

Organic kiwifruit production in Sikkim

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Kiwifruit (Actinidia deliciosa) is a dioecious plant and is widely being studied as its fruit has many nutritional values as compared to the other fruits produced worldwide. Sikkim is the first declared organic state of India. Organic kiwifruit production is a successful venture in Sikkim. The climate and soil of the state are suitable for kiwifruit cultivation. As Sikkim has more area in the range of 600-1500 m height above mean sea level, therefore this crop is suitable for a larger extent of area in the state. Bruno, Allison, Monty, Hayward, Abbott and Tomuri are the cultivars suitable for the state. So far there are no reports of major pest and diseases of kiwifruit in the state. Adoption of scientific package of practice can improve the productivity and quality of kiwifruit ultimately increasing the profitability of organic farmers of the state.

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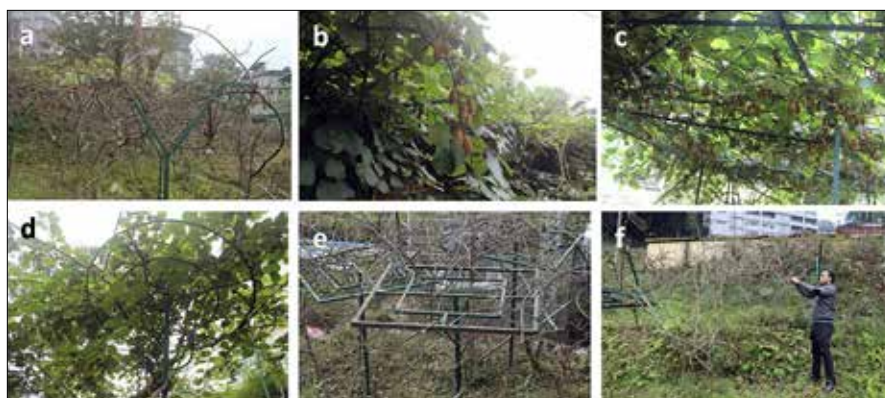
The North Eastern hills are ideally suited for the horticultural industry due to their rich soil resources and agroclimatic conditions, and are a mega center for rich plant biodiversity. In North Eastern forests, the wild cousins of apples, kiwis, and other temperate fruits and nuts can be found growing in their natural form, demonstrating the great range of adaptability of different temperate fruit crops. Sikkim is located between 27° and 28° North latitude and 88° and 89° East longitude in the eastern Himalayas. The Indian Himalayan state Sikkim declared in 2016 that all of its agricultural output had received organic certification although organic farming marked the beginning of Sikkim's organic transition in 2003. Most of the crops are grown traditionally, but farmers are increasingly incorporating new technologies into organic farming systems to add value to the produce, which has the potential to become a niche commodity for both domestic and foreign markets. Kiwifruit (*Actinidia deliciosa*) (A. Chev.) C. F.

Liang & A. R. Ferguson is dioecious plants and is widely being studied as its fruit has many nutritional values as compared to the other fruits produced worldwide. The other name for kiwifruit includes Chinese gooseberry, China's miracle, and New Zealand's wonder. This fruit is now commonly referred to as kiwi in all export shipments. Due to its high mineral, sugar, vitamin, and carbohydrate content, the fruit is extremely nutritious. Kiwifruit contains almost every

mineral, but it is particularly high in phosphorus, potassium, calcium, and magnesium. In addition to be a rich source of starch, protein, and vitamin C, leaves can be fed to pigs, while the aromatic flowers are used to make fragrances.

Area and distribution

Although kiwifruit were first domesticated in China, they were fully commercialized in New Zealand, and since then, they have spread to other nations. Currently,



Different training systems and winter pruning – (a) Tatura trellis system, (b) extended T bar system, (c) bower system, (d) double circle system, (e) double square system, (f) dormant pruning of kiwifruit vine

China, Belgium, Chile, Spain, India, the USA, USSR, Italy, Australia, France, England, and Japan are all experiencing successful growth. It thrives in Himachal Pradesh and Arunachal Pradesh in India. Its cultivation has now begun in Sikkim, Darjeeling, Meghalaya, and the Nilgiri hills of Tamil Nadu as a feasible alternative to other temperate fruit crops. West Sikkim is leading the state in terms of both area and output; the regions of Rinchonpong, Deythang, and Soreng are particularly seeing strong growth. Additionally, it is expanding in certain areas of North and East Sikkim.

Botany

The kiwifruit is a woody, vigorous vine or climbing shrub that can grow up to 30 feet (9 meters) tall. Its deciduous, alternating, long-petioled leaves are 3 to 5" (7.5–12.5 cm) long, oval to nearly circular, and cordate at the base. Mature leaves are downy-white with noticeable, light-coloured veins beneath; young leaves and shoots have red hairs covering them. Mature leaves are dark-green and hairless on top. The fragrant, bisexual or dioecious flowers are borne singly or in clusters in the leaf axils. They have five to six petals, are one to two inches (2.5 to 5 cm) broad and have central tufts of numerous stamens in both sexes, though the female flowers do not contain viable pollen. The flowers are white at first, turning buff-yellow. Up to 2½" (6.25 cm) long, the oval, ovoid, or oblong fruit has russet-brown skin heavily covered in short, stiff brown hairs. When the fruit is young, a prominent, 5-pointed calyx is capped at the base and dehisces from the mature fruit, leaving five small sepals at the apex. The flesh is shiny, juicy, and luscious, bright green, occasionally yellow, brownish, or off-white, and firm until fully ripe. Its center is white and succulent, radiating many fine, pale lines. Tiny dark-purple or almost black seeds, indiscernible when consumed, are strewn throughout these rows.



Farmer friendly low cost structure for propagation of kiwifruit cuttings

Climate

The altitude range where kiwifruit grows naturally is 600–2000 m above mean sea level. When completely dormant, kiwifruit can tolerate temperatures as low as -12°C, but they still need time to acclimate and are susceptible to sudden drops in temperature. While the requirements of other cultivars vary greatly, the Hayward cultivar requires 800 hours of winter rest between 0–7°C. If the winter is too mild, the plant may not lose its leaves and may not flower. Wherever citrus, peaches, and almonds are successful, kiwifruit grows well, though its leaves and flowers are more susceptible to cold than those of orange and peach trees. Fall frosts halt new growth, destroy budding flower buds, and, if they strike after the flowers have opened, stop fruit from setting. It is said that fully-grown fruits have a better flavour after late winter frosts. Winter-time warm and cold spells alternately will lessen flowering. For dry matter accumulation and shoot growth, long days and high temperatures are ideal; 16 hours of daylight and 20°C are ideal. Approximately 150 cm of evenly spaced rainfall annually are adequate during the growing season.

Soil

Deep, well-drained sandy loam soils that are rich in organic matter and unlikely to dry out too quickly in the summer are preferred by kiwifruit over clay loam soils. Soils that are heavy or have poor drainage, as well as salty soils, are intolerable to the plants. While it can grow in soil with a pH of 6.0 to 8.0,

a neutral pH of roughly 7.0 is ideal for them. A too-basic soil can cause a nitrogen deficiency in the leaves. Water-logged, heavy soils are totally inappropriate for its cultivation. Enhancement of soil texture and preservation of soil moisture are aided by a thick layer of humus.

Cultivars

Important pistillate cultivars grown for commercial purposes are Bruno, Hayward, Allison, Abbott, and Monty; staminate cultivars include Alpha, Matua and Tomuri. The morphological characteristics of the stems, shoots, and leaves; the maturity of the fruit and flowering; and the colour of the fruit and flesh do not allow one cultivar to be identified from another. Cultivars have been distinguished using the form of the fruit, the hairiness of the style base, and the shape of the petals.

Field preparation, layout and planting

A location free of spring and early autumn frost, with well-drained soil and comparatively high air humidity, is necessary for the establishment of a kiwifruit orchard. To optimize the utilization of sunlight, rows ought to be oriented in a north-south direction. A kiwifruit vineyard cannot be established successfully unless the soil is thoroughly prepared. The application of well-decomposed farmyard manure and the pulverization of the soil are necessary to prevent the presence of hard pans or stones when plowing or digging the soil. Pits measuring roughly 0.6 m × 0.6 m × 0.6 m are excavated between September and October. One should add 20–30 kg of

well-decomposed farmyard manure to the pit to fill it up completely. The training system and cultivars have an impact on the spacing. Plants should generally be spaced 4 to 5 meters apart from one another. The kiwifruit is dioecious, meaning that the female and male flowers grow on separate vines. For healthy orchards to bear fruit and receive adequate pollination, care must be taken to plant male and female plants in a ratio of 1:8. Although hand pollination is labour intensive, but it results in good quality fruits and higher yields.

Propagation

Vegetative and seed propagation are two ways to propagate kiwifruit. In order to create rootstocks for grafting or budding, seedlings are raised. To boost germination, seeds must be stratified for 6-8 weeks at a temperature of about 4.4°C. It is best to sow seeds in late winter. It needs a growing medium that is well-drained, aerated, and provides a consistent, enough supply of moisture. The growth medium should be sterilized and free of pathogenic organisms. To protect the seed from inclement weather, it is safe to sow it under a glass house or poly house. Successful methods for multiplying kiwifruit plants include grafting, budding, top working, and softwood and hardwood cuttings. Softwood cutting is a commercial method of propagation that yields high-quality plants quickly. Misting, applying bottom heat and using growth hormone are vital. Cuttings are taken from the current season's semi-mature growth. The best cuttings have a thickness of 0.5-1.0 cm, comparatively short internodes, and a length of 15-20 cm. A 2000–5000 ppm IAA concentration results in good rooting. The mature, dormant shoots, which are about 15-20 cm in length and have at least 2-3 nodes, are taken from the preceding summer growth. For hardwood cuttings, their bases are injured and given a 5000 ppm IAA treatment. After that, the cuttings are buried in a moist, coarse-textured rooting medium, either in the field through polythene film

Table 1. Distinguishing traits of kinnufruit cultivars

Cultivar	Traits
Bruno	The fruit's slightly tapering shape toward the stem end allows it to be easily identified from other cultivars. Out of all the cultivars available in India, it is the longest. Ascorbic acid content is higher in fruit than in other cultivars. The plant has a lower chilling requirement and better bearing.
Allison	The fruits are a little bit wider than they are long. The fruits have a medium size and taper slightly on both ends. Compared to other cultivars, its average production and sweetness are likewise higher. It is appropriate for mid-hill regions and a heavy bearer. The edges of the flower's petals are crimped and overlap each other. Low levels of acidity and ascorbic acid.
Monty	Although the cultivar flowers late, it matures quickly. The fruits are medium-sized, oblong, equally thick, and flat on both ends, with a slight tapering. Prolific bearer that occasionally needs to be thinned to produce medium-sized fruits. It has a medium sugar blend and a higher acidity.
Hayward	This cultivar is most commonly grown due to its large, eye-catching oval fruit that has the best keeping quality. The fruit is flat and wide, with a much larger width than length. Its flavour is also regarded as superior, and its sugar and ascorbic acid content are relatively high. This cultivar matures slowly and is relatively shy. Therefore, for commercial production, close planting and late flowering pollinizer are needed. Due to the vine's longer chilling requirement, it is better suited for high hills.
Abbott	This cultivar matures and flowers early. Medium-sized, densely haired fruits have a sweet flavour, low ascorbic acid content, and medium titrable acidity. It grows well in mid-hill regions and requires little chilling time.
Tomuri	Late in the season, flowers typically appear in groups of five (1-7) and have long peduncle hairs. It is a best pollinator for the Hayward cultivar.
Bruno	Early in the season, flowers are typically borne in groups of three (1-5) and the peduncles have short hair. For early and mid-season pistillate cultivars, the cultivar is an effective pollinator.

mulch or on a propagating bench. To avoid desiccation, shoots should receive enough shade and fine-mesh watering after emergence.

Training and pruning

A single apical bud is permitted to grow up to the wire during the first year of the vine's life, and the vine is headed back at a height of 30 to 40 cm from the ground which will be the main trunk. On the main trunk, no more branching is allowed. Two shoots are chosen for the second year and fastened to the center wire from both sides. The secondary arms are these. The tertiary fruiting arms, which bear fruit in the upcoming years, are chosen based on these secondary arms in the third year. To keep these tertiary arms in place, tie them down to the out trigger wire. These laterals are where the first crop forms and develops, or they can be replaced by fruiting arms. Fruiting arms should not be trained parallel to the permanent leaders along the out trigger wires because the shoots from these will compete with the fruiting arms that come directly from the leader, causing dense growth that will

negatively impact vine growth and management. One of the most crucial parts of managing kiwifruit vines to ensure consistently high-quality fruit production is pruning. On wood that has grown from the previous season's growth, kiwifruit blossom and produce fruit. Female vines undergoing dormant pruning start by trimming back their fruiting canes from the previous year to 10-12 buds beyond the final fruit. To encourage the growth of new, vigorous canes, small, weak wood should be severely pruned after a few years. Canes that are broken, twisted, or tangled should be cut off, as should any that cross over from one side of the plant to the other. Any growth that hangs down to the ground should be tied to the trellis or pruned. Remove any extra fruiting spurs so that each cane is separated by 8 to 12 inches. To manage growth, males can be pruned more heavily. Do not overcrowd the female vines. When it comes to male plants, heavier summer pruning is commonly used. After the plant has started to grow, do not prune it in the early spring as this could cause excessive bleeding and harm to the plant.

Insects

So far, no significant pests have been identified on kiwifruit plants in Sikkim. Pests of the polyphagous family may cause some crop damage. Two major pests that cause significant losses are the leaf roller and the greedy scale. Following are the details of the insects attacking kiwifruit in Sikkim:

Insect	Symptoms	Treatment
Leaf roller [Numerous leaf roller species, including the green-headed leaf roller (<i>Planotortrix excessana</i>), the black-lyre leaf roller (<i>Cnephasia jactatana</i>), the brown-headed leaf roller (<i>Ctenopseustis obliquana</i>), and the light brown apple moth (<i>Epiphyas postvittana</i>), are significant and cause significant losses.]	In the lower half of the canopy, on the smooth upper surface of mature leaves, are the eggs. The caterpillars eat folded, immature leaves early in the season and mature leaves later. Pupae are frequently observed near the base of the canopy.	It is found that two sprays of neem oil 0.15 EC (1500 ppm) @ 3 mL/L, spaced 15 days apart, are effective against leaf rollers.
Greedy scale (<i>Hemiber lesiarapax</i>)	It is primarily found on a variety of shrubs and trees in temperate to subtropical climates. It is primarily located on the leaf's upper surface, close to the petioles and the midrib. Early-season crawlers only cause damage to leaves or woody sections, and their populations colonize before the fruit ripens.	It is found that two sprays of either neem oil 0.15 EC (1500 ppm) @3 mL/L or petroleum-oil based spray @ 10 mL/L at intervals of 15 days are effective against the Greedy scale.

Diseases

Under Indian conditions, there are no documented cases of serious disease. There have been reports of certain leaf spots that do not result in losses. On the other hand, soggy conditions which are more likely to happen in clayey soils can result in root rot. Therefore, appropriate drainage systems ought to be tailored. Following are the details of some of the disease affecting kiwifruit in Sikkim:

Disease	Causal organism	Symptoms	Disease cycle	Management
Root rot, Collar rot and Crown rot	<i>Phytophthora coactorum</i> , <i>P. cinnamomi</i> , <i>P. citricola</i> , <i>P. lateralis</i> , <i>P. megasperma</i>	Delayed bud break, wilting and reduced leaf size, and dieback of twigs and shoots are the initial symptoms. When a plant is starved of water and nutrients, its leaves droop, and eventually the vine collapses. The infection begins at the outermost layer and progresses to the crown and main root.	Spring or early summer is when these fungus infections are most common. Sites with inadequate soil drainage are more prone to the disease. The fungus grows in the earth and disperses through contaminated plants, soils, tools, and irrigation water.	Before planting, treat the planting material's roots with a root dip treatment of either copper oxychloride (0.25%) or Bordeaux mixture (1%). Soaking the soil in either 0.25% copper oxychloride or 1% Bordeaux mixture. When choosing locations for new orchards, consider those with adequate drainage.
Leaf spot	<i>Alternaria</i> spp., <i>Botryosphaeria</i> spp., <i>Fusarium</i> spp., <i>Cladosporium</i> spp., <i>Colletotrichum acutatum</i> , <i>Epicoccumpurpureus</i> and <i>Phomopsis</i> spp.	On the leaves, brown lesions are widespread and asymmetrical, while white lesions are confined.	It is observed that pathogens leave tissues rather than directly attacking healthy tissues.	Cleaning up the field, gathering, and burning sick leaves. Removing diseased branches or shoots can help lessen the illness. Implementing the best training system possible to improve airflow and light penetration and stop the creation of a microclimate that encourages leaf diseases. Spraying copper oxychloride (0.25%) or Bordeaux mixture (1.0%) is advised if disease symptoms are observed, especially following wind or hailstorms that injure foliage.
Bacterial leaf blight and Blossom blight	<i>Pseudomonas viridiflava</i>	Only leaves and flowers are affected by this illness. The pathogen causes blossom blight, which significantly lowers the yield, but it has no effect on vine vigour. Dark, angular lesions with a yellow halo surrounding them are the primary symptoms on the leaves. Subsequently, the lesions could grow larger and the necrotic tissues might finally fall apart. The brown, sunken patches on the sepals of closed flower buds are the first signs of blossom blight. The filaments and sterile anthers of the severely infected female flowers are rotten. The hair is usually coloured brown and stunted. Although partially infected flowers may produce tiny or distorted fruits, infected flowers typically shed.	Bacteria are thought to be present on the vines all year round. The infection is favoured by wet conditions and rain during bud break and early flowering.	Keeping the field clean overall and trimming any affected areas aid in disease detection.

Organic nutrient management

When nutrients are properly managed, kiwifruits grow and yield heavily through vegetative means. Since plants are major consumers of nitrogen, organic fertilizers should be used liberally in the first half of the growing season. For a consistent high yield and quality, use well-decomposed, dried cattle manure or compost at a rate of 10–40 t/ha from planting to the age of peak fruit production. Farmyard manure should be applied at a rate of 25 to 100 kg/plant in two splits in February and March. Neem cake, at a rate of 2 t/ha, should be applied in the early spring after the vines have several inches of new growth. Up until maturity, progressively increase the amount of manure applied annually. Vermicompost @ 4 to 10 kg/plant should also be applied during the active fruit growth stage to improve fruit quality and growth production. Mulching with straw and/or manures has many advantages. However, mulch should not be put in direct contact with the vine as this could lead to crown rot.

Water management

Its strong need for moisture is indicated by its vigorous vegetative growth. Foliage orchards require a lot of water, especially in the first two to three years of their establishment. As a result, the foliage orchard's whole soil surface serves as mulch, lowering the need for irrigation. Drooping leaves, a browning of the leaves around the edges, and total defoliation with new shoot growth when the stress is ongoing are summertime symptoms of drought stress. More plant deaths are likely caused by water-related issues than any other factor. Commercial kiwifruit vineyards frequently use overhead sprinklers for irrigation and frost protection (sprinkler heads should be about 3 feet above the training wire). On the other hand, drip irrigation uses water



Fully bearing vines of kiwifruit after hand pollination

more effectively. In the sweltering summer months, plants require periodic watering intervals of ten to fifteen days. Newly planted vines need to be deeply watered once a week during the summer. Never subject a plant to drought stress.

Mulching

Organic matter and soil conservation are aided by natural weed cover. To preserve the soil's moisture, the vine basin should be routinely cleaned and mulched. *Schima wallichii* (local name Chilaune) is the best mulch material in Sikkim, and *Artemisia vulgaris* (local name Titepati) is a close second. Both of these plants reduce the incidence of disease. Weeding is done right before mulching and applying manure. Depending on how quickly the weeds are growing, two or three weeding may be necessary.

Harvesting and yield

Kiwifruit is an exception, as there is no discernible change in the colour of the flesh or skin. Flavour and aroma do not develop because the fruit is harvested hard. It has been determined that a maturity index of 6.2% or higher of total soluble solids is very satisfactory for fruit harvest. Fruit is harvested in Sikkim starting in the first week of November. Harvesting kiwifruit involves easily snapping their stalks at the abscission layer at the

peduncle attachment while the fruit is still hard. The fruits are shaken in a gunny bag or rubbed with a coarse cloth after harvesting in order to remove any remaining stiff hair from the skin's surface. Because the fruit is hard, it is easier to transport to far-off markets. Fruits are suitable for serving at room temperature after ten to fifteen days of storage. Using hand-pollination techniques and managing the kiwifruit orchard are the main factors that affect the average yield. Up to 90 kg can be produced by a plant that is properly grown and maintained.

Storage

When kept in polythene bags with ethylene absorbent, kiwifruit can be kept for a considerable amount of time even at room temperature by carefully controlling the temperature, humidity, and gaseous concentration. After four to six weeks of storage, unprotected fruit may exhibit visible shriveling on the fruit surface as a result of water loss. The fruit began to shrivel after 3-4% of weight loss. Due to premature harvesting or unintentional freezing of the fruit tissue, no significant physiological disorders have been documented during kiwifruit storage.

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