

Agriculture Research and Development Center Bajo, Wangdue Phodrang Department of Agriculture, Ministry of Agriculture and Forests



Guidebook on Vegetable Cultivation





Enjoy vegetable cultivation for better health





Integrated Horticulture Promotion Project 2016-2021

Guidebook on Vegetable Cultivation

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About the guide book

The vegetable Cultivation Guidebook provides the basic vegetable cultivation knowledge based on the practical experiences achieved from the trials conducted at the Agriculture Research and Development Centers of ARDC Bajo and Wengkher. The farming communities in Bhutan reside from the lowest level of 100 masl to the extreme of 3000 masl varying in climate, landscape, and cultivation environment. This particular guide book contains essential features such as altitude requirement for different varieties of crops, planting seasons, soil pH, and its importance for plant growth. The other important output can achieve from this book in the field practical activities outlined in detail to adhere as per the need of those agriculture enthusiasts who are in dire need to take up the activities. Those activities included in detail are seed sowing in a nursery, field management, and harvesting to the storage of the individual crops.

It has become the tradition that the harvesting of fruits and vegetables is contradictory in nature. It is important to understand that fruits should be harvested when fully mature and the vegetables at the tender age or simply called harvesting "right crop" at the "right time."

With the day to day evolution of the plant breeding programs, the vegetable varieties are increasing as per the need of the time and demand of the consumers, so it is important to improve the present cultivation practices based on the need of the hour. The book can be used for kitchen garden purposes as well as small and large scale production of vegetables. It will benefit the farmers who are cultivating vegetables in their field with less technical knowhow, retired officials interested in vegetable production, extension officers, and the upcoming entrepreneurs in the field of Agriculture.

The authors would be grateful if this guidebook is used by different stakeholders and increase the production of the quality vegetables.

The guide book is subject to change in the future as per the need of the time and depending upon the opinion of the stakeholders.

We would like to thank all the Horticulture Staff of ARDC- Bajo, ARDSC-Tsirang, ARDC-Wengkher, ARDSC- Khangma, ARDSC-Lingmethang, for their support in carrying out the field activities and keeping the detail activities for the publication of the book. Credit also goes to the IHPP/JICA experts for their tremendous support in planning and the successful implementation of the activities in the fields. ESPs of the two agencies who should be remembered all the time to come due to their tireless contribution during the process of vegetable cultivation and promotion.

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Program Director's Desk

Integrated Horticulture Promotional Project (IHPP), Agriculture Research and Development Centre (ARDC), Bajo, takes an enormous pleasure to publish the '**Guide Book on Vegetable Cultivation**' which was prepared by Mr. Yuchi Tomiyasu, JICA Expert from 2000-2018, as his parting gift to the researchers, extension supervisors, farmers, practitioners, and stakeholders of agriculture in Bhutan.

Having worked wholeheartedly, tirelessly, and generously for almost nineteen years in the country to generate appropriate technologies in horticulture development, and to develop appropriate training and extension system to enhance efficiency and effectiveness in agriculture research and extension services delivery, the Expert devoted his last few months to put into black and white his ideas, knowledge, skills, experiences, and wisdom into a tangible, valuable, and comprehensive guidebook.

Given the vast knowledge, skills, and experiences of the Expert in horticulture development and more importantly, as a gesture of respect for his contribution to horticulture development in Bhutan, the original content in English which was translated from Japanese with his guidance is retained with changes only in language structure to convey messages clearly and correctly.

The guidebook not only contains comprehensive guidance on major horticulture crops grown in the West Central region of Bhutan but also contains sections on watermelon cultivation, nursery establishment and management, and top-working of the existing fruit crops. IHPP, ARDC-Bajo would like to encourage researchers, extension supervisors, practitioners, and other users to make use of the vast knowledge, skills, and experiences shared in the guidebook. Moreover, we would like to request all users to provide us your valuable views, comments, and feedback to make this guidebook a living, practical, and impact-oriented document.

ARDC-Bajo would like to offer our sincere gratitude to Japan International Cooperation Agency (JICA) for providing Technical Cooperation Project (TCP) IHPP within the framework of which the guidebook is prepared and published. We not only remain indebted to the agency, experts, and officials for your generous assistance to expand horticulture production in the West Central region but also remain determined to continue to promote technologies generated and demonstrated in the farmers' fields.

We would like to wish all users the best in using and implementing the knowledge, skills, and experiences shared in this guidebook to producing quality vegetables sustainably in Bhutan.

Tashi Delek!

Pema Chofil Program Director ARDC Bajo

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1. Vegetable Cultivation in Bhutan

(1) Introduction

Bhutan is located at a subtropical latitude, and its wide range of altitudes is conducive to various agro-ecological zones. These multi-climate conditions can produce almost all types of vegetables across different seasons and throughout the year.

A recent trend in the consumption of vegetables in Bhutan has increased drastically in recent years. Vegetables in Bhutanese markets were only sold in several big city markets until the 2000s. Now peoples can buy vegetables in many Sunday markets and from roadside vendors that sell vegetables across the country. The diversification of vegetables at the cultivation stage has also multiplied in the cultivation, along with upward market demands. Though there are significant numbers of middlemen in the markets, farmers are still able to sell their products directly to consumers across the country. The importance of nutrition and a healthy diet has become increasingly important in recent years which has also fueled market demands for organic vegetables produced in Bhutan.

Despite the tremendous growth in vegetable production compared to past decades, the numbers of vegetables imported from India has also increased. The price competition in relation to Indian vegetables is the major challenge for the Bhutanese farmers. Vegetables are now considered a cash crop, and improvements in cultivation in terms of variety and quality are fundamental for Bhutanese farmers.

In addition, the Buthanese farmer's common practice of 'harvesting vegetables late but fruits early' should be changed. Instead, the focus should be on harvesting fruits and vegetables at the correct time.

Based on these conditions, this vegetable guidebook aims to provide the basic cultivation techniques for vegetable production.

(2) Production of the Right Crop at the Right Time in Bhutan

Production of the "right crop", and at the "right time" is based on a good understanding of natural factors such as altitude, location and climate, and is crucial for vegetable production in Bhutan. These three natural factors are fundamental; however, soil fertility, irrigation, and field management are the responsibility of the farmers. Planning and preparation are essential for implementing vegetable production of the "right crop" at the "right time". Improvements in field soil fertility, correct irrigation and field management along with monitoring crop growth and local conditions are also key to producing the right crop at the right time.

Prior planning is essential to ensure crop production at the right time. The selection of varieties, the establishment of schedule, thorough field preparation and management can increase crop production. In

addition, planning and planting crops at different times ensure a more efficient allocation of available workforce efficiently for a longer period of time and guarantees better income.

(3) Important Technical Information

The field soil in Bhutan is generally poor and acidic. Soil fertility and structures usually differ widely, even across small plots of land. Crop productivity and quality depend on soil fertility, which is key to sustainable crop productions, ensuring high quality and yield. Fertile soil has a sufficient water holding capacity, adequate drainage functions and retains essential nutrients. Soil which is productive for growing paddy rice is prone to high water holding capacity that causes fatal waterlogging conditions for horticultural crop production, especially in rainy seasons. Low fertility soil with a high water holding capacity usually results in the stunted growth of vegetables, less yield and a high risk of pests and diseases.

All Bhutanese farmers rear their own cattle, which is beneficial in improving soil fertility. Continuous compost applications and the burning of dry grasses, husks or straw in the field can improve soil fertility, even if the results are not evident for several years. Applications of garbages and other organic residues from yards and houses are also useful in increasing soil fertility.

Another essential management technique for vegetable production is irrigation. Too much irrigation is worse than too little, as the same as fertilization. Once the applied amount of water or fertilizers are possible to be added, but impossible to be taken them back. It is worth having better irrigation and water harvesting facilities, and using mulching techniques as these are expensive and self-sufficient is possible.

Winter vegetables are usually cultivated in dry seasons when water scarcity. Therefore irrigation is crucial to prevent dryness of the soil. Summer vegetables are grown mainly in the rainy seasons. Due to the high humidity and high temperatures, summer vegetables should be kept ventilated conditions in order to suppress pests and diseases.

Nursery management skills for transplanting vegetables are also essential for yield improvement. The techniques include stimulation of germination, reduction of root damage, protective raising, sowing/planting that can improve both quality and yield.

In general, "vegetables are harvested late and fruits earl" in Bhutan, therefore, the importance of timing and the indices of harvest needs to be understood to obtain better quality products and secure market opportunities.

2. Advantages of High-altitude Vegetables

Bhutan has various agro-ecological zones (from sub-tropical to temperate) with different crop productions and different growing seasons, which constitute a huge advantage in terms of vegetable production. These natural conditions do not exist in the neighbouring countries, with the exception of Nepal.

Summer vegetables can like tomato, chilli, and Brinjal prefer high temperatures like mango, guava, papaya and citrus, and can be grown throughout the year in Bhutan. Winter vegetables like cabbage, radish and carrot prefer cool temperatures, which due to the altitude, can also be produced all year round. Bhutan especially has the best environment for the production of Winter vegetables in high altitude areas in the Summer season. For example, summer potatoes produced in the highlands have been exported to neighbouring countries and are well regarded as being of high quality. Other Winter vegetables such as carrot, radish, broccoli cauliflower, turnip, pea, beans and cabbage produced in the Summer season have god potential for being the next agricultural products suitable for export.

Summer temperatures in India and Bangladesh high and the types of agricultural products that can be grown are limited. This difference in climate constitutes a market opportunity for a small country like Bhutan, with more extensive agro-climatic zones to produce Winter vegetables and the opportunity to generate revenue from exports. The aforementioned vegetables are also potentially suitable for long-distance transportation by road to neighbouring countries.

3. Basic Knowledge for the Vegetable Cultivation

(1) Vegetable Group and Crop Rotation

Vegetables can be categorized by their edible parts; 1) roots or tubers, 2) leaves and/or stems and 3) flowers or fruits.

The table below indicates the scientific classifications of typical vegetables that are grown in Bhutan.

Family Classifications	Examples of Crops
Solanaceae	Tomato, Eggplant, Chili, Tree tomato, Potato
Cucurbitaceae	Cucumber, Pumpkin, Melon, Gourds, Squash, Zucchini, Watermelon, Bitter gourds
Brassicaceae	Broccoli, Cauliflower, Cabbage, Turnip, Radish, Kale, Chinese cabbage, Mustard green, Pakchoi, Komatsuna, Rape
Fabaceae	Pea, Bean, Peanut, Soybean, Azuki, Chickpea, Faba bean, Kidney bean, Lentil, Mung bean (dal), Cowpea
Liliaceae	Onion, Garlic, Chive, Leek, Bunching onion, Asparagus
Chenopodiaceae	Spinach, Beet, Local spinach (Chard), Quinoa
Apiaceae	Carrot, Coriander, Parsley, Celery
Compositae/Asteraceae	Lettuce, Crown Daisy, Burdock, Ground Apple
Convolvulaceae	Sweet potato
Zingiberaceae	Ginger, Turmeric, Cardamon
Araceae	Taro
Malvaceae	Okra

Continuous cultivation in the same fields, using the same family crops, result in less yield, a high wilting disease rate and pest outbreaks. Successive cropping of *Solanaceae, Liliaceae, Cucurbitaceae*, and

Brassica vegetables lead to a deficiency in nutrients, stunted growth and a high risk of wilting disease and infestation. Therefore, "crop rotation" is always the first option for sustainable vegetable production, suppressing the risks of poor quality and less yield from continuous cropping.

The crops listed below must follow crop rotation for at least three to five years to ensure better productivity and quality.

➔ Eggplant(brinjal), Tomato, Chili, Potato, Cucumber, Watermelon, Melon, Bitter gourd, Kidney bean, Pea, Okra, Groundnut(Peanuts), Garlic, Ginger and Taro.

Crops that have fewer problems in relation to continuous cropping in the same field are:

→ Cabbage, Cauliflower, Broccoli, Radish, Turnip, Carrot, Komatsuna(Japanese green leaf), Chinese cabbage, Bunching onion, Bulb onion, Leek, Pumpkin, Sweet potato and Spinach

Crops without any problems resulting from continuous cropping are:

→ Soybean, Azuki bean, Faba bean, Mustard, Rape and grain crops

Crops belonging to the same family as chilli, cucumber and beans are generally regarded as part of the Summer vegetable group; therefore, it is crucial to plan in advance to avoid continuous cropping in the same field.

Crop rotation with paddy rice after Summer vegetables or legume crops (beans) can reduce the problems of soil nutrient loss, stunted growth and outbreaks of pest and disease.

(2) Crop Origin and Suitable Crop Selection

The origin of a vegetable and its climate can indicate the appropriate cultivation time and location. Summer vegetables or fruits prefer warm temperatures for growth and the seed should be sown in the soil in warm conditions and at the correct temperature in the Summer season. Therefore, low altitude areas in Bhutan can produce Summer vegetables in the Winter season with some protection. On the contrary, high altitude areas in Bhutan are suitable for Winter vegetables grown in the Summer season. Knowing the origin of each vegetable can also assist in understanding their characteristics and support crop planning.

Highland crops which originated from South America and North India can be cultivated as Summer vegetables in Bhutan. Winter vegetables which originated from a Mediterranean climate can be grown in the Winter season in middle and low altitude areas, and during Summer in the highlands. Vegetable varieties can be selected according to whether they are an early-, mid-, and late-season variety; their resistance to disease as well as their tolerance of hot or cold conditions is also considered. Based on this

information, and taking account of appropriate seasonal varieties, Bhutanese farmers should also consider agro-ecology and altitude in crop selection.

Origin place	Crop Name	Remarks for the Climate
Mediterranean	Kale, Cabbage, Cauliflower, Broccoli, Pea, Asparagus,	Mild winter, semi-dry and
	Coriander, Leek, Mustard	warm summer
Southern Africa	Watermelon	Desert climate, hot and short rainy season, low humidity
Central Asia	Radish, Turnip, Carrot, Onion, Spinach, Garlic	Hot/dry summer, cool short
		rainy season, severe winter
North India	Cucumber, Melon(cantaloupe)	Low humidity, warm
		temperature, much rainfall
Eastern India	Eggplant, Ginger, Bitter gourd, Okra	High humidity, hot
Southeast Asia		temperature
North-East Asia	Chinese cabbage, Bunching onion, Soybean, Azuki	Cool summer, severe dry
	bean	winter, rain in summer
Central	Maize, Bean, Pumpkin, Zucchini, Cassava, Sweet	Hot temperature, high
America	potato, Tomatillo	humidity
South America	Potato, Tomato, Chili, Groundnut (peanut), Tree	Low humidity, daily
	tomato	temperature fractionation,
		highland, strong sunlight

Vegetables and their origin place

(3) Basic Management for Vegetable Cultivation.

• Soil Improvement

Appropriate conditions of soil, temperature, water and selection of variety are fundamental in ensuring crop growth. Soil improvement is essential before crop production. The primary element for soil improvement is the incorporation of compost or manure (known as FYM or farm-yard manure). The

application of compost, composed of organic residues (humus) can increase soil fertility and improve soil structures, ensuring they have sufficient air and water. Organic residues can provide micro spaces for soil microflora that can aid rapid water drainage, retain fertilizer, increase water holding capacity and provide air supply for the roots. During decomposition of compost in the soil, earthworms and other helpful microorganisms are activated, which can reduce the risk of disease and enhance the healthy growth of the plants. Another recommended method of soil improvement is the utilization of green manure crops. Legume plants such as beans, peas, vetch and dhaincha have a nitrogen-fixing function, and therefore, following their cultivation, they are ploughed into the soil which has the same effect as tons of compost applications. Almost all cropping yards in Bhutan are able to grow green manures between crops, which decompose quickly and are labour-saving. In addition, the incorporation of organic mulching materials like paddy straw and stubble can also be used on account of its organic properties.

The decomposition of organic materials differs widely. Composting depends on microbial decompositions; it is necessary to maintain a high temperature around 40°C, with a water content of 40%-50% and sufficient aeration. In general, organic residues are quickly decomposed in the soil; fresh green leaves require several weeks. On the contrary, sawdust or woodchips take half to one year to decompose due to their hard, organic compounds (lignin and cellulose). Compost making requires appropriate material mixing, in parallel with correct management such as optimum timing and frequency of turn-overs, and an adequate level of moisture throughout the process.





Green manure (Daincha)

FYM/Compost

• Crop Selection and Soil Acidity

Almost all Bhutanese farmyard soil is slightly acidic due to the Summer rainy season, as in other Asian monsoon areas. Soil acidity can be indicated by its pH value, (pH is a French term "pouvoir hydrogène", translated into English as "power of hydrogen" or "potential of hydrogen"). Unfavourable pH levels in soil can cause stunted growth and a deficiency of micronutrients. Therefore, a correct estimation of soil from the perspective of crop growth and weeds is very important. Crops such as Spinach, Garlic and Bulb onion that come from Central Asia which has less rainfall in the Summer season prefer slightly

alkaline soils. Other crops that grow in warm conditions with more rainfall prefer slightly acidic soils and can grow well in soils with a pH range of between 6 and 6.5.

The table below shows the range of optimum soil pH recommended for the growth and development of each vegetable.

Vegetable	Soil pH	Vegetable	Soil pH
Potato	5 - 5.5	Cabbage	5.5 - 6.5
Sweet potato	5.5 - 6	Chinese Cabbage	6 - 6.5
Watermelon	5.5~6.8	Spinach	6.5 – 7
Radish	6 -6.5	Lettuce	6 - 6.5
Carrot	5.5 - 6.5	Pea	6.5 – 7
Bulb onion	6.5 - 7.5	Tomato	6 - 6.5
Bunching onion	6 – 7	Brinjal	6-6.6
Pumpkin	5.5 – 7	Cucumber	5.5 – 7

Reference table of Suitable Soil pH on Vegetables

Soil tests are available in the National Soil Services Center; however, the soil data should be used by experts who have sufficient knowledge of the field undergoing testing and experience of soil science and plant physiology.

Spinach can show less growth in the field despite fertilizer applications in the case of acidic soil. Weeds, such as horsetails, *Rumex*, *Plantago*, *Artemisia*, clover and dandelion, are popular indicator plants of acidic and less fertile soils. Generally, lime for wall painting purposes, wood-ash and dolomite are used in the modification of acidic soils and are applied together with basal fertilizers.

• Vegetable Seeds

Seeds for sowing are always selected after having been recently harvested. Water, temperature and air are important factors for seed germination. Temperature is also an essential factor for seed germination; therefore, temperature requirements should be checked before the seed is sown. The table below provides the optimum temperature requirement for seed germination and transplanting of each vegetable.

The numbers of days from the seeds being sown until germination depends on the temperature and on each vegetable.

The table below indicates the basic requirements in each vegetable crop, including the information of sowing type, germination temperatures and the estimated nursery period for transplanting vegetables.

Crop Nama	Optimum	n ure Crop Name	Optimum	Nursery
Crop Name	Temperature		Temperature	Period (months)
Radish/Turnip	15-27°C	Cabbage/Chinese cabbage	15-20°C	1.5
Carrot	15-23°C	Broccoli/ Cauliflower	15-25°C	1.5
Okra	25-30°C	Bulb onion	17-25°C	2.5-3
Kidney Beans	18-30°C	Pumpkin	25-30°C	1
Pea	15-25°C	Watermelon	25-30°C	1.5
Other beans	22-30°C	Tomato	23-30°C	1.5
Sweet Corn	22-30°C	Chili/Capsicum	23-30°C	1.5~2
Spinach	15-23°C	Brinjal	20-30°C	1.5~2

Direct Sowing

Transplanting(nursery required)

• Direct Seed Sowing

Direct sowing is employed for crops which cannot be transplanted, and there are three major methods: line sowing, spot sowing and broadcasting. Broadcasting is commonly used for rape and buckwheat. Line sowing or spot sowing methods are usually used for growing vegetables. In cases of a lack of seeds, spot sowing can cover larger areas with fewer seed costs and without the burden of thinning. Generally, line sowing is used for small seeds in order to prevent the missing plants from disrupting the optimum planting distance. However, sowing seeds too thickly and thinning the seedlings late has a detrimental effect on the healthy growth of the crop.

A general planting or direct sowing bed has a width of 50-70cm with an optimum length, and ridge height of 15-20cm height.

In Bhutan, the deep and thick sowing of seeds is very popular, sometimes without thinnings, which is not good practice. Line sowing simply involves preparing a bed, making a line using a bamboo stick and 16

sowing the seeds few centimetres apart (one by one). In general, sow at a depth of three times the seed size is always recommended.

Common line sowing vegetables are spinach, mustard, carrot, turnip, komatsuna and radish. After the seed is sown, carefully hand-suppression of the topsoil is recommended to keep the moisture in the bed and to encourage healthy rooting. Next, the beds should be irrigated and covered with rice husk, sawdust, or paddy straw to prevent the seeds from drying. When the seeds start to germinate, remove the mulching materials on top of the germinating seeds immediately. Thinning must be carried out several times after germination (see "thinning" section below for details).

• Self-Harvesting Seeds from Fixed Varieties

Fixed varieties (= open-pollinated varieties) have specific characteristics and can produce the same quality seeds by self-harvesting. The self-harvesting of hybrid varieties does not produce seeds of the same quality and with the same characteristics.

Self-harvesting seeds from open-pollinated (OP) varieties can be used in the coming years. The hybrid seeds cannot be used in the same way as the OP varieties, as the quality and characteristics are genetically separated/changed in following generations.

Vegetable seed reproduction requires more careful management than that of standard vegetable cultivation. It is essential to avoid cross-pollination with other crops in the same family by ensuring that they are separated by a sufficient distance (50m ~100m). *Brassica* family crops, in particular, are easy to cross-pollinate mainly with mustard that is commonly grown in many areas. A variety for seed harvesting must be cultivated away from potential pollination by other crops or varieties, or cultivated separately in greenhouses by means of artificial pollination.

To ensure the quality of the seeds, harvesting on time is essential, and then the seeds are dried completely under shade or in a dryer. During storage, well-dried vegetable seeds are placed into plastic air-tight bags or containers and kept in dark, dry and cold conditions. Several years at high-germination rate can result in seeds being stored in a refrigerator (3°C to 5°C). Well-dried seeds stored in a deep freezer (-20°C to -80°C) are used in many seed-banks worldwide, guaranteeing a century safe storage and conserving the germination rate.

(4). Nursery Management

Nursery management is key to quality harvesting for bulb onion, chilli, eggplant, tomato, cucumber, watermelon, pumpkin, gourds, chinse cabbage, cabbage, cauliflower and broccoli. There are several methods of raising vegetable seedlings; direct sowing in a nursery bed, direct sowing 2~3 seeds in each small pot or soil block.

Nursery bed sowing is a commonly utilized method of transplanting vegetables that require thinning and transplanting (potting) during the nursery period.

The aim of nursery management is raising the high quality of transplants for better yield and quality.

• Sowing Directly in a Nursery Bed

Well-drained soil is essential in nursery beds both during dry and rainy seasons or in greenhouses, due to the fact that frequent irrigation is required during the nursery period.

A standard size nursery bed has a raised width of 60 cm - 70 cm, a height of 15 cm - 20 cm and an appropriate length, depending upon the size of the production crops. It is always advisable to keep at least a one-metre gap between the beds for easiness of planting, watering and weeding management.

The vegetable nursery stage requires the most crucial and intensive management for optimum productivity of the target crop and quality yield. Before nursery bed preparation, incorporate some well-decomposed FYM and prepare the bed. Make a line at a distance of 10 cm between the rows. Sow the seed thinly and cover with soil. When the seed sowing is complete, cover the bed with old newspapers, straw or net to maintain the surface soil moisture for early germination of the seeds.

Once the seeds start germinating, remove the covering materials in order to expose the seedlings to sunlight for healthy growth. Late removal of the covering materials produces long, thin and weak seedlings, due to a lack of sunlight.

• Potting during the Nursery Period

The methods of nursery bed-, soil tray-, or cell tray-sowing usually require seedlings to be transplanted into pots once prior to main field transplantation. Potting is carried out before the first main leaf starts sprouting up until two to three main leaves have appeared. The potting mix and pots prepared before the potting of the seedlings. If possible, potting media (composts mixed with topsoils) should be prepared before four (4) to five (5) months in advance to ensure it has decomposed well. After potting, keep the potted seedlings under a temporary shade covered with a shading net and irrigate the pots sufficiently. In the absence of a shading net, pots may be placed under trees, or a paddy straw mat (gundri) may also be used as an alternative. Remove the shading net in the evening after four (4) to five (5) days, once the seedlings have settled.

After one month of pot raising, the seedlings are ready to be transplanted. It is advisable to monitor them for the presence of pests and diseases and act quickly if any are found. Irrigate the seedlings once a day if there is no rain. Immediately before main field transplanting, seedlings should be irrigated and transplanting should take place on rainy days and late in the afternoon as these conditions are possible to

increase the settlement rate. Soil blocks and half cut the pet bottles or bamboo nodes with holes in the bottom can be used as pot alternatives for raising seedlings.

• Direct Transplanting from Nursery Beds

Winter vegetables (broccoli, cabbage, cauliflower) can be planted directly in a flatbed nursery at a distance of 10cm to 15cm then can be transplanted directly in the field after one (1) month. It is advisable to use trowels to uproot the seedlings, so as to minimize damage when transplanting.

It is NOT recommended to transplant summer vegetables (watermelon, cucumber, pumpkin, gourds, tomato, chilli and brinjal) directly from the nursery beds, as the high temperature and dry conditions could lead to seedlings being lost during the process.

Bulb onions are usually raised in nursery beds by direct sowing. Flatbeds should be prepared with a width of one metre, and line sowing of 7cm to 12 cm is recommended. Since this process is similar to paddy rice cultivation, direct transplanting can be carried out after the nursery period. Since bulb onion seedlings remain in the nursery for a period of 2 to 2.5 months, it is necessary to incorporate sufficient compost or manure before nursery raising. If the seedlings show symptoms of yellow leaves (tip-burn), a small top-dressing is recommended, followed by irrigation.



Potting time with 2-3 main leaves



Transplanting time (5-6 leaves)

• Main Field Transplanting

Field preparation before transplanting is crucial, and the procedure of incorporating FYM and basal fertilization are required when transplanting bed raised in the main field. Disease-free and healthy size and colour seedlings should be selected and transplanted into the field. Deep planting should be avoided, and both the level of the poly pot media and the grand level should be the same while transplanting. It is recommended that transplanting takes place in the late evening time, and seedlings should be sufficiently irrigated after transplanting, then mulched with straw, dry grasses or sawdust.

Taller summer vegetables such as tomato, eggplant, and cucumber should be staked individually at the time of transplanting to prevent wind damage and to provide enough support for fruiting. The height of the transplanting beds should be raised higher for those seedlings without stakes to ensure better drainage and more effective long-term management.





Raised bed for direct sowing

Cauliflower planting Method

(5) In Field Management

Staking

Different types of vegetables have different staking systems. Locally available bamboo sticks can be used to the staking. Tomato and brinjal require one or two stakes of 1 to 2m in height. Kidney beans, bitter gourd, and cucumber require 2 to 2.5 m in height. Using crowbar, dig to a depth of at least 20 cm to strengthen the pole to protect it from the wind or an intruder.

After tomato and eggplant staking, tie them with jute thread in an eight form to prevent from wind damage and support the weight of fruits.

Prepare A-shaped stakes for bitter gourd and pole beans and tie the plants to the stake, as shown in the image below. If possible, prepare two lines of horizontal bamboo supports for the vines.

Providing support for the plants enables them to benefit from sufficient sunlight and air ventilation, and results in easier weeding and efficient harvesting together with quality fruits and pods.





Pole bean A-Shaped Support

Chili: single staking

• Thinning

Thin the seedlings at the right time to produce high-quality vegetables. Direct seeding requires a greater quantity of seeds, and seedlings need to be thinned several times provide sufficient growing space and to maintain a healthy condition. Seedlings should be removed gradually while being thin, and thinning should be carried out two or three times to prevent plants from overlapping. From the first thinning, until the appearance of two to three main leaves, there should be a 3cm to 4 cm gap between the plants. A second thinning should be carried out when the plant has six to seven main leaves. In cases where Chinese cabbage and cauliflower are sown directly, the third thinning is required to maintain the plant to plant distance.

In the case of spot sowing, all the unwanted seedlings should not be removed at once. Two to three plants may be kept after the first thinning, during the second thinning the best plant may be selected. Together with optimum bed preparation and mulching, the method of spot sowing has been shown to enhance labour and cost-saving by comparison with direct line sowing.

Radish	25cm
Turnip	10-15cm
Carrot	10cm
Chinese cabbage, Cabbage, Cauliflower, Broccoli	35cm
Okra	20-30cm
Spinach, Mustard, Komatsuna	Thinning and harvest





Mustard line sowing:

First Thinning



Second Thinning



Third Thinning

• Irrigation

Irrigation is the most skill in field management and must be considered many conditions such as soil type, location, climate, daily weather, type of crop, stage of crop growth, workers' skill, soil fertility and water quality/temperature. Therefore, continuous and careful field observation and field management are required for optimum irrigation. In general, crops from high humidity areas such as cucumber, bitter gourd, eggplant, and taro require more moisture, so that it is essential to irrigation the fields more frequently.

Winter vegetables in Bhutan start at the end of the rainy season. Therefore, irrigation is one of the most important activities throughout the year. Sufficient irrigation should be carried out effectively, especially after sowing or transplanting. However, too much irrigation is always worse than less irrigation in paddy soils which have high water holding capacity and poor drainage. Standing water in the soil causes root suffocation, resulting in disease or infection, stunted growth. Therefore, the correct method of irrigation should be performed based on field observations and crop preference.

Generally, in the Winter season, frequent irrigation is not required compared with the Summer season due to the short daylight hours and lower temperature. Open field irrigation should be carried out in the early morning or late evening time in Summer, and during warm afternoons in Winter, using a showerhead. Irrigation is required once a week or once every ten (10) days is Winter. However, that should be adjusted depending on temperature, rainfall, crop growth stage, and soil characteristics. In greenhouses, the irrigation frequency is increased depending on the climate and altitude. During field observations, the soil water level can be checked by inserting a dry wood/bamboo stick into the soil to a depth of 15cm - 30 cm. When the soil is sufficiently wet, wet soil is visible on the stick.

Mulching by straw, sawdust, or husks are highly recommended to ensure less irrigation and fewer weeding intervals; protection from direct sunlight can maintain soil fertility and microflora. The bed height can be adjusted in high in cases of soils with a high water-holding capacity and during rainy seasons. On the contrary, the bed height should be lower in well drainage soils and during dry seasons.

Summer vegetables are transplanted in March and April in Bajo when the temperature is higher and in the dry season. It is necessary to irrigate continuously after transplanting over a two (2) to three (3) days. Irrigation of vegetable crops should be carried out at intervals of several days in dry and hot climate conditions.

Winter vegetables on North-facing slopes require less irrigation because they are subject to less direct sunshine, which does not cause dryness of the soil surface. The areas are cooler than other directions and have more soil moisture. Therefore, less irrigation is needed, especially on mulching beds.

When the plant reaches a certain height, flooding irrigation can also be applied. It is wise to refrain from the flooding of soils which are prone to becoming waterlogged (Bajo's soil is a typical paddy soil; therefore, flooding irrigation would not be recommended).



Flood Irrigation of Bulb onion nursery



Irrigation with a showerhead

• Fertilization

Vegetable crops have developed under fertilization for centuries to achieve high yield, improved quality, and a better taste. Any type of fertilization is advisable for crop cultivation which requires high quality and yield.

Basal fertilization: All vegetables need basal fertilization. A fertilizer like "Suphala" is recommended for use in basal applications, which contains 15% of three essential nutrients, nitrogen phosphorus and potassium (NPK). The basal fertilizer is applied during field preparation time, together with compost/FYM, before the vegetables are planted or sown. 3kg ~ 5kg of Suphala per decimal (40m, 1/100 acre) is a universal amount for all vegetable cultivation. Basal is the only application used in the cultivation of light leafy vegetables such as spinach komatsuna and mustard green.

Top-dressing(s): Top-dressing is carried out once or twice for vegetables harvested just once, and on a monthly basis for fruit vegetables which are harvested continuously. Depending on the growth stage of the target crop, split applications carried out two or three times are used to ensure continuous nutrient supply, enhancing crop quality throughout the cultivation period

Urea (nitrogen 46%) is known as the most commonly top-dressed fertilizer for leafy vegetables. Due to the high water-soluble character of urea, fertilizer should be applied first, followed by weeding, earth-up and shower irrigation. Suphala is beneficial for all types of vegetables for top-dressing(s). However, these chemical fertilizers should be applied between plants, or on the ridge shoulders, NOT directly on the leaves or near the root zone as they cause damages to the leaves (leaf burn) and root hairs due to the high concentration. Irrigation follows weeding and earth-up with top-dressing(s) to reduce the high concentration of chemical fertilizers and to even out its distribution.

• Mulching, Weeding and Earth-up

Mulching: Direct sunlight, strong winds, and heavy raindrops make the soil surface harder and cause it to lose fertility. The purpose of mulching is for weed suppression and for keeping moisture in the soil. Weed suppression by mulching occurs by eliminating sunlight exposure. The materials commonly used mulching are straw, sawdust, husks, and black plastic sheets. Correct mulching can reduce the frequency of weeding and irrigation and retain the applied fertilizers for a longer period in the soil. Organic mulching materials can also contribute to the gradual improvement of soil fertility, as they are returned to the soil after usage.

Weeding: Weeds should be removed by their roots and then dried. Weeds compete with crops for water, sunlight and nutrients, and might host pests and diseases. Weeding must be done continuously to keep the bed weed-free throughout the cropping season.

Earth-up: This is an essential task to ensure better productivity for root crops. Weeding and earth-up are essential in encouraging new rootings. Moving surface soil can be beneficial for root aeration and water/air percolation as well as enabling roots to penetrate/spread easily in the soil. Therefore, earth-up together with top-dressing and irrigation are advisable. Evidence of the efficacy of earth-up is commonly seen in potato, sweet potato, taro, peanut and bunching onion.

• Pinching and Branch Control

Pinching and branch control are important techniques for fruit vegetables, especially for *Solanaceae* (tomato, eggplant, chilli) and *Cucurbitaceae* (watermelon, cucumber, etc.) to ensure a high yield and a quality harvest. Branches which have grown uncontrollably result in bushy conditions which disrupt the distribution of water and nutrients in a plant. Too many branches without having been pinched and controlled also have a detrimental effect on photosynthesis, that can reduce fruiting numbers and size. Moreover, bushy plants are more likely to be sources of pests infestation or diseases. The allocation of nutrients from applied fertilizers should be maximized during fruiting and harvesting periods, so as not to contribute to the growth of non-productive leaves and stems.

It is necessary to remove the side branches of tomato, sprouting from each main leaf position (rachis) on one or two selected main stems. Since tomato is a fast-growing crop, it is important to check the field at least once a week for branch control. When the sub-branches become too large, it is difficult to identify the main branch(es). Therefore, it is necessary to remove them at an early stage, when they first started sprouting. This is also the case with brinjal and chilli; all the side branches below the first flower should be removed. Two main branches separated from the first flower position should be selected and kept to maintain fruiting, all side branches from each leaf node should be removed. In addition, the first flowers must be removed to encourage vigorous growth.

Cucurbitaceae crops are vine vegetables, and the first stem is called the primary branch. The primary branch should be pinched-off at the sixth or seventh main leaf position, then four to six secondary branches should be encouraged to sprout to yield fruits. All sub-branches from the secondary stems should be removed for better ventilation and to allow sufficient sunlight to reach the leaves, close to which are the fruits on the secondary stems. The female flowers are always found in the secondary blanches when the main stem pinching-off is properly done.

• Other Field Managements

Many specific management techniques are required for fruit vegetables. General methods include staking and branch control purpose with the purpose of improving ventilation and lowering the risks of pests and diseases.

Tying: Once the temperature increases, crops like tomato, chilli, brinjal and cucumber can grow very quickly; therefore, it is important to tie up the plant at intervals of every one to two weeks. In the case of brinjal and chilli, two to three slanting stakes are required, leaving the plant opening in the centre for sunlight and ventilation.

Old Leaves Removal: Old and dead leaves at lower levels are a source of disease infection. Removing those unworking leaves can reduce the risk of pests and diseases and improve ventilation.

• Harvesting and Post-harvest

The late harvesting of vegetables is common practice in Bhutan, resulting in less taste and poorer nutrition of the produce. Although vegetables can be stored for a longer period in a refrigerator, there is less cold chain transportation and fewer packing materials. The use of rice husks and straw as cushioning materials is advised to minimize damage during transportation.

Bulb onion, garlic, potato and sweet potato require post-harvest drying and curing followed by proper storage method for longer preservation and to minimize post-harvest loss.

Asparagus, sweet corn, and young soybean (edamame) should be harvested early in the morning and boiled immediately to keep their fresh and sweet taste or should be put in cold-chain transportation.

Some of the fruits vegetables which are continuously harvested (tomato, cucumber, zucchini, bitter gourd, brinjal, etc.) should not be harvested late, for extending harvesting period and the overall yield.

• Plant Protection

In agriculture, the most challenging issue is pest and disease control both in the field and in storage conditions. Bhutan is moving towards organic agriculture with clear mandates set out in Vision 2020, and the limited number of chemicals are available in the markets. Control by spraying chemicals should be the last option, and it is advisable to try to reduce the recommended dosage half in the field. The following points should be considered to reduce outbreaks of pests and diseases.

- Produce healthy plants (especially in the nursery stage).
- Use resistant varieties
- Carry out thorough field management in relation to each crop of the aforementioned crops, and weeding host plants surrounding the field.
- Follow the raised bed system and ensure good drainage conditions
- Refrain from high-density planting for good ventilation
- Maintain an appropriate level of soil moisture by mulching with straw and grasses to reduce diseases caused by root water stress and an imbalance of soil microflora
- Follow the crop rotation to control soil-borne diseases and pests.
- Cultivate right crop at the right time
- Utilize alternative/integrated methods combined, simultaneously
- Carry out regular monitoring to reduce the risks of pests and diseases.

Even by following the above practices, white cabbage butterflies and aphids are difficult to control. The insecticide should be sprayed as early as possible to eliminate these pests.

The dosage of chemical insecticide is 0.1% (1ml/L water) or in a more diluted form of 0.075%, using 1 ml diluted in 1.5L of water. Do not harvest/consume vegetables for a minimum of two to three weeks after insecticide spraying. Chemical spraying must wear protective clothing (rainboots, musk, waterproof rain suit, goggles, gloves) to protect the personnel from harmful chemicals: Taking a shower is recommended, and hands must be washed thoroughly after spraying. The personnel should refrain from drinking alcohol on the day of spraying.

Alternative materials such as gelatine, starch, kitchen detergent, tobacco extracts, herbal repellents and wood vinegar can also be used for crop protection instead of chemicals. The protective measures are required in case of using tobacco extracts.

4. Summer Vegetables



(1) Transplanting Vegetables

1) Chilli (Capsicum annuum, and C. frutescens)

Chilli is the most popular vegetable in Bhutan and is cultivated in every household.

• Important Points for Cultivation

- The crop should not be planted consecutively; maintain a gap of at least three years.
- It grows over a long period; a sufficient quantity of FYM/compost should be applied to keep the soil fertile.
- Aphid, *Verticillium* wilt, and damping-off are the major challenges.
- Nursery raising is key to high yield and disease control
- Plants should be supported by one or two stakes.
- A high raised bed should be prepared.
- The raised bed method should be followed, avoid high-density transplanting.
- Top-dressing must be carried out at least once or twice (once a month during the fruit-bearing period).
- The seedlings should only be planted when the day temperature increases.
- The first flower at the main stem separation point must be removed

Seeds may be sown in March in areas below 1000 m above sea level (masl), and in April in mid-hill areas. Prepare a bed of 60-70 cm width, with double line planting maintaining a plant to plant distance of at least 30 cm. Avoid deep planting, but after planting, select two to four main stems and tie them to

stakes the eight shaped tying method. Irrigation is required continuously with mulching. When the plant grows bigger or taller, tie the plant at a higher label to the stakes. Remove all side branches below the first flowering position and on the main stems. Check the moisture of the soil frequently, and if the surface becomes dry, it should be irrigated immediately.

During the monsoon season starts, which starts in June, the water content in the soil increases. Drainage is crucial for this particular crop. When the young plants start fruiting, harvest the fruit early. Early harvesting helps the plant healthy and increases the yield potential. Chilli belongs to the *Solanaceae* family; therefore, the cross-pollination may occur. To produce the seed, separate the plants and ensure there is sufficient distance between each variety in order to maintain specific characteristics of those varieties.

2) Tomato (Solanum lycopersium)

Tomatoes originated from the Andes Mountains of South America. This crop prefers daily temperature fluctuations yet neither too hot nor too cold, strong sunlight and dry climatic condition. In Bhutan, quality tomato production is difficult in the rainy season. In lower altitude areas cultivation can start between September and December after the rainy season. In mid-land areas, tomato can be cultivated from March to June before the rainy season until the end of November. Greenhouse cultivation is possible in Summer in highland and Winter in midland areas.

• Important Points of Cultivation

- Tomatoes should not be planted in the same plot for at least three years.
- Tomato is a 'big-eater' crop and requires top-dressings at least once a month during the fruit harvesting period
- Tomatoes should be planted on raised beds.
- In the case of indeterminate varieties, always remove the sub-branches and maintain a single main stem for production using stakes.
- Take care of aphids, whiteflies, fruit bowlers, early and late blights and powdery mildew.
- Tomato is a vigorously growing plant 1.5 months duration from seed sowing to transplanting.
 Raising healthy seedlings is key to yield and disease control.
- Transplant the seedling when the sixth or seventh leaf emerged, 20-25 cm height with the first flowering bud appears.
- Avoid deep planting, plant to plant spacing should be at least 40-50 cm, bed size: 70cm 80 cm, two zig-zagged lines for easy staking and adequate ventilation.

- Stake plants with a stick/bamboo of a 1.5 m length (for indeterminate); mulching is highly recommended to reduce the burden of irrigation.
- The staking method is the same as that of pole beans (see beans procedure).
- Remove the sub-branches (suckers), tie the main branch(es) to the stakes until the fifth harvest (until the 12-20th harvest is possible with the correct management)
- After transplanting, tomato plants grow very quickly. Flowering takes place after every three leaves.
- Tomato prefers less irrigation and high-salt conditions. Too much irrigation must be avoided.



Removal of sub-branches

Cherry tomato

Tasks such as removing sub-branches (suckers), weeding, irrigation, top-dressing, tying, and harvesting are important undertaking though laborious. Regular monitoring is crucial to carry out thorough field management.

When planted in fertile soil and top-dressing has been carried out, only the vegetative parts of the plant growth and production will be less; therefore, it is important to understand the fertility of the soil before planting. If seedlings are planted in poor soil, top-dressing and irrigation should be followed by monitoring the health of the plants. Tomatoes are susceptible to pests and diseases and remove the infected leaves or plants immediately.

Malathion and cypermethrin are usually used pesticides for aphids and fruit bowlers which damage on the crop.

Tomato flowers are coming to every three leaves from the 1st one, in the same direction. The first flowers should be removed to encourage a good yield and to allow sufficient plant growth for fruiting.

3) Brinjal (Eggplant, Solanum melongena)

Brinjal requires suitable temperature between 25°C and 32°C. Areas which has the altitude below 1000 masl, seed sowing in mid-February, potting and transplanting at the end of March. Mid hill: seed sowing at the end of February and planting in mid-April. Since the temperature is low at the time of seed sowing and potting, it is important to cover with a clear plastic sheet to increase the temperature. In Bajo condition, a plastic tunnel is used inside the poly house to meet the required temperature.

• Important Points for Cultivation

- Tomato, chilli, potato, and brinjal (eggplant) belong to the same family, therefore, to prevent planting on the same plot for at least three (3) years.
- Well decomposed FYM/Compost should be mixed at the time of field preparation.
- As it has a long harvesting period vegetable, top dressings should be applied at least twice. Once a month frequency of top dressing is recommended until the end of the harvesting period.
- Plant in raised beds but refrain from high-density transplanting.
- Staking with 1 m high stake, use 2 to 3 stakes per plant.
- The water requirement of brinjal is the highest among the Solanaceae crops.
- Prepare a drainage route, and mulching on the beds is required.

If the plants become old or fewer flowers are observed, top dress it with suphala 500 gram per decimal (10m2. 2m x 5m size), carried-out pruning, allow the suckers to develop for fruit production. Aphid, mite, stinking bug, ladybug (except for seven -dotted ladybugs) should be taken care. The optimum temperature required for the germination in the day-time is 30°C, and the night is above 20°C. Cover the bed with a plastic sheet that can keep to the night temperature higher. Refrain from over-watering after germination as it causes damping-off. Transfer to poly-pots at the 1st-3rd main leaves stage or direct sowing into the pot and thinning seedlings into single. Poly pot size for potting is usually used 8 cm wide and 10-12 cm high.

Transplant seedling: 5-6 leaves, roots reach the bottom of the poly pot. Transplant the seedlings before the root covers the bottom of the pot and soil becomes hard. Prepare the land one week before transplanting, add adequate compost or manure, and incorporate it in the soil. Basal fertilization should be applied, and the bed width 60-70 cm, the spacing between plants is 50 cm, two lines following the zig-zag planting. Irrigate the seedlings before one night of transplanting. Do not plant deep and avoid pressing the soil at the time of planting. Use staking, mulching with straw, then irrigate. Keep two to three main branches and remove all the suckers below the first flower position. It is confirmed that the

first branch gives fruits without fail, so it is good to harvest early for better and uniform fruiting. Unlike other crops, eggplant fruits definitely after flowering.

Two weeks after flowering is the best time for harvesting when the fruit is shiny and little soft. Do not harvest late; the fruit becomes too hard due to the maturity of the seeds inside the fruit. Remove the old leaves of the lower portion for aeration. When the temperature increases, aphids, mites, ladybugs attack the plants. Spray insecticide at the correct doses (not more than 0.1%).





Staking

Fruiting Stage

4) Pumpkin (*Cucurbita moschata*)

Pumpkin is hardy creepers or soil surface runners, commonly available in Bhutan for cattle feed. It is a short day variety and starts flowering after July, followed by fruiting. Currently available local varieties have high water content and become soft at the time of cooking and almost tasteless.

Pumpkin contains high carotene and vitamins and can be stored for a longer duration. It is almost resistant to pests and diseases and easy to cultivate. Pumpkins below 1500 masl can be cultivated in April and harvested within three months. Transplant paddy after pumpkin harvest.

In Bajo condition, the cultivated varieties are European type "Ebisu (Wengkher kakur)" and Japanese type "Kuri". These two varieties have high potentials for cultivation in Bhutan due to its small size and better taste, which are appropriate for family consumption. It also has good keeping quality and easy for transportation.

In an altitude below 1000 masl sow seed in End of January to 1st week of February and harvest in the first week of June. In the mid-hill areas start seed sowing from Mid-February and harvest in Mid-June. Pumpkin can be cultivated till 1700 masl in Bhutan.

• Important points for the Cultivation:

- Excessive vegetative growth causes fewer fruits.
- Two planting methods; 1. Direct sowing & 2. Seedling (transplanting).
- Pinching of the main stem tip at 6-7 main leaves stage to force four to five sub-branches for the fruiting.
- From the 4 to 5 sub-branches, allow fruiting from the10-15 nodes.
- Pumpkin can be cultivated consecutively on the same plot.
- Prepare the soil thoroughly with the addition of the decomposed FYM/Compost before the seed sowing in the field.

Prepare a low mound of 70 cm, water basin formed in the middle of the mound for irrigation. In case of direct sowing, start seed sowing from the 1st week to the 2nd week of February. Sow 3- 4 seeds in a circle (not all the seeds in the same spot), cover the seed with soil maximum three times of seed size depth, do not plant deep. Same as with the other crops, deep sowing of seeds causes slow germination, less germination, and unhealthy seedlings.





Direct sowing using plastic cap

"Ebisu" and "Kuri" variety (average: 800 g)

Prepare a bamboo stick 100-120 cm, make a cross to put plastic at the top. Cut the plastic of 1 m/1 m and prepare a poly cap. After covering with poly-cap, fix the plastic skirt covering by the soil surrounding and keep warm air inside. To make holes at the top, approximately 15-20 holes using the tip of the ball pen for releasing excess water and hot air inside. Open slowly, one side of the plastic after every week, then irrigate. Mulching by sawdust, straw, husks is always recommended.

Carry out the first thinning twice and select single seedling until the several main leaves stage. Once the plant grows (4-5 leaves) and touches the side or tip of the cover, remove the poly-cap, to prevent the plant gets sunburned. When the plant has 6-7 main leaves, pinch the tip of the plant. After pinching, and before the growth of the side branches, mulch it with straw to produce clean fruits. In the case of potting, use two to three seeds in the poly pot in a circular form and irrigate sufficiently. Cover the pots using a

sheet of the clear plastic tunnel. After germination, select one healthy and good form seedling and remove others until the 2^{nd} main leaves stage.

Day temperature should be between 25- 30°C, and the night temperature should not be below 15°C. Maintain the temperature. Use the bigger size poly pot than those of chilli and eggplant.

Apply well decomposed FYM/Compost before two(2) weeks of transplanting and mix well with the soil. Prepare a mound with the Plant to plant distance of 1.5 to 2 m and row to row distance of 2 m, adding well-decomposed FYM/Compost in the mound and mix thoroughly with the soil.

The transplanting time is at the 4th main leaves period and not do deep planting into the field. The root mat covered whole the potting soil, it indicates already late for the transplanting. The late transplanting causes slow growth and less yield. At the transplanting time, making a mound with a ling water basin can provide easy and sufficient irrigation.

Pumpkins can be sown in mid-March in low altitude areas, and the first week of April in mid-altitude areas. Pumpkin consists of male and female flowers on the same plant. At your requirement of artificial pollination (hand pollination), use a male flower without petals of the other plants and touch lightly on the top(pistil) of the female flower. The best time for hand pollination is in the morning, around 8-10 AM.

Remove the fruits at the base of the plants due to its inferior quality and size (small in size), and the quality fruits are usually produced from 10-15 node positions. Topdressing is important at the time of first fruiting. Apply Suphala 500 gram/decimal (40m²) for top dressing. Prevent the chemical fertilizer from the direct contact on the leaves and stems. Apply the fertilizer at least 1 m away from the plant base then irrigate it well.

Harvest the crop 50 to 60 days after the pollination. The size of the fruit increases until one month later, followed by starch development for a period of two to three weeks. Store the harvested pumpkins at room temperature under the roof, not to expose direct sunlight.

• Plant Protection

Red Melon beetle is the main pest that attacks the plant immediately after removing the plastic. The plant is in a tender stage, which is weak in nature and causes maximum damage. This is the critical stage for the application of pesticides. Apply Malathion, Cypermethrin and other contact insecticides @ 0.1% or 0.075%. It is always good to apply in less concentration.

When the temperature increases, the plants grow vigorously and become hard and less infestation by red Melon beetles. The larvae eat young fruits from inside, but the damage can be reduced by keeping in the

plant quick and robust growth. Therefore, two to three insecticide spraying is crucial after transplanting time for the control.

5) Zucchini (*Cucurbita pepo*)

Zucchini is a kind of summer squash, without climbing vine stems. Therefore, no need for pinching/staking required the spacing 70 - 80 cm between plants. Fruits can be harvested at a tender, small and young stage continuously. If harvested fruits in late, the fruit becomes big, spongy, hard, and not worth to taste. After flowering 4-5 days and the size becomes 18-20 cm long is the best time for harvesting. Zucchini does not need a high-temperature condition like that of pumpkin. The optimum temperature of 25° C is suitable for zucchini cultivation. Sow the seed just before pumpkin and harvest around end-April to May (short duration crop). Since April and May are off-season for other vegetables, zucchini has advantages in the market.



Yellow Zucchini (Harvesting stage)



Pumpkin: Fruiting stage

6) Bitter gourd (Momordica charantia)

Bitter Gourd is originated in India; it is one of the highest temperature requiring crops. Below 1000 m areas can sow the seed from March to April. In the midland areas, seeding at the end of April. The summer rainy season with high temperatures and high humidity leads to better growth and development of the plant. Besides that, there are high risks of fruit flies and melon beetles in the raining season. These pests lay eggs, and larvae damage the fruits. Bitter guard is known as a healthy vegetable containing high vitamin C (30 times more than lemon).

• Important Points for Cultivation

- Bitter gourd and melon belong to the same *Cucurbitaceae* family. Therefore, do not plant continuously on the same plot.
- It requires the support of more than 2 m tall stakes.
- It has a long harvesting period; at least one or two times of top dressing is necessary. Once a month of top dressing is highly recommended.
- When planted in fertile soil from the beginning, the vigorous vegetative growth and less yield ar invited as a result.
- High-density planting is not advisable for disease risk control.

Either transplanting or direct sowing methods can be followed. However, potting leads to lesser germination percentage. Therefore, direct sowing is recommended. Sow 2 to 3 seeds per point. At the 2nd to 3rd leaves stage, select only one healthy plant, and remove other plants that are weak, diseased, or off-type.

Prepare a bed of 60 cm wide and sow the seeds keeping plant to plant distance of 80 cm to 100 cm. Provide support following A-shape like that of pole beans or single stakes along with the plant. It is important to understand that side branches are the vines and are not necessary to tie like other crops.

Fruits are harvested in green, not mature conditions for the market. The bitter Guard can be harvested 15 days after the flowering period, and the late harvesting invite fruits to soften during the transportation, yellow to reddish colour inside. Cucumber has more range of harvesting period than Bitter Guard, and very late harvesting is common in Bhutan.

Harvest the seed when the fruit colour changes to yellow. Extract the seeds when the pod becomes yellow but before cracking. Wash the seed thoroughly, dry it on the paper or bamboo basket and store it in normal condition. Storage in a refrigerator can be used but not necessary.

• Plant Protection

Aphids, fruits fries, and red melon beetles are common pests on all Cucurbitaceae group crops. Use chemical spray, physical protection, and keep the plant healthy by appropriate field management. Do not sell or consume the fruits for two weeks after chemical spraying. The fruits harvested during these periods are used for seed extraction. Vitamin C in Bitter Guard is stable from cooking. The consumption of such nutritional rich summer vegetables should be promoted for the Bhutanese healthy life.



7) Watermelon (Citrullus lanatus)

Watermelon is a fruit vegetable, originated from Southern Africa (Kalahari desert) in a minimal rainfall area (less than 300mm annually). It also prefers high temperatures and strong sunshine, a wide-open space with much less competitive conditions. Watermelon is usually cultivated in the open field in Bhutan, and it is difficult to get the yield above 1500 masl without a poly-house facility and appropriate cold protection methods.

Seed sowing below the altitude of 1000 meter is at the end of Jan to the first week of February, and above 1000 masl is in Mid-February. Cultivate watermelon during the dry season in the month of early spring. The flowering and fruiting should complete before the rainy season to prevent from Melon beetle and fruit fly.

There are different varieties of watermelons in the country. It is recommended to cultivate those varieties which are easier for transportation on rough roads of Bhutan.

• Important Points for Cultivation

- Do not plant watermelon continuously at least for five(5) years in the same field where the watermelon was planted earlier.
- Make the field fertile by adding well decomposed FYM/Manure before planting.
- Pinch the main stem at 6-7 main leaves stage to force 4-5 main branches.
- Harvesting watermelon at the right time is very important.
- It is good to plan and produce fruit in early, harvesting till April or May to avoid damages caused by fruit flies and Melon beetles.
- Keeping well drainage conditions throughout the watermelon production

Both direct sowing and pot raising and transplanting are utilized for watermelon production. In the direct sowing method, follow the recommended practices, the same as that of pumpkin. In the case of raising seedlings in a nursery, 2-3 seeds in each poly pot are sown in a circular way. It requires an optimum day temperature of 25°C to 30°C for the germination, and night temperature should not fall below 15°C. Poly-house nursery with plastic sheet tunnels can protect seedlings. Select a single plant in each at the 2nd-3rd leaves stage. Over irrigation must be refrained for preventing damping-off happening. Plough the field deep and incorporate well-decomposed FYM/ Compost for better plant growth and development. Prepare a mound of 70 cm and plant the seedling with 1.5 m between plants and 2 m between rows.

Avoid deep planting, irrigate immediately after planting. Use paddy straws for mulching, capping by 1m/1m of clear plastic (hot-cap, see pumpkin part). Follow the pumpkin recommendation practices for the capping of watermelon. Remove the plastic and pinch the tip of the plant at the 5-6th of the main leaves stage when it touches the sides or top of the plastic hot-cap. It is good to remove the smaller branches and keep a maximum of 4 strong side branches for the fruit-setting. It is better to let the plant for fruiting at 12th to 17th nodes of the side branches for the quality fruit production.

• Artificial Pollination method

Watermelon should be pollinated by hand. Collect a male flower from another plant, then remove the petals then pollinate on the female flower. One male flower can pollinate 2-3 of female flowers. Hand pollinations must be done in the early morning time, before 10 AM (Between 8 AM to 10 AM).

• Field Management

During fruiting time top dress with suphala @ 500 g/decimal. Roots of watermelon spread over a larger area, top dress by lifting the straw and broadcast suphala. At the time of top dressing, avoid direct contact of the main stem and leaves of watermelon with fertilizer. Top-dressing and weeding can be done together. Irrigation should be followed immediately after top dressing.

• Harvesting Indicators

Watermelon fruits are ready to harvest 40-50 days after the pollination. The ripening of watermelon fruit is directly related to the temperature. Total temperature requirement from ping pong size till harvest is 900 to 1000°C. Therefore, it is important to know the harvesting time of watermelon. Tag (date) using a labelled stick near the fruits when it attains the size of a ping pong ball. The fruits are harvested 35-40 days after tagging (ping pong size) under Bajo's condition. When the tendril becomes yellow, it is also indicates harvesting time. When the face of fruit that touches on the ground side changes its colour from pure yellow to deep yellow, it is the right time for harvesting of the fruits. When green variety watermelon changes its colour to dark green and black variety to dark black with a shiny appearance, it is the best time for harvesting. Tapping is also considered as one of the harvesting technique but needs experience with sound identification and tapping expertise.

• Plant Protection

Red Melon Beetle is the most damaging pest; the control at the earliest happening is essential. It is usually observed that as soon as the hot-cap is removed, the Red Melon Beetle attacks the plant and damages the leaves and fruits.



Red Melon beetles



Aphids on the dorsal side of the leaf

Spray with pesticides to protect the crop from red Melon beetle. Schedule 2nd spraying at the time of fruiting.

Fusarium wilt and cracking of the stem(Gummy Stem Blight) are the major soil-borne diseases related to the planting of watermelon continuously in the same field. It is essential to know the history of the crops planted in the area and related crops belonging to the same family (*Cucurbitaceae*). The grafting with pumpkin, wax(ash) gourd, bottle gourd used as a disease resistance rootstocks. Those grafted watermelons can reduce disease risks.

The procedure of direct sowing, mix the well-decomposed compost/FYM and prepare a mound, then sow 3-4 seeds in a circular form. Plastic hot-capping is required as the same as that of pumpkin. When the capping is completed, open one side of the plastic and irrigate the plant. When the plant attains 2 to 3 main leaf stage, select a healthy plant, and remove others per mound. Once germinated, the growth of the direct sowing plant is faster than that of transplanted ones. Other management practices are the same as that of transplanting.



Sorting/Grading

Top & bottom parts removed Sliced for easy consumption

(2) Direct Sowing Vegetables

1) Kidney Beans (Phaseolus vulgaris)

Young pods and seeds of kidney beans are commonly consumed as vegetable and dal. Varieties for consuming young pods should have fewer fibres. Dwarf beans do not have vines, easy for cultivation, a short duration crop with less yield. Dwarf bean varieties can be intercropped with fruits or utilized as green manure in the normal vegetable field rotation. Pole beans can give more production, takes longer duration but needs staking (support). Kidney beans require the optimum temperature of 20 to 30°C

• Planting Time

Below 1300 masl

1st Sowing at the end of February and harvest in May and June, 2nd sowing in August to September and harvest in November and December. Seed sowing is not possible in the month from May to July.

Mid Hill (altitude. 1400 m above)

1st crop Seed sowing: Mid-March to April and harvest from June to August and the 2nd crop seed sowing July-August, then harvest in November. Dwarf variety (May Green) is a short duration crop; it has fewer fibres with a maximum height of 45 cm. Two varieties of pole bean, such as white pole bean and grey pole bean, are recommended in Bajo condition. It is good to harvest in the tender stage for vegetable purposes due to soft and quality pods. In the case of seed production, properly harvest the crop, dry it and pack it in the plastic bag.

• Important Points for Cultivation:

- Do not cultivate beans in the same plot, at least for three years.
- Bird protection is important in the areas with maximum birds.
- Young pods should be harvested in the tender stage for vegetable purposes.
- Provide proper support and staking for the pole beans.
- Provide proper irrigation during in the dry season.

It does not grow well in acidic soil, add sufficient compost before sowing in the field. Prepare the bed of 80 -100 cm width, and between plant spacing is 30 cm. The seeds are sown in two lines with 3 to 4 seeds per hole. Do not seed them in deep. In the case of dwarf beans, prepare a bed width of 50-70 cm, plant to plant distance of 25 cm, and sow 3-4 seeds per hole in 2 lines. Before the bed preparation, irrigate the field for easy germination of the seeds. After sowing, the field should be well-irrigated and mulching with sawdust, paddy straws, or other grasses. When the germination is started, remove the straw on the seedlings but keep the mulching on the beds. When the tendrils appear, give them bamboo supports forming A-shape. The height of the support should be around 2 m long as that of the same as the bitter gourd. Use the crowbar to make a hole if the soil is hard to stand the poles/supports.

At the time of flowering apply 500gm of urea per decimal(10m2) then irrigate well. The soil is fertile, and the growth is vigorous, only the vegetative growth might be observed. Top-dressing should be applied based on your careful observation.

Harvest dwarf beans after 40 to 50 days of seed sowing. The first harvesting of pole bean is after 50 - 60days of the seed sowing. Generally, ten(10) days after flowering is the standard harvesting time for pole beans.



Dwarf Kidney Bean

Pole bean (white variety)



Mature pole bean for seed

Green Shield Bug

When the pods become to turn the colour yellow, it is the best time for the seed collection. Harvested seeds should be sealed in a plastic bag and store in the refrigerator (for the long time conservation, after drying well then store in a freezer, -20C). Beans are usually less affected by pests, stink bug (green shield bug), and aphid are commonly observed. If needs, Spray chemicals in double doses.

2) Okra (Abelmoschus esculentus)

It is one of the typically hot summer vegetables. When the temperature is coming-up, the growth speed of the plants is also accelerated with enough irrigation. The optimum temperature for okra is between 25°C to 35°C. It contains high protein and vitamins and nourishing vegetables that can be harvested in the mid-summer. Consumption of okra is less in Bhutan despite being a health benefitting vegetable.

For altitude below 1000 masl (sub-tropical area), seeds are sown from Mid-March to July. In Mid hill (warm temperature zone) areas, seeds are sown in Mid-April to June. The yield of okra decreases when it is planted above 1800 masl, due to the short harvesting period.

• Important Points for Cultivation

- Do not plant continuously for three years in the same place.
- Sow seed when the soil temperature increases.
- For the long harvesting period, top-dress once or twice at least based on the plant growth. Once a month of top dressings are highly recommended.
- Harvest the pods when young, around the 5-7cm size, 3-6 days after flowering. At least every two days frequency is needed.
- It takes five(5) months from one cycle cultivation. Add sufficient compost, and make the soil fertile before seed sowing. Pot raising is also possible for the shortening the field occupation.
- Sow the seed when the temperature increases (optimum temperature $25^{\circ}C-30^{\circ}C$)
- Prepare bed of 70 to 80 cm width, sow seeds in two lines (not spot sowing)
- Mulching is highly recommended; Okra needs more intensive irrigation during the harvesting season.
- Make a line of 1-2 cm deep using hoe or bamboo stick, do not sow deep.
- Germination takes place after ten(10) days of seed sowing. Pre-germination before sowing into the soil is recommended. Use the shower to irrigate.

Thin it when the plant has 2-3 leaves, keeping a distance of 8-10 cm between plants. The second thinning is carried out when the plant has 5-6 main leaves as the final. In the case of seedlings by poly-pot rasing, transplant at 2-3 main leaves stage.

For increasing the yield, a high density planting between plants spacing of 15-20 cm can be used in a short cultivation period. 30-40cm spacing is highly recommended and cut-back and top-dressed around 1.8m height size to 50cm tall for the secondary yield. The major pest of okra is aphids. Control aphid either by spraying or thin it and maintain the plant to plant distance for aeration. The simple method of sowing is line sowing without bed preparation when the climate is getting warmer. Sow the seed s between rows of 70 cm, then gradually thinning out. Do not dry after the seed sowing. Earth-up several times with top dressing and weeding. Furrow irrigation is possible for Okra cultivation, use suphala @ 500g per decimal (40m2).

• Harvesting method and Indices:

When the fruit attains 7 to 10 cm in size after 4 to 5 days of flowering, it is time for harvesting. The other harvesting index is the tip of the fruit; if you cannot break it easily, it is late for harvesting. It is necessary to monitor every morning and harvest the appropriate size of fruits every day. Harvesting of okra is a laborious job. When the pods' changes to grey, it is ready to extract the seeds, then pack them in the plastic bag and use within one year. When the pods are over matures, the seeds are fallen-off and lost.



The right time for the seed harvest Late for the seed harvest (no seed)

Plant

Protection

Okra is almost a pest-free crop, but it needs regular monitoring. The aphids are found at the backside of shrink, curled, and dirty leaves, so spraying of any insecticides at the maximum doses of 0.1%, 0.05% or 0.075% per litre(L) of water is important.

3) Groundnut/Peanut (Arachis hypogaea)

Groundnut is originated from South America. It requires high temperatures for the growth of the plant. It is an easy crop for cultivation. It prefers well-drained soil. Fruits are damaged when cultivated in a waterlogged condition. After flowering the young pods come into the soil, then nuts/seeds formation starts. Sow seeds in June-July when the temperature is high and in the rainy season. The harvest is in November.

• Important Points for the Cultivation

- Do not cultivate continuously with beans family in the same field.
- It can grow in less fertile soil.
- Earth-up one to two times are necessary.
- It has a long production period; top-dress with (NPK) once or twice together with earth-up and weeding.
- Do not remove or disturb the ovary axis from the soil; the nuts formation will not happen.

Prepare the land in well sunshine areas with good drainage condition, mix properly with well-decomposed FYM/compost in the soil before seed sowing. Maintain a row to row distance of 70-80 cm and plant to plant 30 cm, keep 3-4 seeds per hole/spot, two lines per bed.

Carryout out te first weeding after one(1) month and second weeding when the plant starts flowering (at the time of ovary formation). It is essential to earth up sufficiently for the ovary(pods) development in the soil. Earth up sufficiently with weeding and top dressing can increase the yield. Apply suphala @ 500g per decimal (40m2) at the time of weeding and earth up.

Groundnut is harvested 130-140 days after the seed sowing, and 90 days after flowering. Another harvest index is the lower leaves start yellowish and drying up. During the harvest, keep the plants upside down and leave them dry for 2 to 3 days. After then, wash well and dry them for the storage and market.



Harvesting

Cleaning

Drying

The fresh groundnut (not dried, just harvested) is usually consumed after boiling in 0.5 -1% salt added to water.

4) Sweet Corn (Zea mays)

Sweet corn is a tasty vegetable in spring to early summer, with the maximum plant height is around 1.2 m. Eating young and soft maize is still not popular in Bhutan. The variety is also different from the ordinary maize for feed or grain purposes. It is sweet and soft compare with the normal maize. It is an easy crop with fairly resistant to pest and diseases, can be cultivated in any location when the temperature increases.

Fertile soil can produce a bigger size of plants and fruits. It is advisable to add sufficient FYM/compost at the time of planting.

Seeds are sown after March to July when the temperature increases. It takes about 80-90 days from seed sowing to harvest.

• Important Points for Cultivation:

- Apply sufficient compost at the time of planting to increase the fertility of the soil.
- Plant in the same area for better pollination, do not scatter the crop.
- Harvest the crop on time, not be late.
- Fresh sweet corn is sweet and tasty; it is better to eat on the same day of the harvest.
- At the time of harvest, pay attention to birds' attacks.

Sowing on both flat-bed or raised-bed for sweet corn is recommended with 60-70 cm between rows and 25 cm between plants, spot/hole sowing every two(2) seeds in each.

The growth is slow compared to the grain maize. Therefore, early weeding is important to protect the plant from weed competition. When the plants reach the height of 10 cm, thinning into single per spot. When the plant reaches the height of 30 cm, apply the top dressing with suphala @ 500g per decimal $(40m^2, 1/100 \text{ acre})$ with earth-up. Maize consists of two to three female flowers (cobs) in a plant. The topmost cob is the biggest and has better grains for seed collection. The lower cobs are used as a vegetable (young corn) when they are in a very early stage.

Harvesting Indices

The silk colour changes to brown when the cob is mature. Harvest the cob after 25 days of the silk falling out. The direct checking by the opening of the tip of the cob that is ready if the yellow seeds appear. Late harvest leads to shrinking of the grains and less taste. During the harvesting time, the leaves of the sweet corn ae still green and useful as mulching materials or fodder purposes.

• Plant Protection

Corn borers and armyworms are the major pests. The larvae enter the cob and damages. Regular monitoring and handpicking of larvae are essential. Spray with insecticides at the time of silk formation.



Silk stage: Harvest after 3 weeks

Cob after harvest

(3) Tuber Crops

1) Potato (Solanum tuberosum)

The potato belongs to the same family with brinjal, chilli, and tomato. Avoid planting continuously with those same family crops. Potato prefers a cool climate around 20°C. Therefore, the summer potato from May to October can be grown in highland above 2000 masl, and the winter potato after paddy rice is produced in low altitude areas in Bhutan.

• Important points for Cultivation:

- Do not produce continuously with tomato, brinjal, and chilli. Do crop rotation.
- Choose the disease-free healthy seed potato for the planting.
- Potato prefers acidic soil
- Earth-up is necessary for the good yield.
- Flatbed transplanting and mound cultivation are standard methods.
- The seed potatoes should be cut vertically into appropriate size for transplanting
- Cut seed potatoes coating by ash, then briefly dry and plant. Coating with plant ash protects the seed potato rotten from fungal diseases.

Flatbed cultivation maintains a row- row distance of 60-70 cm. Make a furrow, add compost, spread suphlala (1 kg per decimal over the compost), sow the seed at the side of the compost, avoid direct contact of the seeds with fertilizer, or the compost. Maintain seed to seed distance of 30 cm and cover the seeds with the soil. When the plant becomes 10 cm tall, keep 2-3 main branches and thin other smaller branches. Without thin branches, all potatoes become small size as a result. Remove the smaller and late branches, and continuous earth-up are the key for the quality tubers. After the thinning, the 1st earth up should be performed. At the time of the plant reaches 20-25 cm tall, carried out weeding, top dress it with 500g of suphala per decimal and earth up. Add sufficient soil and cover the larger area to increase the production area or root zone.

Before bed preparation, add and mix a sufficient amount of composts into the soil. Apply 1 kg of suphala per decimal and mix well into the soil before preparing a bed.

In the case of furrow planting, prepare a single raised bed of 40 cm width. Sow seed potato with a planting distance of 30 cm between the plants. Remove the side branches like that of flatbed planting. During the rainy season, it is likely that the soils are removed by rain, remove weeds, add suphala (500g per decimal), and earth-up.

When the leaves become yellow and dry, it is time for the harvesting. Harvest potatoes after the continuously for two to three sunny days. Keep the harvested potato in a cool and dark place with well-ventilation. The harvested potato should not be sown during the dormant stage as it will not 46

germinate. The green potatoes are the result of exposure of sunlight, not covered properly by the soil in the field, that contains "solanine" which is a toxic alkaloid to our health. Therefore, greenish potatoes are not suitable for human consumption. Earth-up and soil dressings are essential to produce the bigger size of potatoes and to avoid the greenish, not marketable harvest.

2) Taro (Colacasia esculenta)

Taro was originated from Southeast Asia, requires a high temperature and humidity climate, the optimum temperature for the cultivation is 25°C-30°C. Therefore, it grows well in Low altitude (sub-tropical) area in Bhutan. Taro also needs high rainfall, good as a hedge crop of paddy rice fields. Under dry areas, plants become weak, so first irrigated the field then plant the crop.

• Important Points for Cultivation

- It gives better production in fertile soil.
- Do not cultivate for 4 to 5 years in the same field.
- Select good varieties for planting
- Bigger and good quality seeds transplanting can result in high yield.

Some varieties become hard on being cooked, and some are astringent in nature. It is wise to choose the tasty cultivars which are available in Bhutan. Select the seed taro, which is harvested in November and plant as the seed in March next year. Dry the surface of Taro seeds, and keep them in a cool place.

Storage of the seeds: Dig a pit, mother and spring (small ones) are not be detached as possible, then keep them upside down and cover it with straw followed by a layer of soil approximately 30 cm. In order to prevent the water/rain, cover with a plastic sheet on the top. Taro is a crop which damages by frost, refrain from storing in a refrigerator.

Before planting, deep ploughing of the field, followed by the addition of sufficient well-decomposed FYM/Compost is important.

The preparation of planting beds width 70 cm, and maintain 50-60 cm between plants. Single line sowing of one seed per hole.

Do transplanting the germinated seed tubers at the right time. Taro is sown in March-April and harvested during October-November. When the plant reaches n 30 cm height, top dress with suphala @ 500 gm per decimal and earth up. When the monsoon ends by September, carryout the last weeding and mulching the field by straw or dry grasses to prevent the soil moisture loss.



Harvesting Taro



The storage of Taro seed tubers



Left: Jpn variety, others: Bhutan local



Storing at room temperature for selling

3) Sweet Potato (Ipomoea batatas).

Sweet potato prefers well-drained, medium fertile soil, under a high-temperature with sufficient sun harvesting conditions. This is a well-known high yield crop, around 50-60 kg per decimal (1/100 acre, 40m2), and easy cultivation crop with fewer pests and disease attacks.

Sweet potato can be planted when the minimum temperature is above 10° C in March ~ April in Bajo; however, it is easy to propagate through cutting in the early monsoon season. In high altitude, only in the summer season can cultivate till 2,500 masl approximately. Sweet potato can be eaten all part of the plant; fresh or dried lower leaves can be used as a nutritious feed for the cattle, and newly sprouting leaves and young stems can be used as green vegetable consumption. It is a high nutrition food containing rich in heat-stable vitamin C, vitamin E, A, B5, B6, fibres, polyphenols, magnesium, potassium, and a detox functional glycolipid "yarapin".

• Important Points for Cultivation

- The sweet potato does not require fertile soil, well-drained sandy soil is good enough for its cultivation.
- A short period crop if the temperature is sufficient
- It can be cultivated yearly in the same field.
- Propagation by cuttings (stems) basically
- Bed cultivation is followed

• Turn the runners and carry out weeding with earth-up.

Plant the seed tubers for raising transplants (cuttings) in April. Fertile soil has to be selected for nursery. Transplants are stem cuttings, leaves with some portion of stem parts are planted above the soil, mulch with paddy straws. It requires high temperatures for the germination so that seed tubers keep inside the greenhouse. In the absence of greenhouses, raise nursery in the plastic tunnel to meet the required temperature. Germination starts after ten(10) days of planting, remove the straw after germination. The germination is delayed under a dry condition, so irrigate immediately. Plant in the rainy season (June-July) is recommendable.

Preparation before the transplanting, apply suphala 1 kg per decimal(40m², 1/100 acre), and prepare the beds width of 50-60 cm. Cut the stem having 5-6 leaves(nodes) around 30 cm length. Insert the cutting in the soil keeping two nodes out of the soil bed. Plant cuttings are laying down position, slanting not straight-up. It is better to plant sweet potato on a cloudy day or when there is light rainfall for better rooting and settlement. Straws or sawdusts mulching after planting is recommended to prevent from drying.

New rooting takes place within one week, and the bud outbreak starts. Since it is a runner, the roots are formed in every node, therefore, while weeding removes the roots formed on the side branches. The nutrient of the crop is stored in a root. It is a known fact that maximum roots give numerous tubers but small in size. If we remove other roots, the nutrient is focused on the base of the plant producing bigger tuber. Turn the runners two to three times and carry out weeding/earth-up.



Planting materials (cuttings)



Planting method





Runners turning-over with weeding

Harvesting

The best time of harvesting is October to November when the tubers become big and the bed cracks. Cut the vines using a sickle and dig out the tubers with a spade at the time of harvest. Dry the leaves and stem and feed the cattle as nutritious fodder.

• Seed potato storage

Dig a pit of 40-50 cm deep, cover the sweet potato with straw or grasses. Above the grasses add soil. In order to protect from rain/water leaking, cover the top with a plastic sheet. It is easily damaged by cold temperature and frost, do no keep in the refrigerator.

The general practices in Bhutan are that the sweet potato is planted without bed preparation and allowed the roots to form everywhere. Follow recommended practices.

Plant Protection

Only one pest is sweet potato weevil in Bajo. The damaged sweet potato by the weevil cannot be eatable. Remove host weeds, all morning glory plants around the field, especially those roots.

4) Yam (Dioscorea spp.)

In Bhutan, it is grown naturally in the low to mid-altitude areas. The propagules are used as seeds formed above the ground, and edible part for human consumption. Ghar Tarul (ingenious variety) is found in the yard almost all places in Bhutan. Ban Tarul (wild edible Yam) is a high-temperature crop, and it grows well in hot areas with maximum rainfall and deep soil. Normally, it is eaten after boiling. The other utilization of yam is to grind it (raw/fresh) and mix it with wheat flour. It acts as a sticker/glue. It is good to prepare roti or chapatti as the yam flour acts as a glue, keeping other flour intact. Steam bread is prepared by mixing of yam flour with buckwheat and wheat flour. Usually, fresh yam tuber after peeling

becomes brownish colour due to oxidization. Put the peeled yam into 1% vinegar water; it can keep the original colour from the oxidization.

• Important Points for Cultivation

Plant the seeds in the soil, having sufficient humus and support with the bamboo poles. Harvest after 2 to 3 years. Collect the seed propagules in October- November, pack it in the plastic bag, and store in the cool place.

When the bud appears in April- May sow the seed propagules between rows 70-80 cm and plant to plant 30 cm. After the germination, when the tendrils coming-up, provide bamboo support (2 m) poles. Weeding is required two to three times in a season. Cover the base with thick mulching using straws and dry grasses to prevent from drying.

The plants dry in November and December and reappear in the coming season from the same place. When the leaves dry, it is difficult to trace the plant for harvesting, so as an indicator, sow 2-3 wheat seeds on the spot. The wheat plant will indicate the location of the yam for harvesting. It can be harvested from December-February. Yam can be harvested in three years depends on the preferable market size.



Support to yam



yam seeds (propagules)



1st year Yam tuber

5. Winter Vegetables



(1) Heavy Vegetables

1) Cauliflower and Broccoli (Brassica oleracea)

Cauliflower and Broccoli are crops separated from Cabbage; therefore, those are in the same cabbage family crop. Cauliflower and Broccoli are known as cool temperature field crops. The flowering is induced by the low temperature (vernalization) then developing under the long-day period. The vernalization of broccoli depends upon each variety around 15°C to 18°C, and that takes place above the temperature requirement of cauliflower (5°C to10°C). Therefore, cauliflower and broccoli can be grown as off-season vegetables because of this flowering behaviour in high altitude areas of Bhutan. The neighbouring towns in India have hotter areas comparing to Bhutan, so the producing off-season vegetables in Bhutan have more market potentials. For example, sow the seeds in June, transplant in July, and harvesting from September. It is best to select early varieties for targetting to produce the off-season vegetables. The problem of the planting of late varieties is that it needs a lower temperature for vernalization. The flowering starts only after vernalization, which will be late for the market as an off-season crop. Early varieties have the market advantages, whereas the late varieties have a bigger size head.

Altitude above 2000 masl, sow the seed in May to July, between 1500 m to 1800 m in July to August and below 1500 m from August to October.

• Important Points for Cultivation:

- Possible to produce a bigger head in fertile soil.
- Add sufficient compost to increase the soil pH.
- Aphid, armyworms and cabbage white butterflies are the major pests.
- Harvest the crop on time.

Though it is a winter vegetable, potted seedlings are easy to plant. Follow the nursery management practices above for details. Generally, winter vegetables are easier to transplant than that of summer vegetables. Since the day duration is in short and less light intensity, direct planting in the field without potting is also possible.

Sow the seeds into the pots and raising seedlings for the transplanting. In the case of direct sowing the seeds in a nursery bed, replant or thin seedlings in the nursery bed at a distance 5-6 cm between plants when the seedlings are 2-3 leaves stage. Cover the plants with net or straw mat for two to three days after transplanting. Do not cover the seedlings for more than three(3) days as it leads to week seedlings. Transplant it after 3- 4 weeks when the plant consists of 5 to 6 main leaves. It is better to use a trowel to uproot the seedlings so that the roots are not too much damaged.

Two types of planting methods are followed, such as flat-bed and raised-bed planting. The flatbed planting is recommended in the dry season. Prepare the land thoroughly mixing with sufficient well decomposed FYM/ compost and 1 kg suphala per decimal.

Prepare beds width as of 60-70 cm, 15-20 cm high and convenient length. The planting distance like the row to row and plant to plant are the same as the flatbed method. Prepare hill/ridges of approximately 4 to 5 cm at the sides of the bed for easy irrigations.

Plant the seedlings in rows keeping row to row distance of 70 cm and plant to plant 30 cm for early varieties. In the case of late variety, increase plant to plant distance to 40 cm but do not change the row to row distance (70 cm). After one month of the transplanting, apply 500 gm of urea per decimal, and carry out weeding with the earth-up immediately after the top dressing. The weeding and top dressing methods are the same as flatbed planting. Since winter vegetables are planted when there is less or no rain, it is wise to irrigate the field once in a week based on the soil condition. It is good to plant small and young seedlings to produce quality heads. When the size becomes enough and exposed to the low-temperature, the head formation is started due to the vernalization.

• Harvest Indices of Broccoli and cauliflower

Broccoli can be harvested two to three weeks earlier than cauliflower. Harvest broccoli when the floret (head) becomes big and compact. Late harvesting of broccoli increases in weight but decreases in taste. While the harvesting always good to keep 3-4 leaves to prevent transportation damage. Use tools like sickle or knife for the harvesting of cauliflower and broccoli. The stem can also be consumed as vegetables.



Appropriate harvesting stage of "Wengkhar late(left)" and broccoli (right)

Harvest the cauliflower when the curd reaches the preferable size. Do not harvest in late. The strong sunlight damages on white cauliflower curd; the colour changes to yellowish. In order to retain the original white colour, tie the top using 3-4 leaves of the same plant using straw or ropes.

Plant Protection

Important pests are cabbage white butterflies, aphids, armyworms and nematodes. Nematodes can thrive well in acidic soil, so use sufficient compost or add lime to make the soil to the neutral. Spraying insecticides to control aphids and white cabbage butterflies such as cypermethrin, dimethoate, and chlorpyrifos.



Cabbage white butterfly



Cauliflower seed



Larvae of cabbage white butterfly



Broccoli Flowers

• Seed Harvesting

During the flowering season, remove the flowering branches (at least half) to produce quality seed. Removing half the flowering branches provide aeration, sunlight, and nutrient to the remaining branches. Aphids are important pests during flowering and seed formation time.

2) Cabbage (Brassica Oleracea var.Capitata)

Cabbages also prefer cool temperatures, which are difficult to cultivate in the summer season. Similar to cauliflower and broccoli, it can be planted in May to June and produce as off-season vegetables in high altitude areas of Bhutan.

Since it has good keeping quality and an easy transportation crop, cabbage has an advantage in exporting to nearby countries. In mid-hill areas, sow the seed in August to September and low hills (sub-tropical) from September to October.

• Important Points for Cultivation

- It cannot fare well in acidic soil.
- Aphids, cabbage white butterfly larvae are two important pests.
- Top-dressing and irrigation are crucial.

Nursery raising and transplanting refer to cauliflower and broccoli recommended practices. Cabbage heads depend upon the healthiness of the plant, so it is important to give proper care until one month after transplanting. High-density planting of 20-25 cm is best to produce small heads with high yield. Press the head with a bare hand, and if it is compact, harvest it. Even though the head is small but hard enough, the growth will stop, so harvest the crop. When the head becomes big then cracks, it is indicating the plant is over-matured. It is always good to harvest the crop on time.



To initiate the flowering process, crosscut at the top of the cabbage head with a knife.

3) Chinese cabbage (Brassica rapa var. pekinensis)

It belongs to the *Brassica* family, and it is originated from North-East China. It also prefers a cool climate like cabbage, cauliflower, and broccoli. The optimum temperature around 20°C is best suited for its growth and development. The harvest is coming 80 to 100 days after sowing, and the grown-up weight becomes 5 to 6kg per head in the late varieties with yellowish core leaves.

Over 2000 m high land areas can sow the seeds in July and harvest from October to December. In the mid-altitude areas sowing season is August, and the harvest is from November to January. The typical winter vegetable for the lowland areas below 1300m that can sow in September, harvesting in December and January. The good part of Chinese cabbage is that in cold areas or season, once the head becomes ready, it can be kept in the field as a standing crop and harvest as and when required.

• Important Points for Cultivation:

- Late sowing or planting of Chinese cabbage leads to failure of head formation.
- Add sufficient FYM/compost during field preparation and plant in the fertile soil.
- Both direct sowing or raising seedling can be employed
- Regular monitoring of aphids is important.

The potting nursery can be followed as the same as that of cauliflower and broccoli. Compare with other Brassica seedlings, Chinese cabbage is softer and needs more careful handling to reduce the transplanting damages. Use younger seedlings to prevent transplanting damage. If the seeds are available enough amount, it is suitable to follow direct sowing. The field for Chinse cabbage cultivation should be good fertile and well-drainage soil. The planting bed width is 60-70 cm, and the between plants 30cm. As basal fertilization, add suphala 1 kg per decimal and mix well them into the soil. In the case of spot sowing (direst sowing: sow the seeds 3-4 per in each), make furrows and sow the seed, keeping a plant-plant distance of 30 cm, and do not sow the seeds in deep. Thining should be done at 4-5 main leaves stage, keep the single and healthy seedling in each spot. When the main leaves become opening and 7-8 numbers stage, perform weeding and top dressing by urea (500 gm per decimal) following by irrigation. Generally, after transplanting 70 days, when the head becomes hard, it is time for harvesting. The harvesting is the same as Cabbage, cut the main stems at the ground level by a knife or patang. In the cold winter area, cover the head with outer leaves and tie the top by paddy straws for protection from frosting damage. It is possible to keep in snow, or in the soil from frozen damages. Bolting/flowering is happening easily in the lowland area, finish the harvesting on time. The head formation period is also bolting(flowering) in a warm condition. If you need to harvest the seeds, do not plant with other Brassica vegetables nearby.



A Chinese cabbage head

White on the bottom and yellow core leaves

Chinese cabbage is still an unfamiliar vegetable in Bhutan, and it contains much water that can be used for Bhutanese stew (datshi) cooking instead of water. It is the inevitable vegetable for making "Kimchi" Korean pickles.

• Plant Protection

The important pests of Chinese cabbage are armyworms, white cabbage butterflies, cutworms, and aphids. Aphids are mostly found at the dorsal side of the leaves. To control aphids and the butterfly larvae, spray chemical as recommended in cabbage.



Aphids are usually observed on flower stems and leaves under warm temperatures





Chinese cabbage belongs to the same *Brassica* family of turnip, mustard green (peka), rape, broccoli, and cauliflower, maintain distance between the crops to prevent cross-pollination for the seed harvesting. Aphid appears on leaves and flowers when the climate is getting warmer. It is mostly seen on the dorsal

sides of the leaves and flowers. Early detection and control are important to protect the crop from this sucking pest.

(2) Root Vegetables

1) Radish (Raphanus sativus)

It is one of the most consumed and popular vegetables in Bhutan. It prefers to grow under cool temperatures but is an easy cultivation crop and adapted to a wide range of temperatures. When the temperature becomes very low, the growth retards, so planting should be planned as per the climatic condition and altitude. June and July are the sowing time for the highland areas and harvesting September to October. In the middle-lands, the sowing is August to September then harvested in November and December. Lowlands below 1000m altitude should be sown September and October, then harvested in December and January. As same as other winter vegetables, radish can be produced in the summer in highland areas of Bhutan. Same as cabbage and carrot, radish harvested from July to October in the high altitude area can get high demands in the Indian market as off-season vegetables.

The varieties like Minowase, Tokinasi, and white neck have a wider cultivation period. The round type varieties like Shakura Jima Daikon and Shogion are cultivated in Bajo for variety diversification. Radish has different uses such as curry, pickles, and storage after drying for the lean season.

• Important Points for Cultivation

- Plough the soil deeper with one to two tillage.
- Add sufficient and well-decomposed FYM or Compost to increase soil fertility.
- Undecomposed compost, clods and stones lead to forking of radish roots.
- Select the suitable and appropriate varieties for the summer production in highland areas to prevent the bolting.
- Proper irrigation must be performed in the dry season cultivation for the proper growth and development.

In order to prevent the forking of radish, it three weeks sowing, then mix and plough well, remove stones in the field and refrain from using undecomposed FYM/composts. Add suphala one kg per decimal then raise the bed higher than the other crops. Make the beds of 60 cm in width for double rows sowing. Prepare the bed edges 3-4cm higher than the flat prepared centre for better irrigation. It is essential to plough well and prepares the soft soil before sowing. Well-decomposed FYM or compost must be applied two to three weeks before the sowing. Set two lines for sowing the seeds with less density. Spot sowing method is also recommended, sow three or four seeds circular in each spot that spaced between 25cm. Do not sow in deep, then irrigate immediately after the sowing. Mulching with paddy straws or sawdusts is also encouraged for keeping soil moisture in the dry season.

Remove the mulch on the top part of the seedlings at the germination. When the plants have 4-5 main leaves, carry out first thinning. During the first thinning, maintain a plant to plant distance of 7-10 cm. The second thinning carries out after one(1) month and maintain the plant to plant distance of 25-30 cm. When the leaves become yellowish-green, add suphala @ 500 gram per decimal followed by weeding.

Most of the varieties can be harvested after two (2) months of the sowing. When the plants are harvested in late, the pith becomes dry, hollow, and hard due to water loss. Further delay in harvesting leads to the formation of flowering stalks due to vernalisation. Therefore, it is crucial to harvest on time. In a dry area, it is important to irrigate the field one or two days before harvesting to prevent the breaking of the edible part of radish.

• Plant Protection

On-time production and harvesting of radish have fewer problems than that of the off-season. Off-season cultivation of radish has the problem of aphids, cabbage white butterflies, and armyworms. Aphids are prominently found at the dorsal side of the leaves, check it periodically and spray with the chemicals.

Mid hill areas facing north have the short sunshine hours in winter, so frequent irrigation is not required. The south-facing slope in low hills has more sunshine hours in winter, and the soil dries fast, whereby regular irrigation is important. Mostly the winter vegetables are succulent(juicy, water-rich) in nature and need maximum water for the production of quality vegetables.

In order to produce quality seeds, it is important to select pest and disease-free healthy plants. Aphids damage on the plants mostly happens at the time of flowering and pod formation, spray chemicals is required such as cypermethrin @ 1ml/litre(L) water or 1 ml per 1.5-litre(L) water. (0.1% to 0.075%)

Continuous seed production from the mother seeds leads to the degeneration of the crop. For maintaining the originality, cut the radish in half and re-plant for the harvesting of the seed.





Cut radish and carrot roots for the mother seed production(left). A Japanese variety "Shogoin" root (centre) and the flowers(right).

Dry the pods in tarpaulin for two to three days after the seed harvesting. The pods are hard and difficult to thresh. To soften the pods, before threshing sprinkle water using watering cans, cover it with plastic sheet for 2-3 days and dry it. Thresh it and store the seed for next season.

2) Carrot (Daucus carota)

Carrot requires optimum temperature between 15°C– 20°C for the cultivation. It can be grown till 30°C due to their long sowing season. In altitude above 2000masl, the seed sowing is done from April-August and harvested from July-November. It takes approximately three(3) months from seed sowing to the harvest. In Mid hill areas, the seed sowing starts from July-September and harvests from October-January. The areas below 1000 masl sow seed in October - November and the harvest from November- February. Therefore, in Bhutan, carrot can be produced whole year round from different locations and marketed.

Generally, two different varieties of carrots are available worldwide, such as Long one or Asian variety and short one or European variety. European varieties are mostly cultivated in Bhutan. In Bajo Kuroda 5 inch, a European variety is cultivated. The seed production in Bajo is solely done for the promotion of the varieties in the region. Carrot is rich in Carotene and vitamins. It is considered as a highly nutritious vegetable. As the same as radish or cabbage, carrots are not produced in other neighbouring countries during summer seasons. With the advantage of high altitude areas, it can be produced as off-season vegetables in Bhutan and take advantages of available markets in the region. Moreover, it can be transported for long distances with less damage.

• Important Points for Cultivation

- Ploughing the field well, and deeper
- Keep moisture from the sowing until the germination
- Do not apply the fresh or undecomposed compost/FYM. Make the soil friable.
- Thin at least twice during the growing period
- Carry out early weeding to prevent the growth competition.

Prepare a bed width of 60 cm and 10 cm high, two lines sowing. Three(3) lines sowing is possible using 80 cm width bed. Make ridges at the sides of the beds for irrigation. Side ridges are not necessary when the crop is cultivated in the rainy season.

Mix well-decomposed compost/FYM, and add 1 kg of suphala per decimal at the time of field preparation. Since the seed size is small, make shallow lines. Do not sow in deep. Softly irrigate after seed sowing using shower or watering can. Mulch it with sawdust or rice husks. Old newspaper or

mosquito net can be used to cover for a small area until the germination. Remove the newspaper or mosquito net as soon as the seed germinates.



The time for the 1st thinning

At the 2nd thinning, eatable the thinned carrots

1st thinning is done at 3-4 main leaves time, keeping between the plants of 2-3 cm. The 2^{nd} thinning is performed when the plant reaches pencil size with 6-7 of the main leaves. Uprooting and use those thinned carrots as vegetables. Top-dressing should be applied at the 2^{nd} thinning time, suphala @500 gm per deci]mal followed by weeding. During rainy seasons, the priority of weeding is high, so early weeding is crucial. The initial growth of the carrot is slow, so the weeding at regular intervals is important to avoid the shading by weeds. Moreover, weeding big sizes may cause the loss of carrot uprooting together; therefore, early and frequent weeding is better. Carrot can be harvested continuously during cold seasons (winter) like Chinee cabbage. The growth period needs three(3) months, and the harvesting is almost the same practice of radish. When the harvest is late, the pith becomes hard (woody), rot, and cracks. Harvesting should be started from the 2^{nd} thinning time until not too late.

In colder places (high altitude areas), the growth is retarded due to cold temperatures, so follow the planting schedule as mentioned above. When there is undecomposed compost, clods and stones forking of carrot root takes place. To overcome such problems, make the soil friable, apply well-decomposed compost, remove stones or clods in the field. When the temperatures decrease, vernalization takes place. The flowering process starts when the temperature is getting warmer, and the seed formation takes place. During the process of flowering, numerous flowers are produced by the plant leading to the distribution of nutrients and the production of inferior quality seeds. To produce the quality seeds without compromising, the required nutrients to the plant remove the smaller flowers and keep the biggest or the best one (one flower per stalk). When the umbels become light brown, harvest the seeds.

Crush the harvested umbels with hand and store the best seed. To avoid the degeneration of the seed quality and to keep the purity of the seeds, cut the seed production plant roots in half (slanting) and replant them as that of radish.

Carrot has fewer pest and disease problems, but in some cases, swallowtail butterflies, powdery mildew, and aphids may damage the crop. Therefore, it is always advisable to thin the plant for maintaining the plant to plant distance as a means to prevent the crop from pest and disease damages.



Variety "Kuroda 5"



Remaining 3 flowers for the seed production (Bigger flower size is better for seed production)

3) Turnip (*Brassica rapa*)

In Bhutan, the turnip is used as a cattle feed. In winter seasons, cut leaves after sun-dried are used as a vegetable. It is resistant to cold but weak against hot and dry conditions; therefore, the production of turnip is mainly located over 2,500m altitude areas from rainy to dry seasons. The sowing in highland is from June to August then harvested from August till winter. In mid-lands, sowing is from August to September, then the harvest from October to December. There is less observed the production of turnip in low altitude areas (below 1000m); however, the production is possible to sowing in September and October, harvesting from November to January. Turnip is known as a high-nutritious vegetable, rich in vitamins, calcium, and carotenoids. The commonly produced variety in Bhutan has purple coloured roots, approximately 500g size.

• Important Points for Cultivation

- Cold-resistant but weak in hot- dry condition.
- Prevent from high-density planting.
- Irrigate properly during dry seasons
- The seed production must avoid cross-pollination with other *Brassica* vegetables

Add well decomposed FYM/Compost and prepare the soil. Make a bed of 70 cm width and sow the seeds in two to three lines. Avoid deep sowing, irrigate immediately after the sowing. First thinning is done at 3-4 main leaves stage. The second thinning is done after 4-5 weeks of seed sowing.



Red variety



Thinning and harvesting

The second thinning when it attains edible size, keep a distance of 15-20 cm between plants and thin the rest. Late harvesting leads to thick skin, hard pith, and weight loss due to the less water content.

4) Bulb onion (Allium cepa)

Onion consumption is the next to Potato in Bhutan. Production is not taken up on a larger scale. It can be planted after rice and harvested before the paddy planting season. Bulb onion cultivation easily fits in the rice-based cropping system. Below 2000 masl, seeds are sown from mid-September to end of September, transplanted in November end to the first week of December. Harvest the crop in June. Below 1300 masl, seed sowing is done in 1st week of October, transplanted in December, and harvested from mid-May- end of May.

Bulb onion contains a high quantity of polyphenols that cleans the blood in our body. Polyphenols protect people from high blood pressure and strokes. Onion is consumed with all types of vegetables and to increase the taste. When it is planted after paddy, which is in a dry season, it is important to irrigate the crop frequently. After harvesting onions, hanged the bulb for storage at the corners of houses. With this formula, onion can be stored for 4 to 5 months. In April- May, when there is a lean vegetable season, it can be harvested green as vegetables.

- Important Points for Cultivation
 - Add sufficient well-decomposed FYM/compost.
 - Timely sowing gives more bulbs.
 - It can be planted after paddy (double cropping).
 - When the temperature decreases, the growth of the plant also slows down, but the irrigation should be continued

Prepare a raised nursery bed of 1 m width, 15-20 cm height with a convenient length. Sow the seeds in rows spacing of 20 cm. Make ridges around the nursery bed for easy irrigation and equal distribution of water to the seedlings. High-density sowing is possible but does not sow in deep. When the seed sowing is completed, it is crucial to mulch with rice husks or sawdust and irrigate immediately. Since the

nursery period takes 2-2.5 months until the transplanting, the nursery weeding and irrigation are essential managements.

After paddy harvest, add sufficient compost and plough the field. Make transplanting beds of 1 m width and approximately 5 cm height and keep footpaths for easy irrigation and weeding. When the seedlings reach 15-20 cm tall, uproot the seedlings like as paddy rice and transplant singular into the prepared beds, as maintaining between plants and rows distance of 15-17 cm, and irrigate the transplants immediately.

When the temperature increases, the plants start growing in February, top-dress with suphala @500 g per decimal then irrigate.



Bolting of onion head

Harvesting time

The bolting onion heads should be removed. The 70% of stems fallen from their neck position on the ground in May, it is time for harvesting of the crop. Curing is the most critical part of bulb onion. One of the ways is to tie up 5-6 bulbs without removing the leaves and hang them under roof with good ventilation, like garlic storage as shown below. High humidity condition invites rotten bulbs, and a low temperature induces the germination.



Harvested and curing on the field

Drying garlic for the storage

In the case of direct sowing, broadcasting seeds on the bed as described above. Thinning in March and April, and consume the thinned onions as a vegetable.

(3) Leafy Vegetables

1) Mustard green (Brassica juncea)

It is one of the most popular winter vegetables cultivated in almost all households in Bhutan. The vernalization of local varieties takes place with a slight decrease in temperature around 14°C-15°C and starts flowering. ARDC (Wengkher and Bajo) started cultivating two new varieties of mustard (Mayuri and Takana). These varieties need a minimum temperature of 5°C for a month to the vernalization. These late varieties start flowering from March and have long cultivation seasons. Above 2000 masl, the seeds are sown in between June-July and harvested from August till March. In mid-hill areas, the seeds are sown in August-September and harvest from October-February. In Sub-tropical areas, seeds are sown in September-October and harvest from November-February. The best altitude for seed production is above 1500masl. It is challenging to produce mustard green seeds in subtropical areas due to the difficulties in achieving the vernalization requirements and the less harvest amount of the seeds.

• Important Points for Cultivation.

- Easy for the cultivation
- The bigger size can grow in fertile soil.
- Below 1600 masl, can be cultivated after paddy rice.

The sowing in flatbed and raise bed are common methods. During the dry seasons, flatbed sowing can be followed for easy irrigation. It is necessary to have a path on every 1 m distance to be convenient for inter-culture operations. In one meter bed, plant 3-4 lines, prevent from deep sowing.

The first thinning is done at 4-5 main leaves stage. The 2^{nd} thinning is at 7-8 main leaves stage, together with weeding, and top dressing by 500 g of urea per decimal. Keep plant to plant distance of 25-30 cm. Those thinned plants can be consumed as vegetables. In high altitude, it is cultivated during the rainy season, prepare the raised bed for easy drainage.

Before the bed preparation, prepare the soil mixing with well-decomposed compost/FYM. Make a bed of 70 cm width and sow the seeds in 2 lines. Do not sow in deep. If the soil is dry, irrigate well after the seed sowing. Weeding, thinning, and top dressing follows the same as flatbed method. When the plant growth starts, start harvesting from the bottom leaves. If the plant density is high, thin out the whole plant and maintains between the plant distance. Flowering begins in March, and the seed harvesting is in May.

Brassica family contains mustard green, turnip, Chinese cabbage, pakchoi, cabbage, broccoli, cauliflower and radish, all need to maintain distance between the different Brassica crop for the seed production. The cross-pollinated flowers cannot give the pure line seeds in the coming year.

There are less disease and pests on mustard. Plant the crop with the addition of sufficient compost and proper irrigation are the important managements for the plant health.

During the seed production process, aphids are the main pest observed in the field; it is important to spray with available pesticides to reduce its population and to protect the crop from further damage. Powdery mildew is the disease related to drought conditions, so irrigate regularly to reduce the multiplication of conidia.



Mayuri (green variety)



Takana (Red variety)



Armyworm larva

2) Spinach (Spinacia oleracea)

Spinach contains iron, vitamins, and minerals, so it is considered as a high nutrition crop without pests risk. It prefers cold climatic conditions and can be cultivated in Summer in the high altitude areas of Bhutan. Spinach is a high nutritious vegetable with favourable taste. Therefore, it is advisable to increase spinach production in Bhutan.

In Bhutan, real spinach is not available. Swiss Chard is mistakenly called as spinach and cultivated in reality. The actual variety of spinach "Jiromaru" is available in ARDC (Bajo and Wengkher). The seeds are produced yearly and distributed to the farmers of these ARDC target regions.

In high altitude above 2000 masl, it is recommended to sow the seed in June-August and harvest in August-December. In November, when the frost starts, the growth stops, but the sweetness increases. In Mid altitude areas, the seed sowing in September-October and harvest in November- January is recommended. Below 1000 masl areas, the seeds are sown in October-November and harvested in December-February.

Swiss chard, quinoa and spinach belong to the same Chenopodiaceae family; therefore, the phenotypic appearances look similar and have a slight difference character. Swiss chard has thick and wide white stems, whereas spinach has green or red thinner stems. Taste is different between those two. Harvesting

of Swiss chard is mainly by cutting the individual stems/leaves whereas spinach can be harvested as a bunch (at once). Swiss chard can be cultivated as similar to spinach.

• Important Points for Cultivation

- It prefers light-alkalic soil, and the growth is stunted in acidic soil.
- Require a fertile soil for the cultivation.
- In hot areas, it is cultivated after rice.
- Fewer pests and diseases damages, less irrigation is required

Add sufficient compost/FYM before the soring, and if the soil is in acidic, add 5 kg lime as a mitigation measure. The optimum temperature required for the seed germination is 15°C-20°C, and less germination occurs above 25°C.

Prepare raised beds of 70-80 cm width, sow the seeds in 3-4 lines, irrigate regularly till the seeds germinate and reduce irrigation after germination. Over irrigation leads to the death of the seedlings/plant.

In a dry place, add sawdust or husk as mulch after sowing to prevent water loss and for the early and even seed germination.



One month after direct sowing



Cutting from the base, thinned harvest

Thinning of the plants at 6-7 main leaves stage and harvest the extra plants maintaining the required plant to plant distance.

Use sickle or knife to harvest the whole plant off at the base, remove the yellow/old leaves, make a bundle for market purposes.

Spinach can be harvested self-produced seeds, keep the required better plants for the seed production in the filed. Spinach contains both male and female plants. When the temperature increases, the flowering starts (starting from mid-February). The seed formation takes place from the end of March to April.

Thresh it properly after drying the plants. The harvested seeds are sealed in a plastic bag and stored in a refrigerator until the next sowing season.

3) Lettuce (*Lactuca sativa*)

There are two different types of lettuce available worldwide, such as head forming like cabbage and open or leaf lettuce. In Bhutan leaf lettuce is popular; the following explanation is mainly about leaf lettuce.

Lettuce is used as fresh green salade and considered as the main salade crop. It is also important for decorations while serving meals to the guests. The cultivation is easy with less damage by pests and diseases, and a long duration crop by harvesting outer leaves continuously. The optimum temperature with sunlight required for seed germination is 15°C-20°C. The seed germination rate reduces above 25°C. More than 30°C induces seeds in the dormancy, and the germination does not occur. Therefore, seed sowing should start in September. Plan the seed sowing as per the altitude.

• Important Points for Cultivation:

- Do not sow the seeds in the hot season. The germination is needed cool temperature.
- Not suitable for cultivation in acidic soil, add lime to amend the soil pH.
- Excess nitrogen weakens the plant health.

To prepare and adjust the soil pH, add sufficient compost and lime into the soil at the ploughing time. While sowing in a flatbed, keep space of 1 meter between the beds for inter culture operation. Sow the seed in 4-5 lines per bed. Prepare a raised bed of 70 cm width and plant three lines. Since the seed is small and requires sunlight for the germination(heliophilous), avoid the sowing in deep. The seeds do not germinate in high temperatures and over-drying condition, it is necessary to give proper irrigation. Use old newspapers or old mosquito nets to cover the seeds for better germination of the seeds. Remove the cover after the seed germination.

The plant can grow faster after the germination, thinning and harvesting start after one month. When the first thinning is completed, mulch it with straw or dry grasses to prevent from splitting of soil and damaging of leaves at the time of irrigation. The harvesting starts from the outer leaves, and if the plant density is high, cutting/uprooting of the entire plant is recommended. Low temperatures cause delays of the growth, and when the temperature increases, the harvesting can be continued. When the temperature increase, the flowering stalk is formed, the leaves taste become bitter, which is indicating the completion of the harvesting time. When the plant is left in the field without harvesting, flower development takes place followed by seed formation. To collect the seed, cut the whole plant and dry them before the seed blew away by the wind.



Leaf lettuce; ready to harvest

4) Chinese chive (Allium tuberosum)

It belongs to the same *Allium* family of onion and garlic and prefers cool temperatures. Chinese chive grows well in the areas above mid-hill. Since the temperature is feasible, its leaves also become soft comparing to that of growing in lower altitude areas. 4-5 times of harvest is possible in the fertile soil. It is also a highly nutritious vegetable that contains high beta carotene and vitamin C.

• Important Points for Cultivation

- Suitable in alkalic soil.
- Well growing in fertile soil, the leaves become thick and better quality.
- Repeat replanting every 3 to 4 years.
- Can be planted easily in small areas
- Harvest the seed in July –August.

Seeds are sown in March for nursery. Prepare the sowing bed of 1 meter wide for nursery. Sow seeds maintaining Plant to Plant distance of 10 cm but do not sow deep. Cover with light soil, irrigate, and mulch it with straw. When the seedling reaches 10-15 cm high, transplant in the field. Add sufficient compost in the field to make it fertile.



Divide stems for the planting

Harvest Time

Prepare 80 cm wide bed and maintain between plants of 25 cm, cut the leaves of seedlings and plant 3-5 seedlings together in each point. Irrigate transplants immediately and mulch with straws or dry grasses.

During the 1^{st} year, harvest only once. In the 2^{nd} year, when the growth of the plant is vigorous, the harvesting by cut leaves from the base. It is possible to harvest 4-5 times in a year by applying sufficient compost and carry out the weeding and earth-up between harvests. 3-4 years after transplanting, when the plant becomes old, divide the dense stems then replant them with appropriate spacing.

(4) Other Winter Vegetables

1) Pea (Pisum sativum)

Pea is consumed in two different forms, such as seed and pod. Mainly green peas are consumed in Bhutan. It prefers cool temperatures, and the young pea plant has high cold tolerance in nature.

Mid altitude areas sow seeds in June-July and harvest from October-December. In subtropical areas, the sowing can be after paddy rice in October-November and the harvest from February-March. Suitable temperature is 15°C-20°C for pea cultivation. The plant grows faster in high altitude areas because of summer season vegetables, but in the mid-altitude areas, the growth is slow after sowing. When the temperature increases in February, the plant grows faster, then fruiting starts and harvesting in March. The altitude below 1300 masl, continuous plant growth and development takes place, and the crop is harvest in February-March. The seeds consuming varieties are "Usui" and "JPN long", and green pod eating pea is a variety from France. Both types of the pea varieties are available in ARDC Bajo.

• Important Points for Cultivation

- Do not cultivate continuously in the same field, crop rotated and maintained a gap of 3 to 4 years.
- Always sow the seed on time.
- Provide support poles of 1.5 m.
- When the soil becomes dry, powdery mildew appears.

Since pea prefers slight alkalic soil, add well-decomposed compost/FYM then ploughing the soil. In the high-altitude areas, it is planted during the rainy season, prepare raised planting beds and provide the drainage. The optimum temperature for growth and development of the plant is 15°c-25°c. Germination can take place below 15°C. For both the flatbed and raised bed sowing, prepare row to row distance of 80 cm and plant to plant 25-30 cm, sow 3-4 seeds in a circular form. In the case of the raised bed method, sow the seeds in two lines.

When the tendrils appear, bamboo or wood poles are set from the outside. Topdressing should be applied at the time of the flowering, add 500 g of suphala per decimal with earth-up. The best time to harvest 70

green peas is the time when the pod becomes hard by touching, and the colour fades to a little whitish. In case of delay of the harvest, it can be used as the seed.

Harvest the pod consumption varieties before the pod becomes hard when the seeds are small and soft. It is important to irrigate the field until harvesting time; otherwise, the plant becomes weak, and the pod bent.

Below mid-hills areas, peas are cultivated in the dry season when the soil becomes dry. Irrigate the field frequently to prevent the occurrence of powdery mildew. Leafminer is one of the minor pests on the pea.



Fruiting peas



Staking time

2) Green onion/Bunching onion (Allium fistulosum)

Green onion is suitable for cooler temperatures, but it can be grown in cold, hot, and dry conditions. The taste is better when harvested during the cold season. "Kujyo" is one of the wide potential varieties, suitable for both seed and vegetative propagation, that grown whole a year at ARDC Bajo. "Kujyo" can tiller new shoots continuously, both white bottoms and green leaves are tasty and consumable.

Mid hill areas seed sowing in March-April, transplanting in August-September and harvest in December-February. When it meets the cold temperature with appropriate long day-time, the bolting starts after vernalization.

• Important Points for Cultivation

- Do not grow well in acidic soil.
- Deep ploughing and add sufficient compost/FYM.
- Separate the stems (2 stems in each) for the easy transplanting.
- Several times soil-dressing (earth-up) are required for increasing the white stem part

Both direct sowing and transplanting stems are available. Sow the seeds maintaining a row to row distance of 70-80 cm. Do earthing up with the soil when the plants become big enough.
Sowing seed in March-April. The suitable temperature is 15°C-20°C, and prevent thick and deep sowing. Irrigate frequently to prevent from dryness of the soil. Germination of the seeds starts in a week. Thin the seedlings when it is thick, keep them until August for transplanting.

Prepare furrow of 15-20 cm wide, add compost in the furrows, cut the leaves and plant seedling at a distance of 25-30 cm with 2-3 seedlings per hill. In the case of single transplanting, keep the plant to plant distance of 10 cm. When planting is completed, irrigate them sufficiently and mulch with paddy straws or dry grasses. Earth-up after one month and repeat it at least several times. The white portion (stem) is the tasty part for the consumption that produced by earth-up practices. After tillering at 5-6 stems, top dress with suphala @500 gm per decimal and earth up. During 2nd earth up, cover up all the stem part.



Cut green part then planting 2-3 stems



Earth-up till neck level

Harvesting in December by digging out whole plants. When the plants are left in the filed until Springtime, flowering and seed formation are observed.



Onion heads become black Prepared bunching onion for market Onion rust is ready to seed harvesting

Harvest the crop in December. Uproot the whole plants, remove the old scales, tie them and sell or consume the stems and leaves. Bunching onion is the least infested by pests and diseases.

3) Asparagus (Asparagus officinalis)

Asparagus is originated from southern Europe and south Russia. There are local varieties (wild) that found and consumed by the people in Bhutan. It is believed that the Fourth King, brought the seed from Europe and the cultivation started in the Kingdom (anecdote). Asparagus can be harvested more than ten (10) years continuously, and have both male and female in different plants. The new shoots (spear) coming up in early spring season are consumed as a green vegetable. The thickness of new stems is highly depended on the soil fertility conditions, and Asparagus is well known as one of the best big-eater crops. The female plants give seeds in August- September. It is consumed as asparagus datshi in Bhutan, which is very popular. It is mostly cultivated above the mid-hill areas.

• Important Points for Cultivation

- Add sufficient compost/FYM and increase soil fertility.
- Make the stump strong and big.
- After harvesting, add sufficient composts, chicken manure, and wood ash to make the stump strong

Prepare nursery in March-April. Sow seed in the sowing bed of 60 cm wide in 2-3 lines keeping seed to seed distance of 2-3 cm. After seed sowing cover with a thin layer of soil, do not sow deep. Irrigate immediately after sowing, mulch with sawdust, rice husks, dry grasses, or paddy straws whichever is available. After germination, follow weeding and irrigation. Raise seedling till July. Transplant the seedlings when it reaches 15-20 cm tall. (Until July). Prepare a transplanting bed of 80 cm wide, maintain between plants distance of 40 cm, and two (2) lined plantings per bed. Transplantings in cloudy or rainy days are recommended. After transplanting, irrigate immediately. In hot and strong sunlight areas, shading until the settlement covering with net or straws. Since it is a long duration crop, avoid weed pressure in the field by mulching.

Do not harvest for 1 to 2 years after the transplanting. Give enough time to make them stump and strong. Start harvesting after three years only. Yield increases gradually after three years if the plants are maintained well. Do not harvest all new shoots, keep two to three thick shoots per plant for the next harvesting and remove weak shoots. Harvesting seasons usually differ in altitude, and spring seasons from March to June is the harvesting season of asparagus. Harvest just sprouted new shoots at 20-25 cm high using sickle or secateurs.

For the seed production, keep several strong shoots for seed harvesting. After seed harvest in September-October, when the upper part becomes in dry, cut the dried parts then plough lightly with enough amount of well-decomposed compost/FYM for the preparation of the upcoming season.





Land preparation for the planting

Enough size of harvesting shoots

4) Strawberry (Fragaria x ananassa)

Strawberry is still a less-commercialized crop produced small scales in Bhutan. The quality is not sufficient, and the fragile fruits with less packing materials and rough transportations are the bottle-necks. However, with the changes in the diet of the Bhutanese, strawberry consumption will be increasing.

When the Bhutanese season changes based on the altitudes, the growth also takes place, it is very important to understand the climatic condition of an individual area for cultivation. Strawberry flowers are induced by a period of low temperature with short daytime, and flowering and fruiting need warm temperatures. Therefore, the flowers normally start in early spring after the winter season. Despite the same variety cultivation, the temperature in Bajo can induce the flower formation from November to December, and the main harvesting season is from February to March. In the case of Paro, Apr to June is the main harvesting season due to the cold and long winter.

Nursery Raising

After the harvest in June-July, the runners develop, and the root formation takes place. These runners are used for the next planting materials, invite rooting from each runner by putting it into a small pot. After the rooting confirmation, cut-off from parents strawberries then raising as transplants.

Transplants from the runners differ in size. The runners come from near to the mother plant are bigger and gradually smaller to the tip in size. Transplants produced near to the mother plants are too big for potting, and the end ones are too small and less rooting. Ideally, the second, third, and fourth ones should be used as transplants. At the separation time, these transplants should have 4 to 5 leaves. Cut the runner 2 cm away from the transplant. The 2 cm cut runner forms the mark for seedling sowing. The flowering takes place on the opposite side of the cut runner. Keep the cut portion of the runner inside the bed, not towards the ridge. Do not plant in deep, irrigate after transplanting and cover by a net. Covering by net provides shade, prevents moisture loss until the settlement. In the absence of a net, keep the potted plants

below the trees to provide shade. When the plants establish properly, take them to sunny areas. Straw berry becomes weak in dry condition and overwatering as well. Frequent irrigation with less quantity of water is important.

In subtropical areas, as it cannot meet the required temperature for vernalization, take the potted seedlings to the higher areas for 4 to 5 weeks. When the vernalization process is completed after 4 to 5 weeks plant the seedlings for early flowering in the lower altitudes.

• Bed preparation and planting

Select a fertile land in the sunny areas, and add sufficient compost then plough the fields before 3-4 weeks. Prepare the planting bed width of 80 cm and 15-20cm height. Keep 50-60 cm width of a path between the beds for easy weeding and other cultural practices. Two lines planting in a bed with 25-30 cm between plants is recommended, and do not plant in deep positions with keeping the crown above the soil. Deep planting leads to crown injury and rotting that result in less production. Deep planting also leads to the slow growth of the new shoots hampering the uniform growth of the plant.



Potted Seedlings with Runners



Transplanted Seedling in bed

When the potted seedling is planted above the required label, roots growth and development slow down, thereby delaying the plant growth. The flowers are coming on the opposite side of the cut runner. Therefore, keep the runners' side in the bed and not towards the ridges. The fruiting at the side of the ridge can be harvesting easily and keeping enough space for the management and walking space between the rows.

When the flower buds are visible at the planting time, it is easy to set the buds towards the passage side. Remove/cut the old and diseased leaves before planting, and frequently irrigated to prevent from drying. In warm conditions, the growth takes place from December-February and starts flowering. When strawberry is planted in October, frequently irrigate to prevent dryness. When the temperature is high in October-November, increase the root system through proper care. Top-dressing of suphala @500 g/decimal after 1 to 1.5 months of transplanting. Try to avoid the direct contact of suphala with root and plant parts, irrigate the crop, and mulch with paddy straws or dry grasses.



Straw Mulching

Plastic Mulching

Mulching with dry grasses and paddy straws purpose to produce clean fruits, weed control, and maintain the temperatures. Remove the dry and damaged leaves and clean the bases(crown) at the time of mulching. Clear the winter weeds and keep the fields tidy.

• Plant Protection

In Bajo, which is warm in winter, anthrax and aphids are the major disease and pest of strawberry. To control anthrax disease spray Ziman (0.1%), malathion and cypermethrin (0.1%) for aphid. Birds are also giving huge damages to fruits encountered in Bajo. Use mosquito net or bird net to cover the plant/fruit. The cultivation practices are the same in all locations, and the main difference is the planting time.

• High Altitude strawberry cultivation practices

Strawberry is cold tolerant and survives even in winter. In the cold seasons, the growth of the plant stops but needs to irrigate frequently to avoid dry-up. In areas where snow or frost are the major problems, cover the plant with straw and dry grasses to prevent frozen injuries. Clear surrounding weeds even in winter seasons.

When the temperature increases from the beginning of February, the growth and development of the strawberry starts. To enhance its growth and development for better production top-dress with suphala 500 g/decimal and mulch it. Strawberry needs pollination; otherwise, fruit size will be small or deformed. It is an entomophilous flower requiring insect to pollinate. Bee is the most important pollinator. In one flower, there are around 200-400 pistils, and all pistils are necessary to be pollinated to have a bigger size with proper shape. Flowering takes place for 3 to 4 days.

In December and January, both morning and evening are cold, and bees do not fly. So normally deformed fruits are produced during these periods. The temperature increases from February and the

movement of the bees are also increased for the pollination. So in this period of time, quality fruits are produced. In order to produce quality fruit, pollination is important.

• Harvest

Harvesting strawberries should be the time when the whole fruits turn to red colour. Since the pulp is soft, harvest gently to prevent damage on the fruit. Strawberry does not ripen after harvest. Therefore, it is good to eat or sell immediately after the harvest. Grapes, watermelon, and loquat do not ripen after harvest.

Crop	Variety	1	2	3	4	5	6	7	8	9	10	11	12	
Crop	variety	January F	ebruary I	March	April	May	June	July	August S	eptember	Octoberov	emb D	ecember	
Pumpkin	Kuri, Tetsukabuto		* ********	> ++>		····•			1					
Tomato	Ratan		«·····						4þ	↔ …	••••••			sowing/nurse
Chili	Yangtsepa		·			->		- 400				_	-	
Sweet corn	Honey bantam			4		+		4			-			*
Zucchini	JPN	4		••••••		-			1			1		transplanting
Brinjal	Indian round		4					_						
Brinjal	Japanese Short		«	····• ++				-						growing time
kideny bean	Pole & White Dwar	f					-		}				-	
Bunching onion	Кијо	(Cut panting		۹					
Cauliflower	Wengkhar Meto Kopi- 1	-								4	•••••		•••••	harvest time
Broccoli	Ryokurei, Desiko		-							4				
Cabbage	Shutoku			-					4			>		
Chinese cabbage	60 Days								*					
Chinese cabbage	80 Days									4				
Radish	Minowase, Shogoir	n	_							4	·*····			
Pea	Usui, France			-							4			
Komatssuna	JPN saag								(۹	··	4.4		
Mustardgreen	Mayuri												-	
Mustard red	Takana mustard		_							4.14				
Water melon	Sugar baby, JPN's		« ······				_							
Bulb onion	Pune red											····•	# •••••	
Carrot	Kuroda 5 inch								4					

1. Vegetable cultivation calendar under low altitude condition (600 - 1300 m ası)

	1	1.11	12					1		1	100 CARAN		
Crop	Variety	1	2	3	4	5	6	7	8	9	10	11	12
		January	February	March	April	May	June	July	August	September	October	Novemb	e December
Tomato	Ratan, cherry mini		4	•••••	+			-					
Chili	Yangtse Pa Ema			4									
Sweet corn	Honey bantam						• •						
Zucchini	JPN's					···· >	-						
Pumpkin	Kuri, Ebisu			«				-					
Brinjal	Indian round			4		++			-				
Brinjal	JPN's short, long			¥	······				-				
Pea	Usui		>							4 ···			
Bean	Gray,white pole				* *******				····•				
Bean	White Dwarf					-		-	_				() () () () () () () () () () () () () (
Cauliflower	Wengkhar Meto Kopi-		_						4				>
Saag	Mayuri			-			î.	4		*	_		
Mustardgreen	Red Rayo			-			1	4		•••			ay
Radish	Shogoin		-						۹۰۰۰۰	****			
Radish	Mino Wase	_	_						€	••••••			_
Cabbage	Shutoku, B master			_						•••••			
Chinese cabbage	60days								<u>ج</u>				
Chinese cabbage	80days												
Broccoli	H crown, Ryokurei							-	·····>			•	-
Bunching onion	Kujo			-			*···						
Komatsuna(Saag)	Komatsuna		-	-		۹	• •	-	·	·····Þ			
Bulb onion	Red, JPN's yellow					*******	•	-		4			
Carrot	Kuroda 5 inch					4							

2. Vegetable cultivation calendar under mid altitude condition (1400 - 1800 m asl)

3. Vegetable of	cultivation calend	lar unde	r high a	titude o	condition	(1800 - 2	2500 m a	asl)	n				
Crops	Varieties	January	February	March	April	May	June	July	August	Septembe	October	Noven	December
Chilli	YangtsePa solo				*					-			
Bean	Grey & White Pole				4		2						
Bean	JPN's dwarf				4 ++++++		*****		******				
Pea	Usui						«	···· }					
Cauliflower	Meto kobi -1						4)	4	¢				_
Cauliflower	Meto kobi -2							4	••••••			•••••	_
Mustardgreen	Mayuri.Red rayo					4			£			*	
Radish	Shoqoin		-			_		4					*
Radish	Mino Wase	_				4		f 🕨 🥤				-	
Cabbage	Shutoku, B master		_		4	***	**	·· • •	4···* 4+4	÷ +			
Chinese cabbage	80 days									↔ …	•••••	••••	
Broccoli	H crown, Ryokurei					4			·····.			1	-
Bunching onion	Kujo				4	·····	+	* ··	****	++		_	
Carrot	Kuroda 5 inch		_		*	···· *	•···• >						

Sowing,/Nursery Planting

Growing

Harvest time











