crops	Morphological characteristics at harvest time
Wheat	Seed heads starts to nod or bow on the stem known as nodding. The kernel will crunch while biting
Buckwheat	75% of seeds become brown or black and the plants have most of their leaves dried
Barley	The stalks and heads turn yellow and the seed heads begin drooping towards the ground Grain ripening takes 2-3 weeks after grain filling is completed
Millet	Black (dark) spot develops at the bottom of the grain at hilar region Leaves turn yellowish and show a nearly dried up appearance
Maize	75% of kernels have a black layer formation at the base of the kernels OR observe the kernel milk line and if it is not visible, the cob is mature

ii. Crop cut procedure

a. Once the sample plots have been located and marked, with the help of wooden pegs and measuring tape, measure an area of 6 m^2 (3 m x 2 m) as shown in Figure 3.

b. Demarcate the area with wooden pegs and tie a rope to each end of the peg.

c. Harvest the crop that falls inside the demarcated area.

d. Thresh and clean the grains by removing husks, chaff, damaged and unfilled grains.

e. Record the weight of the grain with a weighing balance.

f. Record the moisture content using a moisture meter.

g. Record the yield in the crop cut data format (Annexure I).

h. Use this data to compute the yield in kg/ac

iii. Yield Estimation

$$Adjusted\ Moisture\ Content\ \left(MC_{(adj)}\right) = \frac{(100 - actual\ moisture)}{(100 - desired\ moisture\ content)}$$

$$Yield\left(\frac{kg}{ac}\right) = \frac{Average\ yield\ from\ all\ plots(kg)\ x\ 4000\ m^2\ x\ MC_{(adj)}}{6\ m^2}$$

5.1.5 Oil seeds and grain legumes

i. Maturity Indices

Table 2: Maturity indices for oil seeds and grain legumes

Crop	Morphological characteristics at harvest time
Mustard	60 to 70 % of the seed pod turns yellow from green
Sesame	Leaves turn yellow, start drooping and the bottom capsule become yellow
Groundnuts	Leaves begin to yellow and starts drying up
Niger	Leaves dry up and the capitula turns brownish/ blackish in colour
Sunflower	Bracts surrounding the sunflower head change to brown
Grain legumes	Leaves turn pale yellow colour and 90% of pods turn yellow to dark brown or black

ii. Crop cut procedure

a. Once the sample plots have been located and marked, with the help of wooden pegs and measuring tape, measure an area of 6 m^2 (3 m x 2 m) as shown in Figure 3.
b. Demarcate the area with wooden pegs and tie a rope to each end of the peg.
c. Harvest the crop that falls inside the demarcated area.
d. Thresh and clean the grains by removing husks, chaff, damaged and unfilled grains.
e. Record the weight of the grain with a weighing balance.
f. Record the moisture content using a moisture meter.
g. Record the yield in the crop cut data format (Annexure I).
h. Use this data to compute the yield in kg/ac

Processing crop cut sample of grain legumes

1) After the harvest, tie the plants in small bundles and hang them to dry in a shed or store house for 2-7 days for proper drying.
2) Note that respective plot harvest should be dried separately.

3) After drying, the seed should be threshed easily by hand at this time. The plants/pods should be beaten with stick or trampled with feet until all seeds in the pods are completely threshed out.
4) Clean the seeds from soil, stones, debris and any other by materials by handpicking or winnowing.
5) Weigh the respective samples and record the weight in the format (Annexure I).

iii. Yield Estimation

$$Adjusted\ Moisture\ Content\ \left(MC_{\ (adj)}\right) = \frac{(100 - actual\ moisture)}{(100 - desired\ moisture\ content)}$$

$$Yield\left(\frac{kg}{ac}\right) = \frac{Average\ yield\ from\ all\ plots(kg)\ x\ 4000\ m^2\ x\ MC_{(adj)}}{6\ m^2}$$

5.2 Horticulture crops

5.2.1 Vegetable

i. Maturity Indices

Table 3: Maturity indices of Vegetable

Major Vegetables	Maturity Indices
Asparagus	Apex closed and reaches pencil size
Bulb Onion and garlic	Drying and collapse of the "neck"
Cauliflower/Broccoli	Florets closed, head firm on touch
Carrot/Radish	Size of the root before pithiness develop
Cabbage	Firm head
Beans	Before the seeds begin to fill out the pods, pods should be tender and succulent
Chili	Firmness, color
Brinjal	Shiny and soft fruit, full color developed Two weeks after flowering
Tomato	Pink stage (30% pink or red surface)
Pumpkin	Hard skin, 50-60 days after pollination
Bitter gourd	Green color before it turns yellow (after 15 days from flowering)
Peas	Seed development
Green leaves	Size of the leaves
Okra	Before pod maturity, tip breaks under pressure

ii. Crop cut procedure

Main field selection

1) Identify the main field with minimum area of 50 m^2 to accommodate crop cut area (Figure 5).

2) After selection of the main field, the south-west corner of the field has to be located for ease of deriving crop cut area.

3) South west corner is that corner where if one stands at the base of the selected field facing north (Point A in the diagram).

4) Demarcate the main field by walking to the right (towards point B) and up straight (towards point D).

5) If the main field is irregular, then mark the field into a regular shape using rope and pegs as shown in the Fig 1.

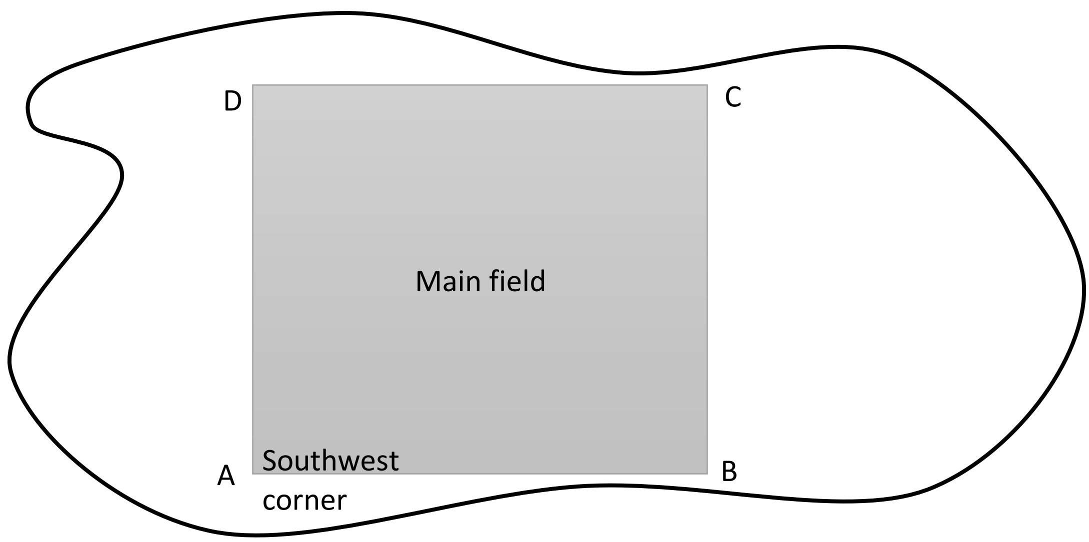

Figure 5: Main field selection for vegetable crop cut sample area

Marking crop cut plots

1) For unbiased selection of crop cut plot, from the corner **A** of the main field, take 10 steps towards the corner **B** of the main field along the edge and then take 3 steps perpendicular to **AB** to reach point **a** and fix the peg there.

2) Point **a** form the starting point for demarcating the crop cut plot. From point **a**, measure 10 m straight distance parallel to **AB** towards **BC** side of the main field and fix the point **b**.

3) Then with the help of rope, fix point **d** and **c** using Pythagoras theorem in a right-angled triangle, where square of hypotenuse (bd) is equal to sum of squares of the

other two sides: $ac^2 = ab^2 + bc^2$. Thus, rectangle abcd (Figure 6 & 7) is used for measurement of yield through crop cut method.

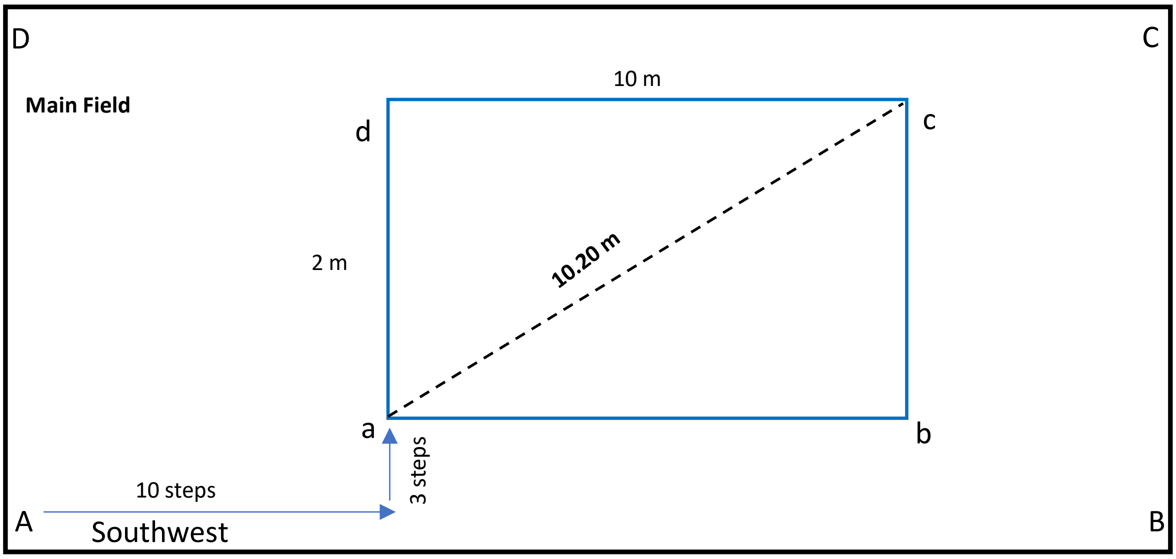

Figure 6: Crop cut plot selection for 10 m x 2 m

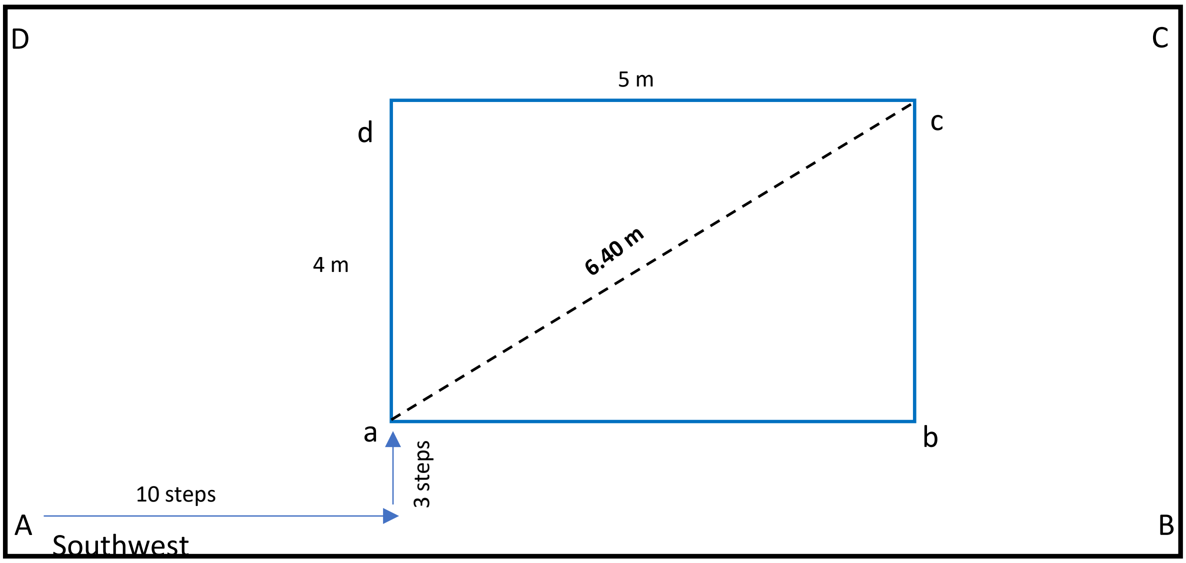

Figure 7: Crop cut plot selection for 5 m x 4 m

iii. Harvesting/Picking

1) Harvest when all crops reaches horticultural maturity (Check maturity indices).

2) Crops like Chili, Tomato, Brinjal, Gourds, Squash, Pumpkin, Peas and Beans, record yield of all pickings in crop cut plot.

3) In case the crops like Cauliflower, Cabbage, Broccoli, Radish, Carrot harvest when all the crops are matured.

4) The plants on the boundary of the plot will be considered for picking only if the roots are more than half inside the crop cut plot.

5) The boundary rope and peg should not be removed until all pickings are done in case of vegetables requiring multiple harvest.

6) Record the yield in crop cut data recording format.

iv. Yield Estimation

The final average yield of the crop in the Gewog will be derived using the formula below;

$$Yield\left(\frac{kg}{ac}\right) = \frac{Total\ average\ yield\ from\ all\ plots(kg)\ x\ 4000\ m^2}{20\ m^2}$$

5.2.2 Potato

i. Maturity Indices

- The aerial parts of plant die out.
- The skin of the tubers doesn’t peel off when rubbed with finger.

ii. Crop cut procedure

Crop cut area

The selected field should be of sole crop and not mixed with maize or other intercrops. Crop-cut area is based on planting specifications and need to consider the ridge length and ridge width. Generally, farmers plant in closer distance of 60 cm between ridges and 15-20 cm between plants.

- Length of sampling plot that includes 40-60 plants covering 400 cm (4 m)
- Width of 4 rows is 60 cm x 4 cm=240 cm (2.4 m)
- Ideal plot size for potato is 4 m x 2.4 m = 9.6 m^2

Crop cut method

1) Take three sample plots from one field/farmer. Demarcate the area which falls under the crop cut area.

2) Dig the ridges with rake to remove the tubers from the soil. Be careful, not to damage the tubers.

3) Remove all the tubers, irrespective of their sizes.

4) Remove soil clods and other soil materials which adhere to the tubers before weighing.

5) Weigh the yield from each sample plot separately and record it in the crop cut data recording format.

iii. Yield Estimation

$$Yield\left(\frac{kg}{ac}\right) = \frac{Total\ average\ yield\ from\ all\ plots(kg)\ x\ 4000\ m^2}{9.6\ m^2}$$

5.2.3 Medicinal Aromatic Plants and Spices

5.2.3.1 Spices

i. Maturity Indices

Table 4: Maturity indices of spices

Crop	Maturity Indices
Ginger and turmeric	Leaves begin to turn yellow and start to dry
Cardamom	Capsules can be easily shelled from the comb and it attains reddish color and seeds inside the capsules become black in color.

ii. Crop cut procedure

Crop cut area

The crop cut area of the spices is mentioned in Table 5. All the crop cut areas should be taken after ignoring at least a meter from the edge of the field if randomly planted and at least two rows from the edge of the field if planted in rows to avoid border effect in the yield estimation of the crops.

Table 5: Crop cut area of spices

Crop	Scientific Name	Crop cut Area	Remark
Ginger	*Zingiber officinalis*	5 m x1 m	Length(5m) should be along the row
Turmeric	*Curcuma longa*	5 m x 1 m	
Cardamom	*Amomum subulatum*	5 m x 2 m	5 m should be along the length of the field

iii. Harvesting

1) Once the sample plots have been located, mark out the plots with the help of measuring tape and wooden pegs measuring an area of 5 m^2 (should consist of 3 rows of 5m length) for ginger and turmeric, and 10 m^2 for large cardamom.
2) Demarcate the area with pegs and rope tied to each end.
3) For ginger and turmeric, harvest the rhizomes from the marked areas, wash or remove the soil debris.

4) For large cardamom, harvest the capsules from the plots using the harvesting knife locally called *churi*.
5) Put the harvested bunch in separate baskets. Separate all the capsules from the comb and remove all foreign materials.
6) Weigh the fresh weight of rhizomes/capsules separately for individual plots.
7) Record the yield from each plot in the crop cut data recording format.
8) Measure and note the fresh weight of rhizomes/capsules from respective plots.
9) For cardamom, find the average dried weight of capsules and record the average yield.

vi. Yield Estimation

Large cardamom is generally dried immediately after harvesting. However, as the drying process takes very long, it is impractical for the Extension Officials to record exact dry weight of cardamom per plot during the crop cut.

To calculate its dry weight, the calculated fresh weight yield per acre should be directly divided by 5 using its fresh to dry weight ratio of 5:1.

$$Yield\left(\frac{kg}{Acre}\right) = \frac{Average\ yield\ from\ all\ plots\ (kg)}{Crop\ cut\ area\ (m^2)}\ x\ 4000\ m^2$$

5.2.3.2 Medicinal and Aromatic Plants

i. Maturity Indices

Table 6: Maturity indices of major Medicinal and Aromatic Plants

Crop	Maturity Indices	When to harvest
Ruta and Manu	Aerial parts of the plant completely dry off.	November-December (harvest in the 2nd growing season)
Ti-yangku	50 % reach blooming stage or just before they begin to discolor.	May-June
Goned	Aerial parts dry up and the seeds turn brown in color.	May - June
Chirayita	Height of the plants reach 120 to 145 cm; the color of the plants changes from light green to pale yellow. Seed have set.	October - November (Harvest in 2nd - 3rd growing season)

ii. Crop cut procedure

Crop cut area

The crop cut area is as mentioned in Table 6. All the crop cut areas should be taken after ignoring at least a meter if randomly planted and at least two rows from the edge of the field if planted in rows to avoid border effect in the yield estimation of the crops.

Table 7: Crop cut sample area for MAP

Crop	Scientific Name	Crop cut Area	Remark
Ruta	*Sassurea lappa*	3 m x 2 m	3 m should be along the length of the field
Manu	*Inula racemosa*	3 m x 2 m	
Ti-yangku	*Dracocephalum tanguticum*	1 m x 1 m	
Goned	*Carum carvi*	1 m x 1 m	
Chirayita	*Swertia chiraita*	5 m x 2 m	5 m should be along the length of the field

iii. Harvesting

a. Ruta and manu are valued for their roots

1) Once the sample plots have been located and marked, measure the recommended area (Table 7) and demarcate.
2) Demarcate using a measuring tape, wooden pegs and rope leaving at least two rows or one-meter distance from the edge of the field.
3) Brisk irrigation must be given to moisten the soil 2 to 3 days before crop cut. Harvest by digging the soil around the roots using pickaxe/crowbar.
4) Dig out the entire root and as far as possible in intact form.
5) Wash the roots to remove soil, dry it under shade for few hours and weigh it using the weighing machine.
6) Record the yield from each sub-plot in the crop cut data recording format.
7) Find the average yield per plot and record the average plot yield in the data recording sheet.

b. Ti-yangku and Goned are the annual crops and grown for their dried aerial clumps and seeds respectively.

Crop cut should be carried out in the morning when dew is still present on the plants to avoid seed losses (Seed falls out easily).

1) Take the crop cut following the recommended crop cut area (Table 1) by demarcating areas using wooden pegs, rope and measuring tape.
2) Cut the whole aerial parts (shoots, branches, leaves and flowers) at 4 – 5 cm above the ground, taking care not to contaminate with soil and foreign materials using a sharp knife.
3) Weigh and record the fresh weight of the plants from each plot including the average yield per plot in the crop cut data recording format.
4) Dry the plants for few hours on tarpaulin to remove the moisture before threshing it.
5) Thresh and weigh the yield from individual plots separately.
6) Record the yield of individual plots in the crop cut data recording format.

c. Chirayita is a biennial or tri-annual crop depending upon the degree of care and management by the farmers.

1) Measure the crop cut area of 5 m length and 2 m breadth, leaving at least 1 m (line planting) or two rows from the edge of the field.
2) Uproot the entire plant including roots and wash off the soils adhering to it.
3) Weigh and record the yield of individual plots in the crop cut data recording format.

vi. Yield Estimation

To calculate the yield of Medicinal and Aromatic Plants, we need to know the Fresh to Dry Weight Ratio (FDR) as given in Table 2. The yield is calculated using the formula below:

$$Yield\left(\frac{kg}{Acre}\right) = \frac{(Average\ Fw\ per\ plot \div FDR)}{Crop\ cut\ area\ (m^2)}\ x\ 4000\ m^2$$

Where,

Fw is the fresh weight per plot

FDR is fresh to dry weight ratio of MAPs provide in Table 2

Table 8: Fresh and dry weight ratio of MAP

Crop	**Scientific Name**	**FDR**
Ruta	*Sassurea lappa*	5
Manu	*Inula racemosa*	5
Ti-yangku	*Dracocephalum tanguticum*	4
Goned	*Carum carvi*	1.1
Chirayita	*Swertia chiraita*	2.5

5.2.4 Fruits and Nuts

i. Maturity indices

Crop cutting exercises must be done only when fruits are fully mature, and broadly there are two categories of maturity indices: destructive and non-destructive. Here only non-destructive methods are discussed. However, it must be noted that description of Maturity Indices described in the Table 6 are generic and may depend on variety and other abiotic and biotic factors. Thus, this should be used only as a general guide.

Table 9: General maturity indices of common fruit

Fruits	Maturity Indices
Apple	Develop abscission band on the pedicel
Banana	Shape turns to roundish from angular
Dragon fruit	Skin turns to pink from green
Grapes	Develop waxy layer on the epidermis
Guava	Skin turns to light green/yellowish from dark green
Kiwi	Hairs on the fruits can be easily rubbed off or when TSS is 6.3%
Litchi	Skin turns to red
Mango	Skin turns to light green/yellow from dark green
Papaya	Colour break at blossom end (dark green to yellow)
Passion fruit	Skin turns to purple or yellow from green
Pear	Skin turns to brown in Asian and white green in European
Persimmon	Skin turns to orange from dark green
Pineapple	Flattening of eyes with some hollowness at the centre
Plums	Develop waxy layer on the epidermis
Pomegranate	Skin turns to red or when juice turns red
Watermelon	Ground spot (spot that touches the ground) turns to creamy yellow from white or when tendrils close to the stem end wilt
Walnut	Husk cracks and fruits drop
Citrus	Change of skin color from dark-green to light- green with some yellow colour at the blossom end

ii. Crop cut procedure

Fruits and nuts comprise of large numbers that often vary in their physiological and horticultural characteristics. Hence, following points are required to be strictly observed while selecting the field for crop cut. This method is applicable to most of the fruit crops including apple, areca nut, avocado, citrus, guava, mango, passion fruit, peach, pear, pineapple, plum, watermelon and walnut.

- Orchard selected should not be of mixed type.
- Selected orchard should have at least 12 to 15 bearing trees. Bearing trees are qualified as those trees that have come into commercial bearing.
- Crop cut should be done only when crops are physiologically mature or ready to harvest (Table 9).
- It is essential to note information such as name of the farmer, location, altitude, average age of the trees, variety of the fruits (give the major one if it is of mixed varieties) and special crop management aspects adopted if any

Fruit trees selection

Once the orchard is selected following the aforementioned sampling procedure, fruit trees for crop cutting are selected as illustrated in Figure 8 below:

1) Mark the south west corner of the orchard (south west corner of where you stand and not necessarily the real south west)
2) Move along as indicated by arrow, marking each fruit tree as bearing **B**, non-bearing **NB** and young **Y**. Non-bearing is qualified as those trees that have attained commercial bearing stage but have not borne fruits in the current season due to biennial nature or other physiological conditions. Young refers to those immature trees that have not yet attained commercial bearing age.
3) Then group the marked bearing trees into clusters. Each cluster should comprise of 4 bearing trees. In the Figure 8 below, fruit trees marked as **B1, B2, B3** and **B4** will make the first cluster, **B5** to **B8** will make second cluster and so on. Thus, there are total of 5 clusters in this case. However, if the orchard has large number of trees, at least up to 15 clusters must be marked.
4) From the clusters (5 clusters in this case), randomly select 3 clusters using either random number table, random function in Microsoft Office Excel or lucky dip methods.
5) From the 3 clusters selected above, randomly select 2 trees each from the cluster thus making at a total of 6 bearing trees.

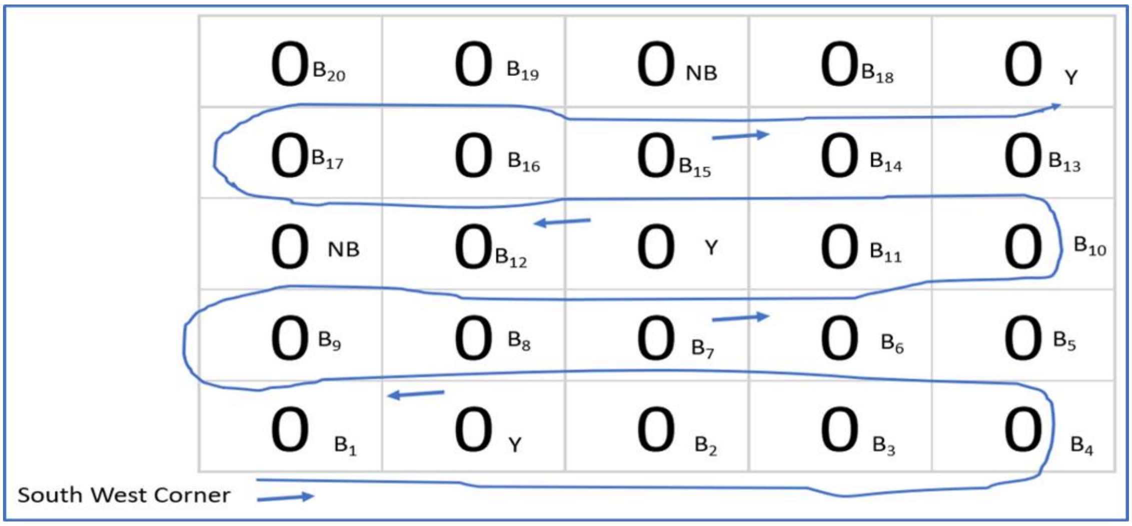

Figure 8: Schematic representation of fruit trees selection for cut crop

Plant selection in plantation crops (fruits)

For fruit crops like banana, which is usually cultivated in extensive scale, then follow this procedure for crop cutting as illustrated in Figure 9. This method can also be applied to pineapple and watermelon when cultivated in large scale.

1) Starting from south west corner, mark/assign row numbers as illustrated in the Figure 9. In large-scale cultivation that covers acres of land, at least 45 rows must be marked.
2) Of the total rows marked, randomly select 3 rows. In the example in Figure 8, row 1, row 3 and row 4 are randomly selected out of 5 rows.
3) In each of the selected rows, mark each plant as bearing, young and non-bearing as in Figure 8 and make number of clusters with each cluster comprising of 4 bearing plants.
4) Then, from the clusters formed above, randomly select 1 cluster from each of the selected rows.
5) Finally, from each of the selected cluster, randomly select 2 plants each thus making a total of 6 plants.
6) In banana, harvest is done more than once, and thus, the final yield must be total of all the harvests

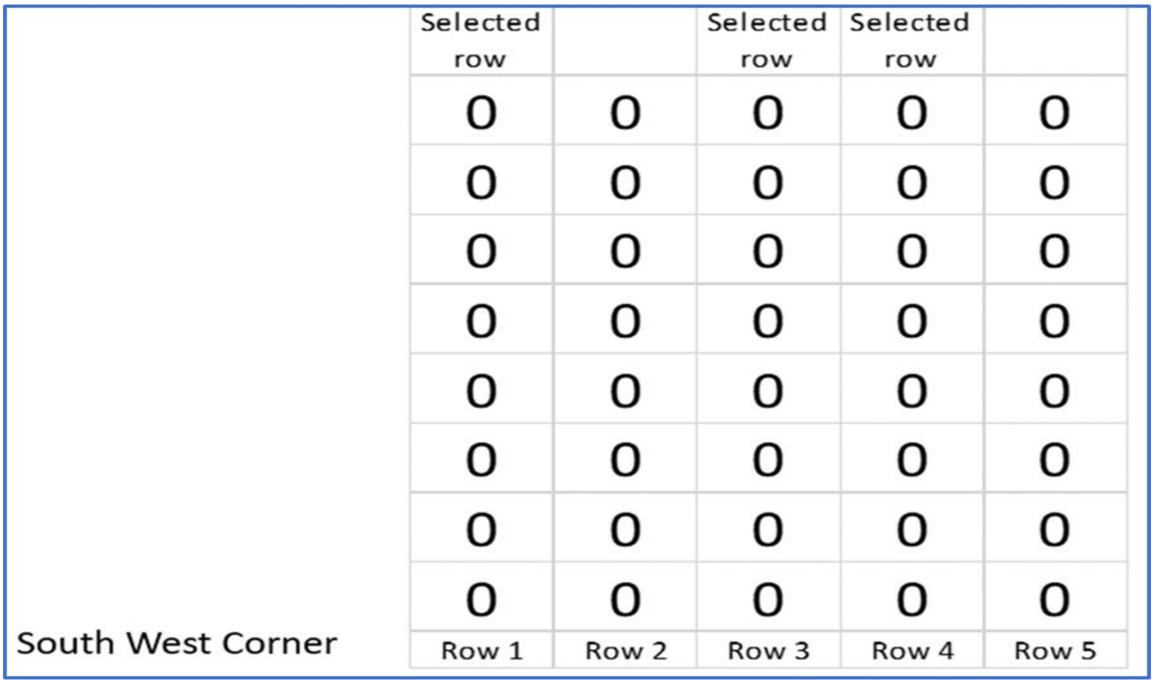

Figure 9: Schematic representation of plant selection in banana

iii. Yield Estimation

Harvest all the fruits from each of the sample tree or plant and note them separately. For estimation of production per acre, use the following formula:

$$Average\ yield\ per\ tree(kg) = \frac{Total\ weight\ of\ fruits\ from\ all\ sample\ trees\ (kg)}{Number\ of\ sample\ trees}$$

$$Yield\left(\frac{kg}{ac}\right) = Average\ yield\ per\ tree(kg)\ x\ number\ of\ trees\ per\ acre$$

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7. ANNEXURES

Annexure I: Crop cut data recording format for cereals, potatoes, oil seed, grain legumes and MAPS

Dzongkhag :
Gewog :
Crop name :

Date of Crop cutting	Name of Grower	Village	Altitude (masl)	Variety	Crop cut plot 1	Crop cut plot 2	Crop cut plot 3	Average Yield from 3 crop cuts (kg) =A+B+C/3	Remark
					Yield in Kg (A)	Yield in Kg (B)	Yield in Kg (C)		

Annexure II: Crop Cut Data Recording Format for vegetables and fruits and nuts

Gewog :

Dzongkhag :

Crop name :

Date of Crop cutting	Name of Grower	Village	Altitude (masl)	Variety (optional)	Yield/Plot (Kg)	Remark

Annexure III: Desired moisture content of cereals, oil seed and grain legumes

S. N	Name of the crop	Desired moisture content
1	Paddy	14%
2	Quinoa	10%
3	Wheat	14%
4	Buckwheat	14%
5	Barley	14%
6	Millet	14%
7	Maize	15%
8	Mustard	8%
9	Sesame	6%
10	Groundnuts	5%
11	Niger	<5%
12	Sunflower	<9.5%
13	Soybean	12%
14	Common bean	9%
15	Mungbean	9%
16	Lentil	9%