

A Beginner's Guide to Growing Strawberries



Photo taken at Farm in Ngobet

Acknowledgement

The compilation of this manual would not have been possible without the financial support provided by Lutheran World Relief. We are particularly grateful to LWR program staff including the director, who made valuable comments and contribution.

The content of this manual was a consultative process, propelled by many individuals and organizations, particularly from the Ministry of Agriculture. We would like to extend my sincere thanks to all of them.

We are highly indebted to key EcoAgribusiness Limited (EAL) and Help Self Help Centre (HSHC) staff for helping in the information research and in consulting farmers on what they might require. Their kind co-operation, guidance and encouragement were exemplary.

I would like to express my special gratitude and thanks to all Nyeri county farmers in advance, who are expected to bear with all the information presented in this manual.

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The Target User of The Manual.

This manual is meant to be used as a reference by extension officers, community knowledge workers, producer organizations and other relevant community organizations. It is detailed not to miss any aspect necessary in commercial cultivation of strawberry.

While it is not recommended for distribution to farming population, the manual will be available to any farmers who are able to utilize it effectively. This category of farmers must purchase the manual, at a price determined by HSHC/LWR to avoid wastage. A simplified version of the manual in form of a brochure is available to all farmers

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1. Introduction

Strawberry farming is a multi-billion dollar business around the world. The fruit is a high value crop for export and local market, though the export market has not been exploited in Kenya due to limited supplies. The estimated total strawberry production in Kenya is 1487 tons while the demand is over 15,000 tons (Horticulture Validated Report, 2014). It is worth noting that 90 percent of strawberry (fresh and pulp) is imported into Kenya (Horticulture Crop Development Authority).

Gradually strawberries is emerged, a sought after fruit in the Kenyan market prompting many farmers interest to venture into the business and establish strawberry farms with the hopes of earning from it. Furthermore farmers are leaning towards replacing the traditional maize and wheat type of farming with more profitable and climate resilient ways that combines both sustainability and profitability. The effect of climate change on rain fed agriculture is making this traditional farming system increasingly untenable.

The strawberry is the most widely adaptable of the small fruits and can be grown throughout Kenya. The wide variation in climates within the Country and the wide adaptation of the strawberry plant permit production, harvesting and marketing throughout the year. However, currently in Kenya it is generally cultivated in the central region. Here, it is increasingly becoming an opportunity particularly for the youth, for self employment and livelihood improvement.

Strawberries are easy to grow, require minimal land and thrive well in a wide range of temperatures ranging from mild to hot. Strawberries are so versatile – they just need sun, fertile, well-drained soil and modest amount of water. Avoid areas prone to frost and soils that have previously grown potatoes, tomatoes because they have a common disease (verticillium wilt). Also avoid sites which have been infested with sedge, nut grass, quack grass, Johnson grass.

2. Economy of Strawberry

Strawberry (*Fragaria* spp.) is a high value crop with great potential for income generation and employment creation through cultivation and application in value added products including yogurt, fresh juice and jam. Strawberry is a delicious fruit taken fresh in several ways. It also makes excellent ice cream and Jam on account of its rich aroma, and is also a good source of vitamin C. It is a soft and a highly perishable fruit, often shipped in frozen condition in Western countries. The estimated total strawberry production in Kenya is 1487 tons while the demand is over 15,000 tons (Horticulture Validated Report, 2014). It is worth noting that 90 percent of strawberry (fresh and pulp) is imported into Kenya (Horticulture Crop Development Authority).

Companies like Trufood, Zesta, Brookside, KCC among others are importing these strawberries to use in their daily production needs with outlets such as supermarkets and hotels requesting for more of them day in day out. The fruits can also contribute to household nutrition through availability of vitamins. Although a ready market exists with high demand especially in urban areas, strawberries are in short supply and highly costly in Kenya's markets. Besides local demand substantial markets exist for strawberries in foreign markets, especially in the European Union. The scarcity is partly due to limited production, since many prospective farmers have not been able to engage in full-scale production. Production constraints include scarcity and high cost of planting materials, lack of knowledge on appropriate planting and crop management practices. There is also low awareness on the huge potential of the crop and available market opportunities.

Strawberry is a high value crop that requires relatively small piece of land to produce and little amount of water at 25mm/plant/week. It's less bulky, has ready market and will provide enormous income and employment opportunities in the rural context. Unlike the staple crops grown by small scale farmers, strawberry is a high value cash crop that can be grown in a small parcel of land and it's less labor intensive. Once established, strawberry is harvested 2- 3

times a week throughout the year for up to three years when a cycle change is made. From the smallest farm of 50 ft. x100ft (or 1/8 acres a farmer will earn a minimum of USD 14,000 over the production cycle.

By growing improved strawberry variety, a modest estimate is that each beneficiary household will earn \$8286 per annum or \$22.7 per day from the cultivation of a quarter of an acre. For a quarter of an acre, a farmer will require to invest \$2208 in splits (propagation materials), irrigation, labor and other inputs per annum. With proper management of the cropping regime, it is estimated that by the 12th month, a farmer would have recouped his or her investment.

3. Strawberry Varieties

Pajaro: It is a fast-growing variety, popular for large berries and good flavor.

Chandler: This is a high-yielding plant that produces large and firm fruits within 60–75 days. The fruits are not only large but have good flavor and firm skin.

Selva: A neutral day variety producing small berries with good flavor and color.

Fern: A neutral day variety with heavy yield of large fruits but lighter than all the others.

Aiko: Uniform, large, long fruit of conical shape, with a pointed end, firm flesh, pale red color, slightly sweet, very resistant to transport and high yield.

San Andreas their External and internal fruit color is dark. They produce fruits consistently throughout the season. One downside is that san Andrea's produces many runners that must be cut to maintain high production.

Douglas: Matures early, has clear foliage and offers good fruits of elongate conical shape and orange-red color. It has firm flesh, which is red-colored with a pink centre, and a good taste.

The crop is high-yielding. Other varieties include Nanandreas, Albion, Red glory, Manhattan.

Recommended Varieties for Nyeri County

Try planting more than one variety. Each will respond differently to conditions. Many farmers in the region have successfully been growing these varieties;

- **Chandler** is best suited for the central and rift valley parts of Kenya because of its ability to produce high yield plants



- **San andreas** also performs very well in Nyeri county due to its high and consistent productivity with ability to resist common diseases



- **Douglas has** also proved to be a high performer strawberry fruit in many areas of the country. Farmers prefer it due to its early maturity, color, taste and its shape.



4. Factors to Consider When Growing Strawberry

Choose your planting site carefully. Choosing an area conducive to growing strawberries is a critical step in commercializing strawberries cultivation.

There are several factors that need to be considered when selecting a site for commercial strawberry cultivation.

Water: Choose a site where there is ready access to a water supply. This can be a permanent river, spring, reliable water project or borehole

Quality of Irrigation Water: Irrigation is essential for high-yield strawberry production. Since strawberry plants are shallow rooted, permanent moisture is necessary to maximize production. An average of 300mm to 450mm (12 to 18 inches) of irrigation water is required over the growing season. Water quality should be adhered to, regardless of the water application purpose. Drip irrigation is increasingly being recommended for efficient water utilization and conservation in strawberry growing.

Soil type: Strawberry plants grow and produce satisfactorily in a wide range of soil types, from sandy to clay loams. Strawberry will respond positively to high organic matter content in the soil. The best soil for strawberry production is a deep, well drained sandy loam, well supplied with humus (over 2% organic matter). Heavy clay soils that are usually poorly drained encourage disease development and impede field operations including weeding. Coarse textured sandy soils are often infertile and droughty, and require more frequent irrigation and greater attention including fertilization practices. Plants established in low-lying mucky organic soils are more vulnerable to frost injury.

Soil Surface Drainage: It is important to pick a site that has good soil drainage and surface drainage. Although strawberry plants need constant moisture to thrive, the plants will rot if left in standing water due to poor site drainage. In areas where there is

poor drainage or heavy soils, constructing a raised bed for the strawberry plants should facilitate better drainage. The strawberry bed should be elevated, at minimum, six to eight inches.

PH requirements: In order to grow strawberries most effectively, the soil needs to be slightly acidic. Strawberry plants will grow best in the soils that has a pH between 5.0 and 7.0, but 5.8 to 6.2 is ideal for maximum growth and production. It is recommended that farmers to have soil testing or collectively obtain professional soil testing services provided by government agencies such as Kenya Agricultural and Livestock Research Organization (KALRO)). Private companies such as Soil-Cares Ltd and Crop Nutrition Laboratory Services (Crop-nuts) also offer testing services. Before planting strawberries, you should test your soil and amend it as indicated to create the best possible environment.

Common amendments are lime and manure. If test results show high PH lime should be applied prior to planting and tilled in thoroughly with the soil. Compost or aged manure from cows is also added, usually at a rate of 2 to 5 bushels per 100 square feet.

Terrain Slope: Strawberries should ideally be planted on slightly inclined slopes. Avoid cultivation of straw berries on steep slopes. Plantings on 10% to 15% on slopes are likely to erode, with some plants being buried and others washed out of the soil. If sloping sites must be used, rows running across the slope or on the contour and with a wide row width are recommended.

Sun light: Strawberries need full sun to produce the largest yields. While harvestable berries will be produced with as little as six hours of direct sun a day, it is best to select a site that is clear of other tall or shadow-casting trees or plants. Planting strawberries away from large trees also is important so that the tree root system doesn't compete with and siphon away needed moisture from the growing strawberry plants.

Variety: Before you begin growing strawberries in your garden, you need to determine which variety of strawberry plant you want

to grow. As new and improved strawberry cultivars are developed annually, it is important to liaise with the relevant ministry for any new developments. Currently the best cultivars for Kenya are Sanhedrin and Chandra. You are advised to visit Kenya Agricultural and Livestock Research Organization (KALRO) or the Help Self Help Centre (HSHC), before engaging in this emerging lucrative cropping system.

Certified Materials: Another factor to consider when picking strawberry variety is susceptibility to *Verticillium* fungus. This fungus causes the most common strawberry disease, Verticillium wilt (or Verticillium rot), which will end fruit production by killing growing strawberries. Since there is no practical way to kill the fungus once infection sets in, this difficult disease is best prevented by obtaining and planting strawberry plant varieties that are certified to be resistant to Verticillium wilt?

Other crops: Strawberries should not be planted in soils where strawberries, raspberries, vine crops, alfalfa, potatoes, tomatoes, peppers, eggplants, beans, carrots, okra or sod have been grown in any of the previous four years, unless the soil has been fumigated. Such sites are likely to contain disease and insect pests that may attack plants. These crops also carry the root rot fungus *Verticillium*, which also attacks strawberries.

In addition, do not plant strawberries into recently plowed grass sod areas. This can lead to devastating weed problems and damage by white grubs, a common turf pest that will feed upon strawberry roots.

5. Strawberry Propagation

Strawberries are planted as splits. Strawberries have runners which grow away from the parent plant and in turn attach to the ground forming roots. This can be split from the parent plant to act as seeds for another plant.



The plants may be allowed to set as many runners as possible but not allowed to set any fruits. All the plants with good root system should be utilized to set a new plantation. Given the best attention and care, a single plant usually produces 12 to 18 runners.

Farmers are advised to get splits which are transplants from the parent plant so as to get fruits of equal quality as the parent plant. There is a possibility that hybrid plants produce fruits of lesser quality as they are not fully made up of one parent plant.

In strawberries gardening propagation is done using vegetative material namely splits of the strawberries crown. There are many

sources of seedlings in Kenya, but farmers must be careful to purchase from only trusted suppliers. This is because splits from different varieties look the same and you might buy the wrong one. The splits must be disease free.

First know the basic morphology of what variety you want to buy. Then visit the selling farm as they pluck out the splits. That way you are assured of purchasing the right variety.

The cost of good strawberry seedling will range from KSH 20-50/split

Table 1.1: The list of strawberries split suppliers in Nyeri County.

Companies	Cost/split	Email	Phone contact
1. Nabulu Farm	20-50	admin@pri-kenya.org	+254 (725) 618 737
2. FaCT Ltd farm.	45-65	Mwangi.maina@ku.ac.ke	
3. KARLO) Njoro	30	info@kalro.org.	0723-662773
4. KARLO THKA	30	director.hri@kalro.org.	020- 2055038.
5. Egerton University/ Department of Crops, Horticulture and Soils	30	nfo@egerton.ac.ke	0512217891/2
6. Ngera Farm	20		0798185505

Management of Splits

You should select disease-free, healthy splits. When sourcing from your farm, select plants that have large crowns with healthy, light-colored roots. If externally sourced, splits should be carefully inspected of mold, the moldy one being rejected.

Splits sourced from a distant and cannot be planted immediately, must be wrapped in wet paper towels or bags and stored in room temperature, for a maximum seven days. They must not be exposed to dryness or exposed to direct sunlight unless planned for immediate planting.

6. Environmental Conditions

Temperature

Day-neutral strawberries will flower and set strawberries whenever the temperature is in the range of 20⁰C to 29⁰C (35⁰F to 85⁰F). 29⁰C is considered the upper limit at which day-neutral strawberries will produce flowers. Those growing strawberry in greenhouses should observe this fact and try and adjust temperature conditions.

Soil pH

Strawberries prefer slightly acidic soils with a pH of between 5.5 and 6.5. Too low pH values may require applications of ground limestone to increase the pH of more acid soils. Soil pH level over 8 adversely affects certain strawberry nutrients, especially the iron levels in certain cultivars. Yellowing in strawberries is also common where soil pH is high. The use of green manures and acidifying fertilizers can reduce the soil pH to some degree.

Soil Salinity and Alkalinity

Strawberry plants are extremely sensitive to salinity, especially at the transplant stage. Highly alkaline soils can occur in bands or patches throughout a field. This can cause yellowing or chlorosis of the plants, a condition that can lead to significant yield losses or complete plant die-back.

7. Strawberry Cultivation – Field Operations

Land preparation: Strawberries cultivation starts with thorough land preparation in order to raise a vigorous crop. Test the soil for PH as strawberry does the best in areas where the soil is in 6 to 6.2 PH. The soil needs to be well drained and weed-free. A bed raised to 15cm with a width of 1metre by any convenient length should be prepared, and well fine cattle/goat/sheep manure incorporated into the soil at a rate of a 20 kg bucket per square meter.

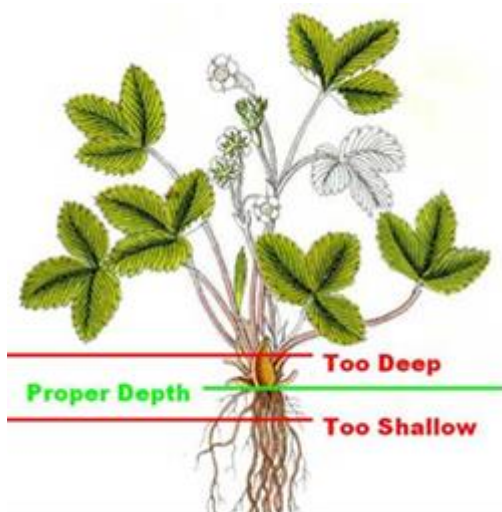
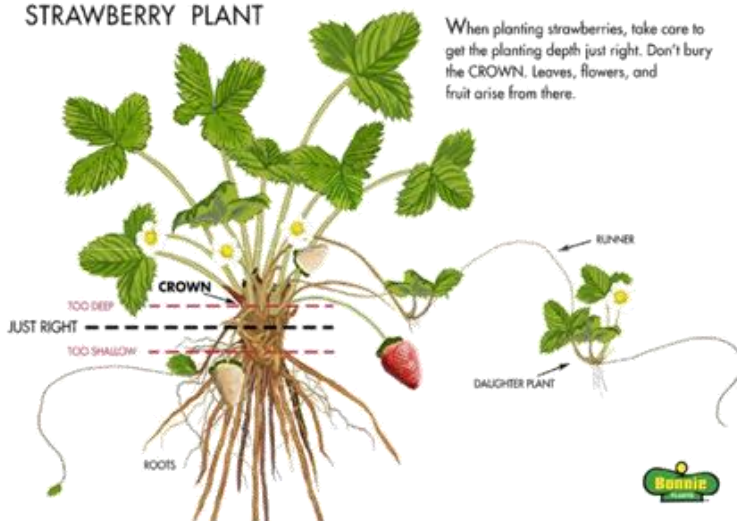
NB. Do not grow strawberries in land parcel previously cultivated with such plants raspberries and egg plants, at least for the past three years. (Please refer for the previous section on not to do plants)

Planting: Dig out a hole big enough to spread out the roots of the splits. In the bottom of the hole, create a mound or hill of soil that is flush with the surrounding soil level. Put the strawberry plant on top of the hill inside the hole so that the crown is at soil level and spread the roots out down the sides of the hill. Fill in the hole and ensure that the soil level is even with the middle of the crown. Planting too shallow may cause the roots to dry out before they establish, and planting too deep can also damage growing strawberries.

See the figure below for proper crown placement.

STRAWBERRY PLANT

When planting strawberries, take care to get the planting depth just right. Don't bury the CROWN. Leaves, flowers, and fruit arise from there.



It is very important: If you bury the crown, the plant could easily rot. The crown is what looks like the base of the plant before the roots start.

This crown cannot be covered when planting the strawberry plant, either in garden beds or containers. However, it should not be left too exposed either, always check to ensure that the crown is sitting just above the soil. Water them well.

Once the plants are planted, press to firm the soil around the roots and then water thoroughly.



Spacing: The strawberries should be planted on a wet ground ideally on raised beds with a spacing of between 30cm. The rows should be 60cm apart. Strawberries are runners and it is therefore necessary to ensure that at least 30 cm between plants remains.

Fertilizer and manure application: Compost should be applied every so often, during planting and after every seasonal harvesting. During the fruiting period foliar feeds may be applied to boost the yields. Rooting media or enzymes which include plantone and Anatone may also be applied. Anatone is a broad spectrum for roots, flower stimulation and fruit retention and may enhance strawberry plant establishment

Watering: Irrigate daily in the afternoon during the first month after planting for good crop establishment and 2-3 times a week from the second month from initial planting onwards. Use of drip irrigation is recommended as it waters at the root and considerably conserves the scarce resource.

Mulching: Mulching is recommended after planting in order to conserve moisture, control weeds and keep strawberries clean.

Pruning/stripping: Thinning to 2- 3 splits per crown should be done every 7 months to allow rejuvenation and increase strawberry yields.

De-blossoming: To increase fruit production, prune off the flowers the first time they appear. This is also recommended to avoid premature fruiting, which may lead to stunting and poor development of the crop.

Removing the flowers also promotes root and runner development, thereby insuring a large crop the following year.

Weeding: Weeding is one of the most important practices in a new strawberry planting and it should be done frequently (once a week) for the first 6 to 8 weeks. Weeding kills the weeds and loosens soil for better runner penetration.

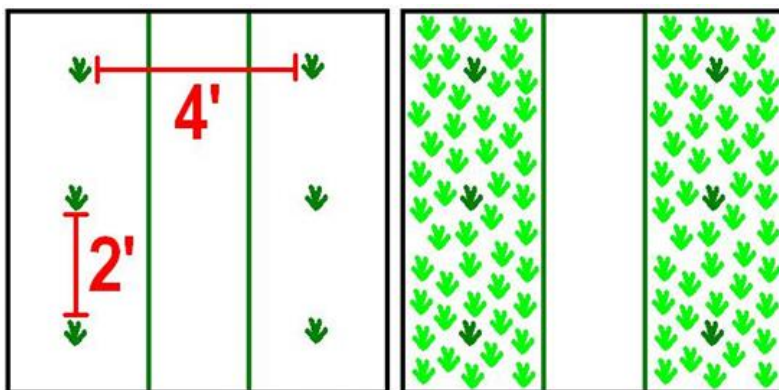
8. Planting Systems

There are several methods to planting strawberries but for our purpose we will only illustrate two-Matted and Hill system.

8.1 *The Matted Row System:*

The matted row system works well for any cultivar that sends out a lot of runners. To grow strawberries with this system, set plants about 24 inches apart in rows 4 feet apart. Allow runners to spread freely and root at will within the row to form a crisscrossed, matted row about 24 inches wide.

This system of growing strawberries will produce the largest number of strawberries, but the quality of berries does not match the hill system. It is good in situations where berries are for processing into value added products.

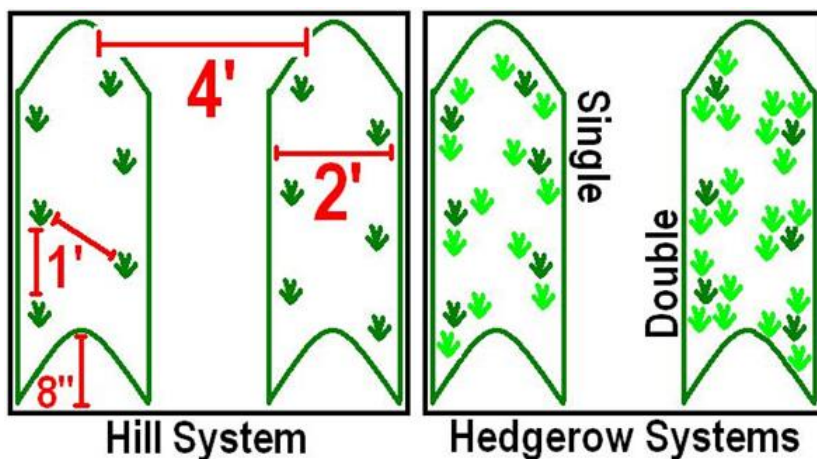


Matted Row System

8.2 Hill System (Mound System)

This method requires the most work and yields the biggest berries. Set plants 30cm (1 ft) apart in rows 60cm (2ft) apart. You can also plant double or triple rows with 30cm between each row and 60cm between double or triple rows and let the runners root. When planting using the hill system, plants must be turned under every two to three years. It is recommended to remove flowers from the plant the first growing season. The second season will be the best harvest when flowers are removed the first season. Decreasing in quantity and quality the following year, some growers choose to replant each year.

All runners are removed from every strawberry plant in the hill system as soon as they are identified. Removing the runners causes all the productive capacity of the mother plants to remain with the mother plants. This energy will result in additional lateral crowns adjacent to the original crown and more flower stalks for fruiting. The hill system is often preferred because it results in a higher quantity of higher quality berries, while the matted row system usually produces a higher total number of strawberries.



9. Creating Special Growing Environment

Once the plants are in the ground, it is important to create an environment that is most conducive to growing strawberries.

Mulching

After you've planted your strawberry plants, mulch the strawberry bed with shredded leaves, compost, or straw. Mulching also keeps the soil temperature down, mitigates the weed problem, and keeps the fruit cleaner by keeping the strawberries off of the dirt. Most varieties of strawberries produce better when their roots are in cooler soil.

Water

Irrigation is essential for high-yield strawberry production. Since strawberry plants are shallow rooted, permanent moisture is necessary to maximize production. An average of 300mm to 450mm (12 to 18 inches) of irrigation water is required over the growing season. Growing strawberry plants require a permanent source of water, as regular watering is a must. Water strawberry plants regularly and more often in hot, dry weather and maintain a constant moist environment. Water should be provided to the plants either through rainfall or direct irrigation. Up to two inches of water can be given while the fruit is forming, from early bloom until the end of harvest.

Water at the base of the plants, not on their leaves or fruits, and also don't let water splash on the leaves or fruit, as this can encourage disease. Also, try to water in the morning so the surface water can evaporate by evening.

The best method is drip lines and direct-point watering (put hose on low pressure and water at base of plants)

Protection

Strawberries must be protected from birds, snails and heavy rain. Birds will eat the fruits, slugs eat the leaves while the rain cause flower drop. You can protect the crop from birds and direct rain by covering your rows with bird netting. Additionally, copper ribbon will keep the snails away.

Renovation

Renovation is an important part of strawberry care. Strawberry beds can usually be carried over for 3 to 5 years or more if the plants are vigorous, the bed is kept weed-free, and the planting is properly renewed or renovated every year. This is done to give new runner plants the chance to replace old or weakened plants. The bed should be renovated shortly after the harvest is complete.

To renovate, thin the plants in the rows to about 15 cm (5 to 6 plants per square foot is the maximum acceptable). Then, mow the tops of the plants to one inch above the crowns. Take special care not to damage the crowns. If the foliage is disease-free, rake the leaves and compost them or incorporate them into the soil. Fertilize with a balanced (NPK, 10-10-10) fertilizer. Narrow the rows to between 30 and 45 cm by hoeing or tilling.

A good, aggressive renovation effort will see about half of the strawberry plants removed. After plant removal, work the mulch medium into the soil with a tiller. Since strawberries have a shallow root system, spreading a thin layer of soil (about a half inch) around the crowns can help facilitate new root development.

Continue to water the plants at least 1 inch per week for 3 weeks and maintain the planting as weed-free. Allow early runner plants to root where they will be maintained until your desired row width is re-established.

Irrigate the planting well, wetting the soil to a depth of 15cm (6 inches). During the rest of the growing season, irrigate to provide

25mm (1 inch) of water per week, and continue to control weeds. Runner plants will emerge and should be placed to fill out the row to the desired 60cm (2 foot) width, similar to the planting year.

Keep the planting healthy and vigorous throughout by controlling weeds, maintaining the proper plant density and row width, and watering regularly.

NB: Whenever you begin to notice the growing strawberries losing vigor or struggling to maintain their vitality, or if your yields begin to decrease, you may have reached the end of your strawberry bed's lifetime. When this occurs, start over with new plants in a new area.

Pollination

The more heavily pollinated a strawberry is, the bigger and better the berry becomes.

NB: The more pollination that occurs, the bigger your strawberries and your overall yield.

There are three different methods to enhance pollination in strawberries:

Hermaphroditic (self fertile)

Strawberry plants produce flowers that are hermaphroditic. That means each strawberry flower contains both the male stamen and the female pistil, but must be disturbed by wind or other movement for pollination to take place.

Insects

This is actually the best method of strawberry pollination. Insects, especially bees, will find and pollinate strawberry flowers quite effectively. Butterfly and beetles will also fertilize the strawberry (albeit less effectively) by spreading pollen around.

Plant plants with flowers that attract bees such as sunflowers around the strawberry beds. Remember, insect diversity is the best options.

Wind

This is not a substitute for insects, but should be seen as complimentary. Even gentle breezes are sufficient to transfer the pollen of the few millimeters from stamen to pistil. So, even in the absence of insects (greenhouses), strawberry pollination can still occur.

Benefits of Strawberry Pollination

1. Heavy pollination increases the overall yield of strawberry plants.
2. Cross pollination leads to decreased deformations and an overall higher-quality.
3. Cross pollination results in larger overall strawberries than self-pollination or same-variety pollination.
4. Natural strawberry pollination increases commercial viability also. Bee pollination results in brighter and redder berries, which are more pleasing to customers. Natural pollination also improves quality by reducing spoilage.

10. Planting strawberry under Greenhouses Condition

An ever-increasing hectare of strawberries is produced under greenhouses condition, equipped with the modern production inputs. Green houses are good especially in controlling insects, birds and impact of heavy rains. All these in combination or singly have the capacity to destroy more than half of the crop.

Planting arrangement

Planting arrangement is more or less the same as in the open field, but there are other differences

Irrigation and Nutrigation

Plants are best irrigated in protected cultivation with dripping systems. It is advisable for plants to receive nutrients and other dissolvable inputs with every irrigation session.

Pollination

Under greenhouse conditions, the activity of natural agents like wind, honeybees, and other insects is highly restricted by the protective structure. Bee's provide good pollination for strawberry plants and performs much better than hand pollination. Therefore, the placing of beehives close to the green house is absolutely essential to ensure good pollination. One or two beehive with good access to the greenhouse is sufficient for pollination about 8,000 strawberry plants (half acre of strawberries plants).

10. Plastic culture

The bulk of modern commercial production uses the plasticulture system. In this method, raised beds are formed each year, are fumigated and are covered with large plastic sheets, under which the irrigation tubing is installed. Plants are planted through holes punched in the covering. Runners are removed from the plants as they appear, to encourage the plants to put most of their energy into fruit development.

The main advantages of this mulch are:

- A considerable increase in soil temperature of the active root zone of the plants. This enhances plant physiology and enables much earlier flowering and fruit bearing.
- Prevention against weed growth, thereby saving on herbicides and work
- Protection of the beds from erosion by strong rainfall

11. Special Sensitivities of Strawberries

Salinity

The strawberry is one of the most salt-sensitive crops. Salinity in the root zone radically decreases root development from the crown, water uptake, growth rate, and fruit yield. Salinity damage can be due to high concentration of salts in the root zone, the accumulation of specific ions to toxic levels, or imbalances in ion ratios. This is brought about by poor drainage, salty irrigation water and excessive fertilization or application to wet foliage

Symptoms of salt injury include dry and brown leaf margins, brittle leaves, stunted plant growth and dead roots and plants. There are a number of solutions to salinity

- Maintain adequate drainage to remove excess salts from the root zone.
- Ensure deep plowing to mix the soil more completely.
- Avoid formation of hard pans in the soil.
- Maintain high bed height .High beds provide improved drainage.
- Add organic amendments to heavy soils to increase drainage.

12. Strawberry Plant Nutrients

Maintaining balanced nutrients levels helps growing strawberry plants reach their maximum potential. It is recommended that:

First, a balanced (10-10-10) fertilizer should be added just before planting strawberry plants. Add one to two pounds of fertilizer per 100 square feet. This helps increase the nitrogen levels in the soil.

Second, apply another round of fertilizer in the sixth month and again in a year, depending on plant growth.

Third, strawberries can be fertilized after every harvest. This is done to keep the plants vigorous. Be sure to water the fertilizer well to get it to soak in down to the roots of the growing strawberries.

NB: Appropriate application is highly advised. If you apply too much fertilizer, you will get excessive leaf growth and poor production of flower stalks.

On the other hand applying fertilizer to wet strawberry plants can result in phytotoxicity.

No fertilizer particles should remain lodged in the plants.

Nitrogen Levels

Nitrogen is an important nutrient and will substantially affect quality and yield of strawberries. The plant quickly responds to every positive or negative change in its nitrogen status. Application of nitrogen fertilizers stimulates vegetative growth of leaves, petioles and shoots.

However, heavy applications are not recommended because excessive vegetative growth will result in dense leaf canopy that will retard developing of fruit, and increase chances of fruit rot diseases (gray mold). Excessive nitrogen also causes fruit softening, delayed ripening, decreased yield and increased powdery mildew and mite pressure.

Nitrogen deficiency is manifested in middle-aged leaves turning yellow.

Typical nitrogen fertilizers used on strawberries include urea (46% N), ammonium nitrate (34% N), potassium nitrate (13% N) and calcium nitrate (15% N).

The following table shows the symptoms of lack of nutrients:

Leaf	Possible Causes
Uniform yellowing	Nitrogen or sulfur deficiency, or poor soil drainage
Yellowing with veins remaining green	Zinc, manganese or iron deficiency
Yellowing of leaf base	Copper deficiency
Darkening of leaf base or center vein	Potassium deficiency
Dark green foliage	Phosphorus deficiency
Leaf scorch	Potassium or magnesium deficiency or salt toxicity
Growing points damaged with restricted growth	Calcium or boron deficiency
Brown-black veins	Copper or boron deficiency
Fruits Symptoms	Possible Causes
Poor pollination (bumpy fruit)	Boron deficiency, frost damage or high temperature during flowering
Hard seed	Calcium deficiency
Soft, poor colour and flavor	Potassium deficiency

13. How to Grow Certified Organic Strawberries

Conventional growing methods use fumigants, chemicals, and other methods to maximize production and profits. But the market is becoming increasingly concerned over agrochemical based production systems due to their deleterious effect on human health. Hence the trend toward organic produce has opened a new opportunity for growers to supply certain niche market that is expanding every day. This market offers premium price over conventionally-grown counterparts.

Organic strawberries must be grown free from conventional pesticides and chemicals. To achieve this natural fertilizers rather than chemical-based substitutes are vital part of the strawberry growing process. Specifically strawberry plants have a higher relative nitrogen demand especially in early stages of growth. To maintain productivity and nitrogen levels, in the absence of agrochemicals; you'll need to use organic fertilizers.

To get your organic strawberry plants off to a good start, clear the area of all weeds and grass, and dig two to three inches of compost into the top few inches of soil.

Blood meal is a good option as it has 13% nitrogen. Other organic sources of nitrogen include fish meal, soy meal, and alfalfa meal. Aged manure is also a good source of nitrogen, but you have to be careful to not supply too much nitrogen to your strawberries as that can cause excess vegetative production and fewer berries. Too much nitrogen can kill or burn up strawberries. However, so do not put raw, fresh chicken manure on strawberries (or any other extremely nitrogen-rich material).

1. Apply well done manure to the soil surrounding strawberry plants at a rate of 1 kg and make sure it is rich in phosphorus. Young strawberry plants require phosphorus for healthy root growth and greater fruit production.

2. Mix seaweed manure into the soil surrounding plants to release nitrogen in the soil. Nitrogen is an important element for optimal strawberry growth.
3. Add a layer of straw mulch around strawberry plants as they start to grow; this mulch helps keep the fruit clean once it grows and cuts down on weed growth. Pine needles also increase acidity in the soil, which is beneficial to strawberry growth.
4. Fertilize the soil around strawberry plants again if leaves appear light green or unhealthy.

TIPS

1. Prepare soil a month in advance of planting, if possible, by mixing in at least 1 inch of compost, decaying plant matter such as dead leaves, and blood or bone meal.
2. Maintain strawberry plots for no more than three years at a time; beyond that, the plants are susceptible to disease. Start with a fresh planting in another area.
3. A liquid seaweed-based fertilizer can be applied during the growing season to boost growth.

Warnings

- Avoid planting strawberries where they have been grown previously or where eggplant, tomatoes or raspberries have grown, to help prevent disease. Wait at least three years before replanting strawberries in these areas.
- Do not fertilize plants that are bearing fruit or flowering, as it may damage them. Avoid over-fertilizing as well, as this encourages extra leaf growth, resulting in less fruit.

The second strategy of an organic strawberry cultivation is to develop a habit of diligence when it comes to pulling weeds. Hand-pulling is the first resort of most non-chemical growers. Shallow cultivation can also be successfully utilized. There are a

number of such as organic herbicide labeled for use with growing strawberries called Green-Match Ex and bio-pesticides like Serenade, but they must be used in combination with other physical methods. While virtually impossible to completely eradicate even with conventional methods, strawberry pathogens can also be deterred by the use of diatomaceous earth.

Developing a schedule of weeding and sticking to it is important in the fight against unwanted growth. It is absolutely essential to control weeds if you plan to maximize on fruit output.

Prepare a weed-free site that gets 8 to 10 hours of strong sunlight per day, and add well-drained soil with a pH between 6 and 6.2. To avoid verticillium wilt, don't plant in sites where raspberries, cherry tomatoes, peppers, eggplants, or past strawberries have grown before.

Maintain all the good agricultural practices and strawberry preferences as summarized below:

Plant only disease-free, healthy plants in soils with good drainage and air circulation. Avoid areas of poor drainage, mostly ensured through raised beds. Keep your plantings away from areas that may harbor large populations of mites or microbes detrimental to your strawberries. Managing weeds is also important as they can provide habitat for and harbor problem organisms as well.

Lots of sunlight and rich soil. Strawberries need a minimum of six hours of sun exposure per day. Soil that is high in organic matter is absolutely necessary as well. Strawberries also prefer slightly acidic soil with a pH between 5.5 and 6.5. Test your soil for pH, and then amend it if needed to raise its acidity level

Mulching heavily underneath the leaves of your plants is also important. Soil, by its very nature, is home to legions of microbes. In many strawberry plantings, rain droplets splashing into dirt and thereby sending droplets of pathogen-infected wet

mud up onto the vegetative components are the cause of disease and death. A heavy layer of mulch avoids this common problem.

Fungi species and many parasites find happy homes in the dead or decaying leaves that fall from strawberry plants over the course of their lives. Being vigilant to remove any dead or decaying plant matter from your beds will help minimize problems.

The third option is the variety selection. Be sure to select a variety that has at least some resistance to powdery mildew and Verticillium wilt. The other main pests of strawberries are slugs and snails. To keep them away, the best thing to do is install copper edging around the perimeter of your bed. Slugs and snails won't cross copper because it creates an electric reaction when it comes into contact with their slime. Bird netting or fencing of some sort is also a good idea to keep out the bigger pests like squirrels, birds, and rabbits.

14. Disease and Insect Control

Strawberries are subject to attack by fungus diseases, such as root rots and gray mold, and several types of insects, including tarnished plant bugs and strawberry bud weevils, but many problems can be prevented with proper planning and care. Plant varieties that are resistant to red stele and *Verticillium* root rots. Discourage insect pests by keeping the planting weed-free. Prevent gray mold by keeping the plant rows narrow to improve air circulation and mulching between rows.

14.1 Strawberry Pests

The following are common species of pests known to attack strawberries.

- ***Aphids*** - A well known pest insect that can quickly settle into soft tissue and damage the plant by sucking sap from just below the leaves. Symptoms include clusters of aphids at plants tips or on the undersides of leaves. In severe cases the plant may begin to wither.

They are managed quite easily by sprays of Malathion and dimethoate. Applying soapy water to plants or releasing lady bugs into the garden can help with aphid infestation.

- ***Birds*** - Birds, especially pigeons, can cause an array of problems including eating seedlings, buds, leaves, fruit and vegetables.

Can be easily be controlled covering the area with nets on all sides, or simply SB green houses.

- ***Crown Borer*** - Adults are small, brownish red snouted beetles that feed on foliage and berries. Larvae are little, white, legless grubs that tunnel through the crowns. Short of using chemicals, infected beds must be destroyed. When replanting, keep at least 300 feet away from original site.
- ***Cut Worms*** - Fleshy green to black striped worms.

The cut worms can be controlled by dusting the soil before planting with 5 per cent chlordane or Heptachlor dust at the rate of 50 kg per hectare and mixing it thoroughly in the soil by cultivator.

Cardboard collars can be used to keep the worms from getting to the plants. Also mothballs or blood meal can be spread around the bed. Digging up the ground in early spring will help to expose and kill cut worms.

- ***Spider Mites*** - Barely visible white, green or brown mites that feed at the base of plants on leaves and flowers. Mites can be a nuisance in dry weather. Irrigation can, therefore, be a control measure. Affected plants are stunted and yield poorly.

The mites can be controlled with 0.05 per cent Monocrotophos + 0.25 per cent wetablesulphur. Spraying the plant forcefully with water, ensuring to spray the undersides of leaves may help to rid this pest. Spray with Kelthane and other appropriate pesticides (acaricides) are advised in dry seasons.

- ***Nematodes*** - Severe in sandy soils than in clay with high organic matter content. Several types exists like the lesion nematodes (*Pratylenchus* spp), which attacks roots causing amber to dark-brown spots. In severe cases, the roots rot.

A bud nematode (*Aphelenchoides* spp) that causes what is called red plant as it lives and feeds among the developing leaves.

Use nematode-free plants, practice crop rotation and soil fumigation to curb the pest.

- ***Slugs and Snails*** - Slime trails and irregular holes in fruits are evidence of slugs and/or snails. Use straw as a mulch to serve as a barrier between your plant and the wet soil. Also you can try putting stale beer in pie plates and setting them in the strawberry patch. Slugs will crawl in and drown.
- ***Wire worms*** - are the larvae of the click beetle. They are also known as click beetle because of their yellowish brown color. They eat themselves into the rhizome of the strawberry plant, as a result of which the strawberry plant will start to become slack.
- ***Tarnished plant bug or lygus bug***: The adult is coppery brown with piercing and sucking mouth parts.

The bugs feed on achenes. The stink bug may also damage the berries causing uneven ripening.

Sprays with diazinon, Malathion or dimethoate.

14.2 Strawberry Diseases

The most common diseases of strawberry plants include powdery mildew, leaf spot, leaf blight, slime molds, red stele, verticillium wilt, black root rot, nematodes, gray mold, rhizopus rot, and leather rot. If symptoms such as powdery spots or brownish red spots on leaves, curled leaves, rotten spots on fruits or decreased yields are detected, remove all infected plant matter as soon as possible; preferably when the plant is dry.



Powdery Mildew: Appears as a white powdery deposit over the leaf surface and leaves become stunted and shrivel.

Remedy: Keep the soil moist and grow in cooler locations.



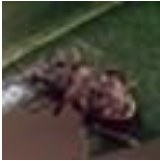
Grey Mould: You will see fuzzy grey mould on affected buds, leaves, flowers or fruit. Infected plant parts eventually shrivel and die. Grey mould is encouraged by overcrowding, so make sure you plant your splits at the appropriate distance apart. Hygiene is very important in preventing the spread of grey mould.

Remedy: If detected, remove the infected material and destroy.



Fungal Leaf Spot: Irregular purple/brown spots surrounded by a yellow ring- the spotting spreads throughout the foliage especially in warm, humid conditions. The plant weakens when the infection is severe.

Remedy: Remove affected leaves and ventilate covered crops.



Leathery Rot

The fungus penetrates into the plant at the moment when there are wounds. The root neck of the affected plants shows a reddish brown discoloration. The plants will wilt and dies.

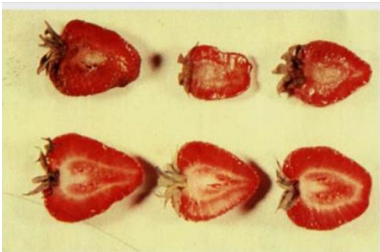
Remedy: Use healthy planting material and/or use resistant varieties.



Red Root Rot

An affected plant will form no or only few flowers. The small fruits will dry out.

Remedy: Use certified planting material.



Blossom-end Rot and Stem Rot.

This fungus occurs especially in long-range crops. In an early stage small brown spots can arise on the buds. After the flowering the calyx tails turn brown, the fruits discolor brown and dry.

Remedy: Keep the growing environment green

15. Strawberry Harvesting

Harvesting of strawberry fruits starts 2½ months -3months after planting. Harvesting seasons come 2-3 times per year. During the harvesting season, pick every 2-3 days. The lifespan of the crop is 3 years.

A great increase in the number of ripe fruit occurs over the first 4 to 6 days of harvest. Berries are harvested every other day under normal temperatures for about 6 to 7 pickings. Avoid picking the fruit when plants are wet. Keep harvested berries out of the sun and place them under refrigeration as soon as possible. Hand-pick berries daily if possible and picks all berries that are ripe. Pick berries when they are fully colored for optimal size and flavor. Berries do not improve in quality after picking.

Toss out all moldy berries. This will help prevent rots from spreading. Grading and packing often takes place in the field, rather than in a processing facility.

The average picker can harvest 10 kg (12 to 15 pounds) per hour over the entire season. Under excellent conditions, up to 175 kg in a 10 hour day may be harvested by the average picker.

16. Post harvest managements

Pack house practices

Sorting - done in the field and involves the removal of damaged and misshapen and dirty fruits. Remove all the fruits without a calyx.

Pre - cooling; this is done to remove the field heat, to minimize deterioration. At small holder level, farmers can use charcoal coolers. For distance markets, forced air pre-cooling will be necessary.

Grading;

The fruits are graded into different sizes for marketing.

According to the shape and the size

1st grade: 6 - 9 fruits per punnet.

2nd grade: 15 - 25 fruits per punnet

3rd grade: 28 - 32 fruits per punnet

under sizes can be processed into jam or juice.

Packaging:

Strawberries are packed into the pun nets in readiness for the market.

NB: avoid washing the fruits in the pack house since it destroys the skin and hastens deterioration.

17. Market for Strawberry

Companies like trufood, zesta, Brookside, KCC among others are importing these strawberries to use in their daily production needs with outlets such as supermarkets and hotels requesting for more of them day in day out. It is crystal clear that there is demand for this sweet soft red fruit of *Fragaria* genus here in Kenya. Why are these companies importing? This is simply because we cannot produce enough ourselves. Very few farmers in Kenya have embraced strawberry production and they have been smiling all the way to the bank on weekly basis, others talk of daily basis.

Normally, the safest way is to concentrate where the first market would be the consumers in surrounding towns and processing companies. The direct community would be a good place to start marketing your strawberries. This way, a farmer is always assured of a place to sell his produce. Local fruit stores, restaurants and other small users such as cake makers are also good buyers of strawberries in Kenya. Industries which produce food flavors, natural flavored yoghurt, jam etc also buy strawberries

Step 1: *Look For Market Early Enough*

But because the fruits are highly perishable (stays fresh for 4-5 days after harvesting).

It is advisable to start looking for market early enough to avoid incurring losses.

Demand is readily available in major urban markets especially among green-grocery suppliers. You can also access a larger market by marketing to companies like Brookside, Trufood, KCC and major supermarket chains. In that case, you will require investing in good packaging and getting accreditation from The Kenya Bureau of Standards.

Step 2: Harvesting and Selling Your Produce



Strawberries are highly perishable and hence a great deal of care in harvesting and handling as well as its marketing also requires to be organized carefully. Usually the fruit is picked in the early morning and sent to the market in the afternoon of the same day or is picked in the late afternoon, stored overnight in a cool place, and sent to market the following morning.

For local market the fruit should be harvested when fully ripe, but for transport to distant markets, it should be harvested when still firm and before color has developed fully all over the fruit. Harvesting should be done preferably daily. Since fruit is highly perishable, it is packed in flat shallow containers of various types (cardboard, bamboo, paper trays etc.) with one or two layers of fruits. Harvesting should be done early in the morning in dry conditions. Washing the fruit bruises it and spoils its luster. Harvesting It is important to practice proper “picking hygiene”

when harvesting berries as disease can be easily spread if good fruit is handled after bad fruit. Always wash hands after removing moldy, deformed or over-ripe fruit and before harvesting your good berries.

Pick every two to three days in mild climates or daily in very hot weather and keep the green caps attached to each berry. In order to preserve flavor and shelf life if you don't plan on eating your harvest right away, pick into a shallow, paper towel lined container, no more than three or four layers of berries deep.

Pick ripe strawberries by pinching through the stem above the fruit.

Never pull on the berry itself. All strawberries will last several days under refrigeration

18. Financial Gains and Cost Benefit Analysis

A 1/8th piece of land can produce between 30kg and 50kg of strawberries per week.

It is possible to recover your initial investment (or break-even) within just 6 months of starting the farm!

The yield varies according to season and locality. A yield of 20 to 25 tons per hectare is excellent, though yields up to 50 tons per hectare have been

For the purpose of calculating cost benefit analysis of strawberry, we take 1/8 of acre, which is common with farmers.

Cost of Production/Year

The table below provides itemized cost of production.

Operations	Units	quantity	Price/unit	Total Cost
Land preparations	Tractor Hours	1	500	500
Ridge making	Labor days	2	300	600
Soil sampling	-			
Transportation	-			
Transplanting	Labor days	3	300	900
DAP	kg	20	40	800
Urea	kg	20	40	800
Farm yard manure	Pick-up	1	2000	2000
Hoeing	Labor days	18	300	4500
Insecticide/pesticide	liters	1	2000	2000
Harvesting	Labor days	48	300	13800
Packing	crates	3	440	1320
Transporting	KM	100	30	3000
Sprits	number	2250	20	45000
Total cost				75220

Revenue stream

Item	No of harvest	Volume/week	Total volume	Sales/kg	Total revenue
Weekly Harvest/year	52	35kg	1820kg	110	200,200
Total revenue					200,200

Net revenues

Total cost	75220
Total revenue	200200
Net revenue	124980

19. Nutrition Value of Strawberry

Strawberries are very juicy health-packed fruits which can be eaten whole, made into fruit salads, ice cream, jam, milk shake and smoothie juice.

The following table shows the nutritive value of a serving (147 g) of edible strawberries.

Energy	45	Vitamin A	45 IU
Protein	1.0 g	Vitamin C	94 mg
Fat	0.0 g	Niacin (Vitamin B3)	540 mcg
Carbohydrate	11 g	Folate	2929.38 mcg
Dietary fiber	2.0 g	Manganese	540 mcg
Calcium	23.2 mg	Iron	0.6 mg
Magnesium	16.6 mg	Selenium	1.16 mg
Potassium	170 mg	Zinc	0.0 mg
Phosphorous	31.5 mg	Sodium	0mg