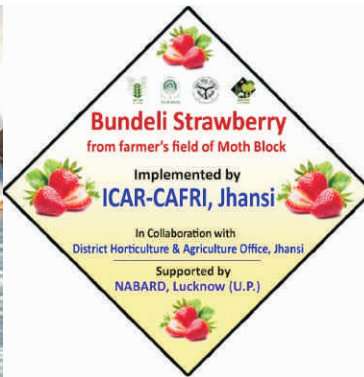




Technical Bulletin
CAFRI/2022/02

Strawberry Production Technology

Ashok Yadav and A Arunachalam



ICAR-Central Agroforestry Research Institute

Jhansi 284003, Uttar Pradesh, India

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The document has been prepared fully in academic spirit for educational and ready reckoning purposes. The information in the document is based on primary observations and secondary information from published sources.

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Government of India
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FOREWORD



Agroforestry can be a multifunctional tool for high food production, poverty population reduction, input reduction, water conservation, improved soil quality, biodiversity conservation, climate change mitigation, and climate change adaptation. The agroforestry interventions have provided food, fodder, fiber, firewood, and timber demands of the growing population in a scenario of decreasing arable land availability, degradation of soil and water resources, increasing pollution hazards and threats to the environment and ecosystem from global warming and climate change.

Horticulture-based agroforestry (AF) has contributed a lot to human well-being through a variety of ways, including production (timber, fuelwood, nutritious fruits, pasture/fodder, etc.) and environmental conservation through carbon sequestration. In horticulture-based agroforestry, various models, such as the agri-horticultural system, agri-horti-silviculture, horti-pasture, etc., play a variety of roles in terms of production potential, the improvement of marginal and degraded land (through the incorporation of the horti-pasture system), economic benefits, and the security of the nation's food and nutrition. Horticultural crops are high-value crops that provide more profits per unit of land than staple food crops. The income generated through cash crops has resulted in reducing hunger by satisfying the need for food and other essentials. It is impossible to overstate how crucial the horticulture-based agroforestry system is to raising land productivity, creating jobs, expanding exports, enhancing farmer and business economic conditions, and most importantly, ensuring the public's nutritional security. Nowadays, strawberry cultivation is increasing day by day due to higher returns from it. The high value of strawberries creates a potential for a significant profit in different parts of the country as well as abroad.

I congratulate the team of project Investigators for the successful implementation of the two Strawberry projects in the Babina and Moth blocks of the Jhansi district of U.P. and also for the worthy publication of this strawberry production technology bulletin. I hope that this scientific publication will be very useful for researchers, extension workers, and other stakeholders involved in promoting strawberry cultivation-based agroforestry among farmers.


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Preface

Agroforestry combines the benefits of agriculture and forestry in the areas of ecological, food, and livelihood security. The road to sustainable agriculture and food security is paved by agroforestry. The Bundelkhand region is amongst the most degraded ecosystem coupled with the poor socioeconomic status of the farmers of this region is less than the state and national average. The farmers of the region are suffering due to bio-physical and socio-economic constraints such as aberrant climatic conditions, frequent drought, and land degradation problems. Under such situations, the general crop production is either low or extremely uncertain, or unstable in the region. Therefore, rapid and significant changes need to be done in the farming system with the introduction of diversified and high-value crops under different agroforestry systems to combat the serious effect of climate change as well as to increase the income of farmers. While the region has a recent shift from millet to a wheat/rice cultivation system, with ecological challenges including climate change, crop diversification is the prescription for enabling resilience and also assured income to the farmers.

Keeping this in view, the strawberry crop was introduced in the Babina and Moth blocks of the Jhansi district for the very first time through two NABARD-funded projects under the Farm Sector Promotion Fund (FSPF). This document includes the production technology of strawberries in detail as well as the success story of the strawberry crop in the region. The information in this document will be helpful for farmers, researchers, and academic students.

Ashok Yadav
A Arunachalam



Acknowledgement

The authors are thankful to NABARD Lucknow for the financial support and technical support by the ICAR-Central Agroforestry Research Institute that enabled this publication. The information compiled in this document is from various sources as well as from the outcome of the NABARD-sponsored project implemented by CAFRI in the Jhansi region. This publication has been prepared to provide comprehensive knowledge of production technology as practiced in the NABARD projects. The authors are thankful to the Director, ICAR-CAFRI for guidance, support, design, and conceiving the idea of bringing this publication for the benefit of agroforestry practitioners to promote strawberry cultivation at the national level to increase their socio-economic status. In particular, the convergence of the UP State Department (Horticulture and Agriculture) and the cooperation of the Jhansi Administration led by the District Magistrate and CDO Jhansi that helped in the successful implementation of the NABARD projects. Last, but not the least, we thank all the farmers who took part in this endeavor of strawberry cultivation in the Bundelkhand and also the project staff who helped in the collection of field data and resource information.



NABARD funded the study on Strawberry cultivation and intervention in Bundelkhand.



The Govt. of Uttar Pradesh supported the study through U.P. Horticulture and Agriculture Departments.

Jhansi Administration facilitated the whole study in farmers' field.

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1 Background

The Bundelkhand region is characterized by challenging bio-physical and socio-economic settings including aberrant climatic conditions and its related land degradation problems. Further, over-exploitation led to declined quality of natural resources in the rainfed ecosystem. Under such situations, the general crop production is either low or extremely uncertain or unstable in the region. In the present scenario there is utmost need to identify, introduce and integrate the new potential crops (food, fodder, fuel, fibre and fertilizer for better income, nutritional and environmental security).

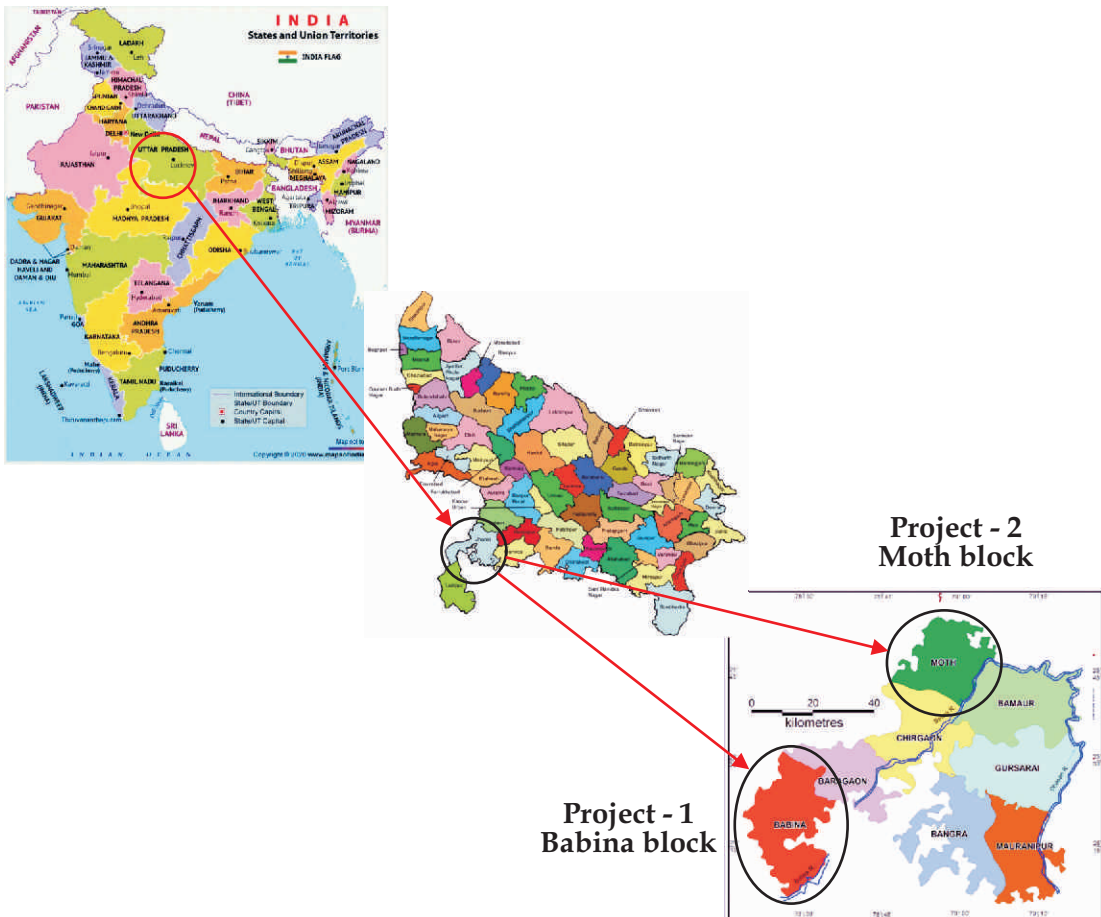
Strawberry is short duration crop (4-5 month) with good source of nutrients and vitamins and results in quick and high return in short span of time. It require cool climate, with bright sunshine and moderate rainfall, is ideally suited to strawberry cultivation. Earlier it was grown in temperate areas but now a days is has introduced by many states and growing successfully in plain areas as well. In India, it is cultivated in tropical and subtropical areas like Himachal Pradesh, Uttar Pradesh, Maharashtra, West Bengal, Nilgiri hills, Haryana, Punjab and Rajasthan. Due to remunerative price, its gaining popularity in plain areas now a days.

Being rainfed and degraded agro-ecosystem of Bundelkhand region, strawberry a remunerative crop will provide a boost to the growth of agriculture sector in the area. Beside this it will leads to improvement in socio-economic status of the farmers and increased in productivity and sustainability in the different existing agroforestry system.

Keeping these things in mind a short duration crop (4-5 month) i.e. strawberry was introduced which has high nutraceutical value and can result in quick and high return in short-span of time. Therefore, two collaborative projects on strawberry with financial supports of NABARD were implemented by ICAR-Central Agroforestry Research Institute, Jhansi along with District Administration Jhansi, District Horticulture and District Agriculture Departments, Jhansi.

2 Strawberry Intervention

Selection of farmers was done from Babina and Moth blocks of Jhansi district and were mobilized for land preparation, bed preparation, mulching and drip installations. Healthy and disease free tissue culture raised strawberry plant of two varieties i.e. Winter Dawn and Camarosa were procured from KF Bio plant Pvt. Ltd., and provided to the farmers, and got planted during mid-November-December. Knowledge on different intercultural operations such as irrigation, weeding, pruning, plant protection measures, harvesting and packaging were transferred to farmers by the scientists from ICAR-CAFRI Jhansi. Since the planting was done 1.5 to 2 months late of normal planting time, the fruiting started only from the mid-January and continued up to mid of April.



3

Strawberry Cultivation Practices

3.1 Soil

Strawberry prospers well in sandy to loamy soils and grows well in acidic (pH 5.5 -6.5) to neutral soils (pH 7.0). It also thrives well in soils with high organic matter. The soils should be free from poor drainage and harmful micro-organism. Before plantation of strawberry, sterilization of soil is absolutely necessary. Various methods of sterilization are as follows:

- **Physical method (Through Sun):** Covering the soil or bed with black plastic film for 6-8 weeks. The sun-rays will heat up the soil that kills most of the fungi.
- **Chemical method:** Application of hydrogen peroxide (H_2O_2) with silver checks different harmful pathogen presents in the soil. Strawberry beds need to be made sufficiently wet at least two days before application of soil sterilization. When the bed is wet, the moisture therein assures the activities of soil microorganisms and nematodes, etc. and enhances the efficacy of sterilant applied. The different sterilizers used in strawberry are methyl bromide, chloropicrin mixed with 1,3-dichloropropene followed by metam sodium or chloropicrin alone followed by metam sodium have been proven effective in controlling the soil-borne pathogens. However, these chemical should be used with sensitivity as they may lead ill-effects on human health. Planting should be done after a 6-7 hours waiting time to allow the chemical to be effective.

3.2 Climate

Strawberry requires desirable microclimate with consistent temperature, adequate rainfall as well as drainage and decent wind. Strawberry flourishes well in temperate climate but it can also be grown in subtropical climate also. Strawberry is a short day plant and for flower initiation, strawberry need a photo period (sunlight) of 8-12 hrs. for about ten days. The optimum temperature required for strawberry cultivation is between 20 and 29°C and when temperature goes above 30°C, the fruiting in the strawberry is affected at much higher rate.

3.3 Manures and Fertilizers

Depending on the soil type and the planted variety, a basal fertilizer dose of 25-50 tonnes farmyard manure, 75-100 Kg N, 40-120 kg P_2O_5 , and 40-80 kg K_2O /ha may be used. Foliar applications of urea (2%), zinc sulphate (0.5%), calcium sulphate (0.5%), and boric acid (0.2%) are advantageous for quality and better production in addition to the recommended dose of manures and fertilizers.

3.4 Irrigation & Fertigation

3.4.1 Drip irrigation

Drip irrigation is commercially adopted for strawberry cultivation. Strawberry has shallow root system. During dry seasons, the water stress may lead to crop loss and plant death. Even the moderate moisture stress can lead to reduced strawberry fruit size and poor fruit quality. Therefore, it needs frequent drip irrigation to maintain the moisture level in the root zone. On the other side, strawberry is delicate to waterlogging conditions as it leads to oxygen deficiency in the root zone and results in enhanced attack of fungal and bacterial diseases. In some places, sprinklers are also used during early stages of strawberry planting.



3.4.2 Fertigation

Fertigation is an effective technique for applying nutrients which involves injecting fertilisers through an irrigation system. Fertigation technology is becoming more and more popular all over the world due to promising outcomes that demonstrate its capacity to significantly increase water and nutrient use efficiency.

Fertigation schedule

Till now very meagre information is there for fertigation schedule for strawberry in India. According to KF Bio plant Pvt. Ltd., the fertigation schedule for strawberry for 1000 m² is mentioned below

25-50 days after plantation

- 12:61:00 @ 1kg (Monday, Wednesday & Friday)
- 13:00:45 @ 1kg (Tuesday, Thursday & Sunday)

50-60 days after plantation

- 19:19:19 1 kg (Monday, Wednesday & Friday)
- CaNo₃ 0.5 kg (Tuesday, Thursday & Sunday)

60-100 days after plantation

- 16:08:24 -375g (Monday, Wednesday & Friday)

- 0:0:50 -375g (Tuesday, Thursday & Sunday)
- Micronutrient @12g once a week

3.5 Planting time

The time and planting season for strawberry cultivation depends on the geographical conditions and climate of that particular area. The planting time in different part of the country is given below.

North India: September-January

North East India: November-January

South India: November-January & August

Maharashtra: Last week of August-November

Central India: October-November



Right planting

Too high planting

Too deep planting

3.6 Planting method & spacing

The planting material of the strawberry should be healthy and free from disease and insect-pest. The strawberry plant should have big crown with light colored roots. The planting should be done manually when soil is dry and climate is cloudy if not cloudy it should be done in the late afternoon. The hole should be created in bed where plant plugs are planted carefully keeping 25 % portion above the soil and remaining 75% portion need to be buried in the soil. The crown should be kept above the soil level and the soil must not touch the crown of the strawberry otherwise it may lead to infection in the crown. Light irrigation (5-10 mm) should be given just after the strawberry planting. Normally in strawberry two row system and four row system are prevalent but in India two row system is most commonly adopted. The specification of these two system is described in table 1.

Table 1 Details of two and four row system for strawberry cultivation

Planting system	Two Row System	Four Row System
Parameter		
Bed Width (cm)	60	100
Pathway between two beds (cm)	40 -50	40-50
Height of the bed (cm)	40-45	40-45
Mulching film width (cm)	100	125
Plant's/ acre (Nos.)	22,000	44,000

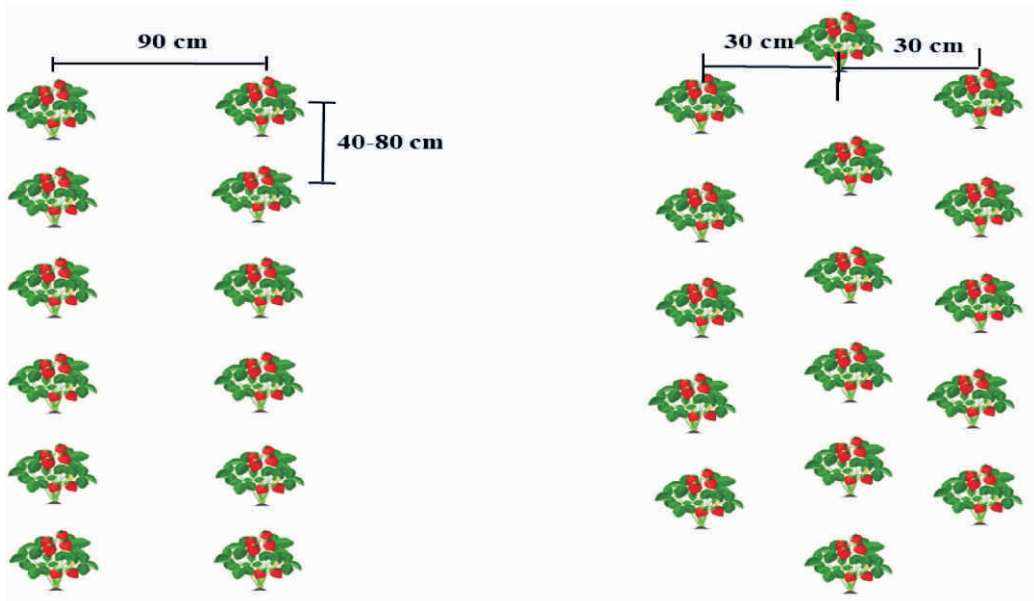


Two row system of planting



Four row system of planting

For fruit production strawberry plants are grown 30 to 45 cm apart with a distance of 60 to 90 cm between the rows. All runners are kept removed during the time of



Matted row planting system

Hill row planting system

3.7 Mulching

Mulching is most important cultural practice because it plays an key role in soil moisture conservation, weed control, regulation of soil-hydrothermal regime, prevent the fruits from soil born disease and keep the delicate fruit neat and clean. The mulching film should be UV stabilized and thickness of the mulching should be 25-30 micron. Different types of mulching is being used in strawberry i.e. Black/Black polythene, Black/Silver polythene double colour, transparent or white polythene, straw and jute based mulching.



3.8 Intercropping

Strawberry is planted as intercrops in young orchards. However, alternate interspace between two beds can be viably used to grow different vegetables.



3.9 Weeding

Frequent weeding of strawberry plots is very essential. Weedicides like Paraquat and Simazine can be used to keep the weed growth under control in between two beds. However, the mulch is very effective in weed control and helps in appreciably conserving soil moisture.



Weeding operation in the strawberry field

3.10 Yield and Harvest

Harvesting should be done by manually and according to the market. If produce has to be sold into long distance market then fruit should be harvest when it attains 50-75% maturity and for local market fruit should be harvest when it attains 75-100%

maturity. However, in general the interval should be around 2-3 days. After harvesting of strawberry fruits, it should be kept in cool place or refrigerator. The fruit are very delicate and should be kept in soft tray packed in plastic punnet box to avoid injury to fruit. The fruit which are damaged one or which got damaged after harvesting need to be sorted out to avoid spoilage of other fruits. The fruit should be packed in well ventilated card-board boxes or rigid plastic containers for transport. Long distance transport would require facilities of refrigerated vans. The yield of the strawberry depend upon several factors such as variety, management practice, nutrition dose, and many other parameters. The yield varied in strawberry from 100 to 1200g/plant with an average around 400-600 g per plant.



3.11 Special Horticultural Practices for Strawberry

Time to time different special practices need to be done in strawberry for getting good yield. The different practices are:

- **Leaf pruning:** Removing old leaves that are no longer contributing to the fruit production would help in moving the photo-assimilate to other sinks, including fruit. Dead leaves prevent air circulation in the canopy, and also leave your plants more susceptible to disease.
- **Bud and Shoot thinning:** Removal of 1-2 buds/ plant improves fruit yield and quality. However, excessive bud removal reduces production of number of fruits and drastic yield reduction.
- **Deblooming or flower pruning:** Deblooming can be define as removal of flower for specific purpose. Normally, strawberry first flower comes so early that even before proper root development. Therefore it is advised to remove first flower of the plants to develop better root system, which later on gives better yield. If first flower is not removed, the root and shoot development is generally poor with less plant vigor which ultimately affecting plants yield.
- **Bio-solarization:** Bio-solarization is an alternative technology to soil fumigation used in agriculture. It is closely related to bio-fumigation and soil solarization, or the use of solar power to control nematodes, bacteria, fungi and other pests that damage crops.

4

Nutritional and non-Nutritional deficiency/ disorder

Nutritional deficiency

S.N.	Nutrient	Symptoms and control measures
1	Nitrogen (N)	<ul style="list-style-type: none"> • The plant remains small and may turn from green to light green or yellow. • Severe deficiency leads to shortening of the petioles which later turn into red-purple leaves, reduction in leaf area, root weight, and fruit size. • High doses results into fruit softening, late ripening and reduce the fruit yield and also increase the chance of powdery mildew disease and mite attack. • In nitrogen deficiency calyx and leaves of the strawberry becomes purple colour. However, the old leaves also show reddish color which should not be confused with nitrogen deficiency.
2	Phosphorus (P)	<ul style="list-style-type: none"> • Initially plant becomes dark green with reduction in leaf size, upper portion of leaf show dark metallic shine on severe deficiency of phosphorus whereas lower surface becomes red purplish. • The calyx of the strawberry fruit becomes reddish and decrease in fruit size is observed. • The size of strawberry fruit and flowers remain smaller in size than the normal roots becomes less abundant, stunted and darker. • The different fertilizers such as triple super phosphate should be applied as pre-planting measure and mono-ammonium phosphate (MAP) should be applied early in the season and after cutting back for second crop. • Apply phosphorus as basal dose on the bed before strawberry planting @50kg/acre.
3	Potassium (K)	<ul style="list-style-type: none"> • The symptoms first appear on upper margins of the old leaves, the serration tips becomes red in color and the injury gradually moves inwardly among the veins, the mature leaves shows browning and upper side shows drying symptoms. Darkening and necrosis of leaflet basis and center.

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		<ul style="list-style-type: none"> • Low potassium deficiency leads to reduction in runner formation if produced the runners will be short and thin. It also leads to poor quality of fruit (color, texture and flavor). • KNO₃ (Potassium nitrate) <i>i.e.</i> 13-0-46 is the best fertilizers to fetch potassium demand of the plants. • In the strawberry fields, the application of KCl (Murate of potash) should not be applied due to its high content of toxic chloride.
4	Calcium (Ca ⁺²)	<ul style="list-style-type: none"> • The immature leaves shows tip burn symptoms, leaf tip unable to open fully and turns into black colour. Leaf petioles may become necrotic and leads to leaf collapse. • Young leaves of the strawberry becomes cupped shaped with puckered, or distorted, with blunt tips and a glob of syrupy liquid can be found on the leaf blade midribs of the strawberry. • The dense seed appearance on the fruit either in small patches or on entire fruit and these fruit may have a hard texture and acidic taste. • The root of strawberry plant becomes short, shubby and dark in color. • Before planting apply lime or dolomite whereas through drip time to time calcium nitrate can also be given. • Different calcium source such as phosphate fertilizers can be applied in the soil <i>i.e.</i> rock-phosphate (~46% CaO), single superphosphate (~28% CaO) or triple superphosphate (19% CaO)
5	Copper (Cu)	<ul style="list-style-type: none"> • The copper is relatively immobile within plants, hence its deficiency symptoms mainly occurs first on new growth, and youngest leaves are worst affected. • The strawberry plants becomes susceptible to fungal diseases due to copper deficiency • The deficiency on strawberry leaves show chlorotic to bleached blades, particularly on their leaf bases. • Yellowing of leaves takes place but their leaf veins remain green, but sometimes become brownish-black. • Apply nutrient based on soil and plant leaf test recommendations

6	Zinc (Zn)	<ul style="list-style-type: none"> • On the young leaves, development of green halo along the serrated margins, discoloration of the leaves along with serrated margins of leaf blades and chlorosis of interveinal area takes place. • The leaf blade of the strawberry becomes narrow at the base and eventually elongated on severe deficiency • The strawberry fruit size may remain normal, but the numbers of fruits are reduced. • The application of zinc chelate (14% EDTA-Zn) is efficient method to avoid zinc deficiency because it is highly water soluble and hence can be applied through drip irrigation. • Apply the zinc sulfate ($ZnSO_4$ with 36% Zn) at the time of planting in soils with low in zinc. • Zinc oxide (ZnO contains 80% zinc) a slow-release product is a viable option can be applied in the soil and it becomes available towards the end of the crop.
7	Boron (B)	<ul style="list-style-type: none"> • The young leaves of the strawberry show puckering and tip burning, later on the leaves shows marginal yellowing and crinkling symptoms with reduced growth from the growing point and leaf becomes asymmetrical. • The root growth becomes stunted and stubby due to boron deficiency and fruit becomes deformed. • The moderate boron deficiency in strawberry reduces the flower size and reduces the pollen production which results into small and bumpy fruit with poor quality. • Apply borax (11% boron) to the soil before planting. • The ideal concentration of boron is 1 ppm. The foliar application of boron is very effective when it is applied just before flowering. • New deficiency in strawberry plant can cure by application through foliar spray, or fertigation with a soluble boron compound such as: Boric acid (H_3BO_3) with 17% B.

8	Magnesium (Mg^{2+})	<ul style="list-style-type: none"> • Old leaves show chlorosis symptoms in the interveinal regions of leaf which later turns into necrosis, marginal scorching symptoms forming a halo appears near the leaf base. • Marginal leaf scorching first appears on the upper leaf margin, which leads to yellowing and browning of the leaf margin and later on this leaf scorching proceeds towards center of the leaf in between the veins. • The fruit are soft in texture and light in color. • If magnesium becomes deficient in soil, apply dolomite as pre-planting measure. • Application of soluble $Mg(NO_3)_2$ (Magnesium nitrate) or $MgSO_4$ (magnesium sulfate) in the soil or through drip irrigation or through foliar spray.
9	Iron (Fe)	<ul style="list-style-type: none"> • The leaf blade turns yellow whereas veins retain their green color. • In severe cases, the yellowing increased and leads to chlorosis or bleaching and turn the whole leaf into brown color. • Strawberry fruit size and quality are not much affected. • When deficiency of iron appears, use iron chelates such as Fe-DTPA (7% Fe) and Fe-EDTA (13% Fe) through fertigation or foliar spray.
10	Manganese (Mn)	<ul style="list-style-type: none"> • Young leaves become pale green to yellow later on the vein becomes dark green and interveinal region of leaves become yellow in color. Later on, scorching and curling of leaf blade margins towards upward side and these scorching areas proceeds towards center of the leaf and broad rays are extending from the veins. • The reduction in the fruit size is observed • In soil, when manganese is deficient (<20 -30 ppm) manganese sulphate can be applied through fertigation. In severely deficient soils, Mn-EDTA (13% Mn) can be applied by fertigation or by foliar spray.

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11	Copper (Cu)	<ul style="list-style-type: none"> • Symptoms occur first on new growth, and youngest leaves are mostly affected, leaves develop chlorotic to bleached blades, especially on their bases, veins remain green, but may sometimes become brownish-black. • Apply copper sulfate @ 20 kg/ha in soil or (CuSO₄) or 0.5% Copper sulfate can be applied through foliar application.
12	Molybdenum (Mo)	<ul style="list-style-type: none"> • The burning of leaf edges of the strawberry due to accumulation of unused nitrates. • Its deficiency is similar to nitrogen deficiency <i>i.e.</i> paleness and stunting. • Apply application of molybdic acid monohydrate (MoO₃·H₂O (59.6% Mo), or sodium molybdatedihydrate Na₂MoO₄·2H₂O (39.7% Mo).

Physiological disorders

S.N.	Physiological	Symptom & Causes	Control Measure
1.	Albinism	<p>Symptoms:</p> <ul style="list-style-type: none"> • The fruits remain irregularly pink or even totally white and sometimes swollen and this makes the fruit unmarketable and reduction in the market price of strawberry. The fruits have acidic taste and are less firm compare to other normal fruit and due less firmness they are prone to damage during the harvesting and becomes susceptible to Botrytis infection. <p>Causes:</p> <ul style="list-style-type: none"> • It may be due to abnormal climatic climatic conditions and extremes in nutrition. • Warm weather during the growing season followed by overcast and foggy skies leads to formation of albino fruit • High nitrogen and low sugar level in the fruit 	<ul style="list-style-type: none"> • Grow strawberry in optimum conditions or under protected conditions. • Apply optimum dose of nitrogen fertilizers.

<p>2.</p>	<p>Distorted or misshapen fruit:</p>	<p>Symptoms:</p> <ul style="list-style-type: none"> • Nubbin or button berries type • Cockscomb strawberries or fasciated type <p>Causes:</p> <ul style="list-style-type: none"> • Poor pollination • Insect pest (Tarnished plant bug, thrips & mites) • Frost damage • Weed pressure and overcrowding • Old strawberry plantings • Anthracnose infection on blossoms • Poor nutrient management • Dry soil 	<p>Control Measure</p> <ul style="list-style-type: none"> • To avoid cold injury or frost damage to flowers, used low tunnels when there is chance of abnormal weather. • Used optimum dose of micronutrient such as calcium and boron • To avoid inadequate pollination, put honey bee colonies in the strawberry field. • Avoid application of weedicide (i.e. 2,4-D amine) during the flower and fruit formation.
<p>3</p>	<p>Hollow heart and split fruit</p>	<p>Symptoms</p> <ul style="list-style-type: none"> • The fruit are hollow from inside core and in later stages it gets split from tip of fruit. • Mainly splitting occurs from distal of the fruit. However, rarely in some conditions cracking occurs from stalk end also. <p>Causes:</p> <ul style="list-style-type: none"> • High dose of fertilizers, micronutrient and plant growth regulator may results in this type for deformity. • Rapid growth of the fruit and development of the fruit leads this type of problems. • Apply optimum and recommended doses of fertilizers, micronutrient and plant growth regulator. 	<p>Control Measure</p> <ul style="list-style-type: none"> • Apply optimum and recommended doses of fertilizers, micronutrient and plant growth regulator.

4	Marginal Leaf Burn	<p>Symptoms</p> <ul style="list-style-type: none"> • Burning of the strawberry leaf takes place from the leaf margin. <p>Cause:</p> <ul style="list-style-type: none"> • Salinity in the irrigation water • Burning leaf margin may be due to excess dose of fertilizer • The deficiency is similar due to K, Mn, and Mo deficiency. 	<p>Control Measure</p> <ul style="list-style-type: none"> • Check the salinity time to time in irrigation water and take precautionary measures to control the soil salinity. • Use appropriate dose of fertilizers
5	Yellowing of Leaves	<p>Symptoms</p> <ul style="list-style-type: none"> • Yellowing of leaves <p>Cause:</p> <ul style="list-style-type: none"> • The application of herbicide may lead to yellowing of the leaves which is similar to the deficiency of Fe, Zn and Mn. 	<p>Control Measure</p> <ul style="list-style-type: none"> • Use appropriate dose of herbicides
6.	Phyllody	<p>Symptoms</p> <ul style="list-style-type: none"> • In this disorder appearance of leaf-like structures develops in the place of fruit or flower parts. • The symptoms of non-infectious phyllody appears early in the season but resolve themselves later in the season. <p>Causes:</p> <ul style="list-style-type: none"> • Infectious phyllody: caused by mycoplasma infection. • Non-infectious phyllody: caused by excess chilling of plants. 	<p>Control Measure</p> <ul style="list-style-type: none"> • Removing deformed fruit early can help conserve root carbon reserves for the next flush of marketable fruit. • Use appropriate insecticides for controlling the sucking pest.
7.	High Temperature Injury	<p>Symptoms</p> <ul style="list-style-type: none"> • The direct sunscald affected fruit portion, loose the moisture content and peel starts shrinking and drying. The fruit peel color degrade slowing and become light pinkish red to light brown in color. • The in-direct sunscald affected fruit peel losses color and 	<p>Control Measure</p> <ul style="list-style-type: none"> • Use low tunnel to avoid the problem of direct sunscald problem • Use transparent mulch in area where high temperature prevails in strawberry cultivation

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		<p>become pale yellow to whitish in color. The watery appearance takes place between fruit and black plastic mulch and this later attract other fungal disease on the fruit.</p> <p>Causes:</p> <ul style="list-style-type: none"> • Higher temperature also cause two types of sunscald in strawberry fruit i.e. direct and indirect type sunscald. 	
8.	Salt Injury	<p>Symptoms:</p> <ul style="list-style-type: none"> • The excess of salt results in reduced growth rate and fruiting. • Appearance of marginal leaf 'burn' symptoms on the strawberry leaves is observed. <p>Causes:</p> <ul style="list-style-type: none"> • Calcium chloride is most harmful even at very low concentration i.e. $EC < 1 \text{ dS/m}$. • Sodium sulfate can have negative effect on strawberry production at $EC < 3 \text{ dS/m}$. 	<p>Control Measure</p> <ul style="list-style-type: none"> • Soil and water testing must be done before strawberry planting. • Soil reclamation measures need to be done if soil has high salt concentration.



5

Integrated Pest Management in Strawberry

S.N.	Name and Causal Organism	Nature of Damage	Control Measure
1	Cyclamen Mite:	<ul style="list-style-type: none"> • They attack on leaves, flower and fruit of the strawberry. • Stunting and crinkling of the leaves takes place due to heavy infestation of the spider mite. • They feeds on flowers which later withers and die • The fruit remain small in size on the affected plant and seeds stand out on the peel of the fruits. 	<ul style="list-style-type: none"> • The natural enemies <i>i.e.</i> <i>Scolothrips sexmaculatus</i> (six spotted thrips) & <i>Orius tristicolor</i> (minute pirate bugs) feed cyclamen mites can be used for control measures. • Spray sulphur @ 1.4 g/liter as symptoms appears and spray at 14 days interval • Spray vermitec (Abamectin 1.8%) @ 0.4 ml/liter at interval of 7 days and maximum 5 spray can be applied.
2	Tarnished plant bug (TPB): <i>Lygus lineolaris</i>	<ul style="list-style-type: none"> • Nymphs and adults both eat the developing flowers and fruit, sucking the plant liquids out with mouth pieces that resemble straws. • They produce fruit that is malformed and is commonly known as "cat-faced" berries, "button" berries, or nubbins. 	<ul style="list-style-type: none"> • Managing TPB is essential, because crop losses from damage can be as high as 90%. • Remove the weed in field may reduce the insect population. • Don't spray until after the bloom is finished to protect bees and other pollinators. • Early spraying is preferred because it prevents TPB population growth during bloom.

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3	Slugs	<ul style="list-style-type: none"> • The slugs injure the strawberry plants by eating fruits and making holes of various sizes during the night time and they hide themselves during the day time. • The presence of glistening patches or streaks of dried slime seen on the plants and in the ground nearby the strawberry plants are the marks of identification of slug attack. 	<ul style="list-style-type: none"> • Avoid straw mulches in the strawberry fields as they encourage the slug populations. Apply poisonous slug baits in the field. • Before cultivating the strawberry remove the debris and plough the field well to minimize the slug effect.
4	Birds	<ul style="list-style-type: none"> • They damage the fruit through their beak and makes the fruit unmarketable. 	<ul style="list-style-type: none"> • Installation of different audio and visual scare devices in the field as soon as strawberry start fruiting in the field can be effective option. • Installation of anti-bird net can control the problem of bird.
5	Spider Mite: <i>Tetranychus urticae</i>	<ul style="list-style-type: none"> • The adult of the mite lays egg on below side of leave • Yellow patches on the leaf are caused by the feeding of mites • Webbing on flowers and fruits shows the presence of spider mite. 	<ul style="list-style-type: none"> • Spray vertimec/ abamectin 1.8% @ 1.4ml/liter at seven days interval and should not be sprayed more than five spray per season.
6	Whitefly: <i>Trialeurodes vaporariorum</i>	<ul style="list-style-type: none"> • The whiteflies suck the strawberry plant sap and reduce the vigor of plant and their by reducing their yield. • The adults of whiteflies secrete honeydew which encourage the growth of sooty mold which further reduces the quality of the plant. 	<ul style="list-style-type: none"> • Remove the host plant and keep field sanitation. • Azadiractin 4.5% @ 2.5 ml/liter can be used as preventive spray.

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			<ul style="list-style-type: none"> Natural enemies include lacewings (<i>Chrysopa</i> spp. and <i>Chrysoperla</i> spp.), big-eyed bugs (<i>Geocoris</i> spp.), minute pirate bugs (<i>Orius</i> spp.), big-eyed bugs (<i>Geocoris</i> spp.), and parasitic wasps like <i>Esncarsia pergandiella</i> can be used as biological control.
7	<p>Strawberry Leaf Roller: <i>Ancyliscomptana fragariae</i></p>	<ul style="list-style-type: none"> The incidence of leaf roller occurs prior to bloom in the field. The fully grown larvae are little green or bronze caterpillars that reach up to 1/2 inch long. After the attack, larvae are first observed on the lower surface of the leaves under silken covers and later on upper side of the leaves which have been folded or curled and tied with silken threads. Larva (immature stage of this insect) after hatching burrows into the flower bud and damage the developing flowers. Fruit becomes deformed and becomes unrenderable. 	<ul style="list-style-type: none"> Remove and destroy the rolled leaves to get rid of this pest. A pre- or post-bloom spray application may be necessary if the infestation is bad. It is advised to spray an insecticide before to flowering.
8	<p>Cut Worms: <i>Agrotisipsilon</i></p>	<ul style="list-style-type: none"> The larvae of the insect feed on leaves, buds, and developing strawberry fruits Cut irregular holes on the foliage Destroy emerging leaves at the crown portion 	<ul style="list-style-type: none"> Timely remove the plant residue in strawberry field to reduce egg-laying sites.

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		<ul style="list-style-type: none"> • Makes holes in the fruits 	<ul style="list-style-type: none"> • Weeding should be done because it may serve as an alternate host for young cutworm larvae. • Fumigation of the beds before strawberry planting will kill larvae.
9	Strawberry Bud Weevil: <i>Anthonomus signatus</i>	<ul style="list-style-type: none"> • In unopened flower buds, insect cuts a tiny hole, deposits an egg there, and then girdles the stem right below the bud. • The dried-up flower bud dangles from the stalk till it finally fall on the ground. • The young weevils hatch from the girdled buds and pupate in the ground. 	<ul style="list-style-type: none"> • Application of insecticides in border area (the first 5-10 rows) may be sufficient for control.
10	Flower Thrips: <i>Franliniella tritici</i> & <i>Franliniella occidentalis</i>	<ul style="list-style-type: none"> • The thrips feed on foliage, inflorescence, and fruits of the strawberry by piercing and rasping the plant cells and sucking the contents, which results in cell collapse. • Necrotic flecking or bronzing beneath the calyx and also on seeds and strawberry fruit • Fruit may crack, and it may also take on a bronze tint. • The bronzing on the entire fruit and cracking may be seen on the fruits. Seeds becomes prominent. 	<ul style="list-style-type: none"> • Field sanitation and remove weed and other host plant time to time. • Spray spintor (Spinosad 11.6 %) @ 0.4 ml/liter and maximum 5 applications per season and not more than 2 consecutive applications. • Two spray of actra (Thiamethoxam 25%) @ 0.5g/liter at an interval of seven days. • Minute pirate bugs (<i>Orius</i> spp.) and predatory mites (<i>Neoseiulus</i> spp.) feed on thrips.

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			<ul style="list-style-type: none"> Entomo-pathogenic nematodes and entomo-pathogenic fungi such as <i>Beauveria bassiana</i> can be effective with proper timing and application
11	Sap Beetle <i>Stelidota-geminata & Glischrochilus-quadriseignatus</i>	<ul style="list-style-type: none"> The beetle's forms hollowed-out cavities on ripe fruit which is similar to slug injury. The damage fruit make prone to other organisms which will lead to finally fruit rot. Larvae damage is less obvious because larvae develop in decomposing fruit whereas the adults feed near the fruit surface or bore into the fruit and found in the cavities of chewed fruit or next to the receptacle The injured fruit or overripe fruit are more prone to attack by beetles. 	<ul style="list-style-type: none"> Field sanitation is very essential for controlling this pest. Harvest the mature or ripe fruit as soon as possible otherwise it will attack the fruit. Trapping the beetles with bait basket of overripe fruit or beer and placing the traps between the boundaries of the field and wooded areas.
12	Two-Spotted Spider Mites (TSSM) <i>Tetranychus-urticae</i>	<ul style="list-style-type: none"> The mite feeds on foliage and leads to leaf stippling and bronzing of the leaves. The heavy incidence may lead to reduction in the yield. Yellow stippling, bronzing, and curling downward of older leaves are signs of mite damage. Mites generally form colonies and exhibit webbing undersides the leaves. 	<ul style="list-style-type: none"> Use registered miticide for controlling the two-spotted spider mites Use predators for biological control. <i>Amblyseius fallacis</i> and other predatory mites that feed on spider mites are currently commercially available Avoid the use of high dose of nitrogen because it encourage mite's population in the field.

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13	<p>White Grubs (Rose Chafer, Asiatic Garden Beetle, June Beetle) <i>Popilla japonica</i>, <i>Macrodactylus subspinosus</i>, <i>Autoserica castanea</i>, and <i>Cotinianitida</i></p>	<ul style="list-style-type: none"> • White grubs weaken the plants by damaging their roots, and they act as a gateway for the root diseases. • The adult's beetles feed on the strawberry leaves skeletonized leaf, reduction in flower bud formation can be observed which will ultimately affected the yield of strawberry. 	<ul style="list-style-type: none"> • Soil management of grubs is very difficult. • Use pheromone traps and feed lures for controlling the beetles. • The traps should be place at least 20 yards away from the strawberry field. • Deep ploughing should be done and drenching the soil of bed with chlorpyriphos @ 2ml/L water.
14	<p>Aphids <i>Chaetosiphon-fragaeifolii</i>, <i>C. thomasi</i>, and <i>C. minor</i></p>	<ul style="list-style-type: none"> • The new shoot, petioles, veins of lower side of leaves and bud in the strawberry crown are key infection site of the aphids. • Aphid damaged the plant part by sucking out the plant juices. Aphid excretes large quantities of honeydew on different plant parts of strawberry on which sooty mold grows. 	<ul style="list-style-type: none"> • Control the aphid before they become serious, because they are vector for viral disease. • Flupyradifurone, imidacloprid, thiamethoxam, acetamiprid can be used as control measure.
15	<p>Rootworm <i>Paria fragaria</i></p>	<ul style="list-style-type: none"> • The root worms are actively feeding on strawberry roots and the injury may lead to other root disease such as black root rot. When they attack on leaves, they form shot holes. 	<ul style="list-style-type: none"> • Sticky traps may be helpful in killing the adults of strawberry rootworm. • Fumigation of soil can get rid from rootworm. • Deep ploughing of the field and crop rotation can minimize the incidence.
16	<p>Root Weevils <i>Otiorhynchus</i> spp.</p>	<ul style="list-style-type: none"> • The weevil hides during the day and damage the strawberry plant at night. The adults can't fly, so they have to walk through the field. 	<ul style="list-style-type: none"> • Fumigation of soil can get rid from larvae of this insect.

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	<ul style="list-style-type: none">• The larvae tunnel through the roots and crowns, resulting in significant damage.• A reddish-brown frass that resembles sawdust surrounds the crown as proof that it has been attack by root weevil.• Plants showed wilting symptoms and their growth becomes stunted under the stress of fruiting or hot weather.	<ul style="list-style-type: none">• Deep ploughing of the field and crop rotation can minimize the incidence.• Carbofuran @ 6-10 kg/ha and parathion (0.017%) are applied as preventative measures close to the plants.
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Integrated Disease Management of Strawberry

BACTERIAL DISEASE

Disease and causal organism	Symptoms	Control Measure
<p>Angular Leaf Spot Causal organism: <i>Xanthomonas fragariae</i></p>	<ul style="list-style-type: none"> • The warm days and cool night led to the infection of angular leaf spot in strawberry leaf. • Initially on lower surface of the leaf water soaked irregular lesions appeared and these lesions enlarge into translucent areas between the veins and exudate bacterial liquid. Later this exudates dries up and form a whitish film. • Later on as the disease proceeds, the reddish brown spots appears on the upper side just corresponding to the lesions on below side of leaves and eventually these spots become necrotic and infected areas show yellowish margins on outer region of the spot. • Later on, the rain and overhead sprinklers led to spread of the pathogen from infected leaves or planting material. • Bacterium can lead to vascular collapse and strawberry blossom blight. 	<ul style="list-style-type: none"> • Fumigate the soil before strawberry planting kills the inoculum. • Use healthy planting material • Remove the dry and infected leaves from the field and burned them. • Adopt crop rotation practice in the field. • Weekly application of copper fungicides at a rate of 0.3 lb of metallic copper per acre without causing phytotoxicity to the plants. • Actigard® , (Syngenta) can effectively control the disease.

FUNGAL DISEASE

<p>POWDERY MILDEW Causes: <i>Podosphaera aphanis</i> <i>& Sphaerotheca maculari</i></p>	<p>Symptoms:</p> <ul style="list-style-type: none"> • This disease infection takes place when there is cool to warm temperatures with high humidity. • Appearance of whitish powdery growth on below surface of the strawberry leaves followed by upward curling of leaf edges. 	<p>Control Measure:</p> <ul style="list-style-type: none"> • Use healthy planting material and resistant variety • Avoid overhead irrigation when there is already infection.
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	<ul style="list-style-type: none"> • As the disease proceeds further, on the upper leaf surface formation of dry and purplish patches appears. • The infected strawberry flower die off or fail to bear fruit or form deformed fruits • The powdery mildew infection leads to formation of hardened or desiccated fruit or it will give a seedy appearance to mature fruit. 	<ul style="list-style-type: none"> • Optimum dose of fertilizer need to be given and excess nitrogen should not be given. • Apply fungicides prior to the onset of symptoms in the area where the disease appears every year for effective and sustainable control of the disease. • Spray Amistar (Azoxystrobin 50%) @ 0.5 ml/liter at an interval of 14-21 days and maximum 6 spray can be applied. • Application of Sulphur @1.5 g/liter at 14 days interval can be effective for controlling the disease. • Apply Rally 40 W (Myclobutanil) @ 0.5g/liter at 7 days interval and maximum 4 spray can be applied per season.
<p>BOTRYTIS FRUIT ROT/GRAY MOLD</p> <p>Causes:</p> <ul style="list-style-type: none"> • Causal organism : <i>Botrytis cineraria</i> • Wet and cool weather conditions has more incidence of the disease. • Rainy weather are the pre-disposing factors because the spores of the fungus are spread by wind or by water 	<p>Symptoms:</p> <ul style="list-style-type: none"> • The disease appears on the different plant parts such as petals, stalk, fruit caps and the strawberry fruit. • On the strawberry green and red fruit, below the calyx small brown color lesion are appeared which rapidly enlarge and cover the fruit surface with velvety grayish to brown color mats of fungal mycelium and spores. 	<p>Control Measure:</p> <ul style="list-style-type: none"> • Remove the infected or damaged plant parts (dead flowers and fruits) will reduce the infection • Spray cafta f (Captan) @ 2g/liter at the beginning of the flowering and before fruit formation.

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<ul style="list-style-type: none"> • Closer spacing and keeping dry older leaves on the plant lead to infection of the disease. • Infected planting material in the field. 	<ul style="list-style-type: none"> • These Infected areas on leads to fruit rot and turns soft which can turn dry and leathery if humidity is low. • On flower the spore of the fungus either damage it or it remains dormant until the fruit develops. 	<ul style="list-style-type: none"> • Application of Kocide (Copper hydroxide) @ 2g/liter or blitox (copper oxychloride) @ 2g/liter as a preventive measure when conditions are conducive. • Application of Topsin - M (Thiophanate Methyl 70 %) @ 2g/liter at the flowering initiation, mid of flowering and at the end of flowering.
<p>CHARCOAL ROT</p> <p>Causes</p> <p><i>Macrophomina-phaseolina</i></p>	<p>Symptoms</p> <ul style="list-style-type: none"> • The new leaves remain green in the center becomes dry and ultimately die. • The wilting of the leaves takes place and vascular tissue inside the crown turns into orange to reddish brown in color. • The primary roots of the strawberry becomes dark brown in color from inside. • The symptoms on foliage and crown discoloration are akin to wilting caused by fusarium. 	<p>Control Measure</p> <ul style="list-style-type: none"> • Fumigation of the bed before strawberry planting is necessary. • Crop rotation, sanitation in the field, good management practices and use of resistant or tolerant varieties can reduce the infection in field. • Spray of Aliette (<i>Fosetyl aluminium</i>) @1 g/liter can be applied and not more than 4 application/season
<p>LEAF SPOT/ PURPLE LEAF SPOT:</p> <p>Causes</p> <p><i>Mycosphaerella fragaria</i> (asexual form <i>Ramularia brunnea</i> Syn. <i>R. tulasnei</i>.)</p>	<p>Symptoms</p> <ul style="list-style-type: none"> • The disease infection takes place on different plant parts such as, leaf, stolons, petioles, calyx and fruit 	<p>Control Measure</p> <ul style="list-style-type: none"> • Use healthy disease free planting material cultivars that are resistant to leaf spot

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	<ul style="list-style-type: none"> • Formation of a tiny, circular mark on the leaf with dark brown to purple edges and a grey center which later on combine and result in death of the strawberry leaf. • On upper leaf surface, formation of purple lesions take place and the color of center or inner portions of this lesions is brown which later turn into white color with purple or reddish margins. • The several lesions combine to form large lesion which ultimately leads to death of the leaf. 	<ul style="list-style-type: none"> • Timely remove the infected leaves will minimize the infection • Minimize the use of sprinkler irrigation because it led to the dispersal of fungal spores • Application of Kocide (Copper hydroxide) or blitox (copper oxychloride) @ 2g/liter as a preventive measure when conditions are conducive
<p>FUSARIUM WILT Causes: <i>Fusarium oxysporum</i> <i>f. sp. fragariae</i></p>	<p>Symptoms:</p> <ul style="list-style-type: none"> • The disease symptoms are similar to the charcoal rot. • Internal root tissues are usually not discolored. 	<p>Control Measure</p> <ul style="list-style-type: none"> • Follow crop rotation, which will reduce the disease pressure in the strawberry • Apply fumigation or soil solarization of beds before strawberry planting • Varieties such as Ventana and San Andreas had some tolerance • Good management practice can avoid the stress factors which mainly lead to this disease
<p>ANTHRACNOSE: Causes: <i>Colletotrichum</i> <i>cutatum</i></p>	<p>Symptoms:</p> <ul style="list-style-type: none"> • Formation of dark brown to black color lesion which are sunken and lens shaped on stolons/runners and leaf petioles and later on become enlarge, dark, elongated and dry. 	<p>Control Measure</p> <ul style="list-style-type: none"> • Apply fumigation or soil solarization of beds before strawberry planting • Use healthy and resistant variety for planting material

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	<ul style="list-style-type: none"> • On green strawberry fruit lesion are brown in color whereas on red fruit black type spot appears which are round to oval and sunken type. • The plants growth becomes stunted, yellow and wilted followed by death of the plants on severe infection. 	<ul style="list-style-type: none"> • Dipping roots of plants in fungicide solution before planting • Good sanitation and crop rotation should be practiced in the field.
<p>CROWN ROT/ LEATHER ROT: Causes: <i>Phytophthora cactorum</i></p>	<p>Symptoms:</p> <ul style="list-style-type: none"> • Initially plant becomes stunted and wilting of the foliage takes place. • Later on the advancement of the disease lead to collapse of the plant and crown turn into deep dark red color. • Leaf becomes brown to purplish and infected strawberry fruit becomes brown and becomes mushy as the infection progresses, forming a tough cape on the outside while the interior tissue is smooth. The fruit's interior cavity may have fungus mycelium in it. 	<p>Control Measure</p> <ul style="list-style-type: none"> • Crop rotation, sanitation in the field, good management practices and use of resistant or tolerant varieties can reduce the infection in field. • Apply fumigation or soil solarization of beds before strawberry planting • Use fungicides when there incidence of the disease.
<p>PHYTOPHTHORA CROWN ROT Causes: <i>Phytophthora cactorum, P. citricola, P. parasitica and P. megasperma</i></p>	<p>Symptoms:</p> <ul style="list-style-type: none"> • The strawberry plant growth becomes stunted and plant collapses down on as disease proceeds. • The leaves remain short and vascular tissue of the strawberry crown shows brown discoloration on cut. • The infected root of strawberry plant develops black rot. 	<p>Control Measure</p> <ul style="list-style-type: none"> • Use healthy and disease free planting material • The soil should have proper drainage. • Fumigate or soil solarization of bed should be done before strawberry planting.

<p>LEAF BLOTCH & PETIOLE BLIGHT</p> <p>Causes: <i>Gnomoniopsis comari</i> synonym <i>Gnomonia comari</i>, anamorph <i>Zythia fragariae</i>)</p>	<p>Symptoms:</p> <ul style="list-style-type: none"> • The disease mainly occurs in the winter and early spring, especially after a lot of rain. • On the first few leaves of the young plants, tan to grey lesions quickly spread from the edges and take up between 25 to 50% of the leaf surface. • Fungus leads to petiole or calyx blight which change the infected areas brown to black. • The small blacks to brown color fruiting bodies of the fungus are present on the lesions, which is typical character of this disease. 	<p>Control Measure</p> <ul style="list-style-type: none"> • Field sanitation and soil fumigation is essential before strawberry planting
<p>VERTICILLIUM WILT</p> <p>Causes: <i>Verticillium dahlia</i></p>	<p>Symptoms:</p> <ul style="list-style-type: none"> • Stunted plant growth, interveinal and marginal browning of the outer leaves that eventually lead to collapse of the plants • Formations of brownish-black streaks or blotches on the interior green leaves are all signs of the disease. 	<p>Control Measure</p> <ul style="list-style-type: none"> • Field sanitation and use of resistant cultivar. • Fumigation or soil solarization of bed should be done before strawberry planting. • The soil's fungal inoculum is reduced by crop rotation with broccoli or by using cereal rye or ryegrass as cover crops. • Avoid the application of excessive nitrogen fertilizer.

		<ul style="list-style-type: none"> • Soil fumigation with formalin (5000 L/ha) or chloropicrin (210 L/ha), include adequate crop rotation.
<p>RED STELE</p> <p>Causes: <i>Phytophthora fragariae</i> var. <i>fragariae</i></p>	<p>Symptoms:</p> <ul style="list-style-type: none"> • Stunted plant growth, interveinal and marginal browning of the outer leaves that eventually lead to collapse of the plants • Formations of brownish-black streaks or blotches on the interior green leaves are all signs of the disease. 	<p>Control Measure</p> <ul style="list-style-type: none"> • Fumigate or soil solarization of bed should be done before strawberry planting. • Use healthy strawberry plant and planting need to done in well drained soils because it will minimize the disease risk. • Use recommended fungicides if the disease in not controlled through above methods. • Grow red stele resistant cultivars such as Allstar, Pathfinder, Darrow, Earliglow, Guardian, Redchief, Delite, Sparkle, Stelemaster, Sunrise, Joliette, Surecrop, Midway, Tribute and Tristar
<p>RHIZOPUS FRUIT ROT</p> <p>Causes: <i>Rhizopus</i> spp.</p>	<p>Symptoms:</p> <ul style="list-style-type: none"> • On the fruit, water-soaked discoloured patches appear and quickly get bigger in size. 	<p>Control Measure</p> <ul style="list-style-type: none"> • Field sanitation (infected plant part) need to be performed in timely manner.

	<ul style="list-style-type: none"> • Fruit wilts, becomes brown, and leaky as a result of the fungus's enzymatic activity. • On the diseased fruit, a white fungal growth with black, spore-bearing sporangia grows under conditions of high humidity. 	<ul style="list-style-type: none"> • Harvest the ripe fruit just after the rain to reduce the disease incidence. • Plant the resistant variety which has thick cuticles. • Handle the fruit carefully during harvesting, packaging and transportation • Rapid cooling need to be done just after harvesting of fruit. • Use fungicides if the disease is pervasive across the entire strawberry field.
<p>MUCOR FRUIT ROT</p> <p>Causes:</p> <p><i>Rhizopus</i> spp.</p> <ul style="list-style-type: none"> • Mucor spp. • The high humidity led to infection on strawberry fruit • The fungus of this disease survives in dead and decaying organic matter present on field or nearby field. 	<p>Symptoms:</p> <ul style="list-style-type: none"> • The symptoms of this disease are similar to Rhizopus fruit rot. • The fungus of this disease enters into the fruit through damaged skin followed by secretion of enzyme which leads to rotting of the fruit. • The wiry mycelium of the fungus covered the fruit with round and black spore on the fruits. 	<p>Control Measure</p> <ul style="list-style-type: none"> • Field sanitation (infected plant part) need to be performed in timely manner. • Harvest the ripe fruit just after the rain to reduce the disease incidence. • Plant the resistant variety which has thick cuticles. • During harvesting, packaging and transportation, the fruit should not be damaged because it will be more prone to infection.

<p>LEAF SCORCH</p> <p>Causes: <i>Diplocarpon earlianum</i></p>	<p>Symptoms:</p> <ul style="list-style-type: none"> • Round to angular shape purplish to brownish blotches appear on strawberry leaves. • The ill drained soils and long period of leaf wetness due to frequent rains increase the incidence of the disease. • Poor air circulation in the strawberry canopy led to spread of the disease. 	<p>Control Measure</p> <ul style="list-style-type: none"> • Fumigate or soil solarization of bed should be done before strawberry planting. • Use healthy strawberry plant and planting need to done in well drained soils because it will minimize the disease risk. • Use recommended fungicides.
<p>EARLY BLIGHT</p> <p>Causes: <i>Phomopsis obscurans</i></p>	<p>Symptoms:</p> <ul style="list-style-type: none"> • Initially the lesion on the leaves appears as a circular spot which has similar to the leaf spot disease, however the phomopsis lesions have mainly as reddish halo which is absent in the leaf spot disease. • Later on, irregular, circular (often) and zoned lesion appears on the strawberry leaf. • Usually, the lesion consist of 3 zones i.e. outer zone (reddish to purplish), middle zone (light brown) and inner zone (dark brown). • Finally the lesions which are along with veins become v-shaped which is a typical symptom of this disease. 	<p>Control Measure</p> <ul style="list-style-type: none"> • Fumigate or soil solarization of bed should be done before strawberry planting. • Use healthy and resistant strawberry variety. • Application of blitox (copper oxychloride) @ 2g/liter as a preventive measure when conditions are conducive. • The disease can be checked with 2-3 sprays of hexaconazole (0.5 ml/L water) or 5 sprays of carbendazim (0.5g/L water) spaced 21 days apart.

VIRAL DISEASE

<p>Pallidosis related decline of strawberry</p> <p>Causes:</p> <p>SPaV or BPYV, & transmitted through greenhouse whitefly (<i>Trialeurodes vaporariorum</i>) and aphids.</p>	<p>Symptoms:</p> <ul style="list-style-type: none">• The symptoms of this viral disease are confusing with nutritional deficiencies or abiotic disorders.• Strawberry plant growth become s stunted and root becomes brittle along with reduced rootlets.• Leaves become purple to red in color and yield of the plants is reduced.	<p>Control Measure</p> <ul style="list-style-type: none">• Use healthy strawberry plants free of infection.• Timely management of aphid and whitefly vectors• Rough out the weeds in strawberry because it can act as virus reservoirs
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7

Flow-chart of Processed Products of Strawberry

Strawberries are extensively used in food processing industry. Several strawberry processed products are in high demand in market, among them jams, juices, crush, ready-to-seve, beverages, jellies, purees, sliced berries, canned, dried and frozen strawberries and wines attracts consumers and provides benefit to stakeholders. Strawberries are also used as constituents in diverse kind of food products such as yoghurts, ice cream, breakfast cereals, cakes or chocolates. The ICAR-CAFRI prepared two products *i.e.* Dried Strawberry & Jam.

In the European countries, strawberry products like jam assumes significant position on breakfast tables. In India, fresh strawberry consumption and utilization of processed products are gaining momentum owing to its flavor, taste and nutritive values. However, different strawberry products, flow chart is mentioned below.

STRAWBERRY CRUSH

Removal of rotten, over ripened, contaminated, diseased and decayed fruits

↓
Washing and sanitizing of selected raw strawberries

↓
Crushing

↓
Sugar sieving

↓
Cooking of fruit pulp (crush)

↓
Sugar syrup preparation

↓
Addition of other raw materials in mixing tank. (Pulp 28%, sugar, water, thickener, preservative, acidity regulator)

↓
Homogenization (Optional)

↓
Pasteurization (95-98°C for 10-30 sec)

↓
Hot filling in bottles

↓
Final packing, labelling and storage



STRAWBERRY JAM

Weigh 500 g of fresh wholesome strawberries



Remove sepals (green leaf-life structures) and wash strawberries and chop the strawberries into small pieces using a knife to



Add strawberries to pot and then add 60 ml of water



Cook for 5 minutes to soften strawberries



Add 0.5 g citric acid. (Note: This should bring the pH to 3.5 or below which is desirable for jam setting. Verify the pH using a pH meter)



Add pectin gradually while mixing, in order to prevent clumping



Bring to a rolling boil and then add sugar while mixing



Return to a rolling boil and cook for about 3 – 5 minutes while continuing to mix. This will avoid sugar caramelization and off-taste



Check that the jam is set by placing a drop of the jam in a cup of cold water. If the drop remains lumpy, the jam is set. If it disintegrates, the jam needs more time to cook.



After setting, pour jam into jar and seal properly, label, and leave to cool.



STRAWBERRY LEMONADE

Take healthy strawberry fruit free from infection



Remove the sepals and wash it to remove the dust particles



Crush the sugar into powder in a mixie jar.



Add strawberry fruit and grind well to make a soft pulp and transfer this pulp into to a bowl.



Add lemon juice to this pulp mixture, followed by water and mix it well.



Take a glass and place 2-3 ice cubes and fill ¼th with the strawberry lemon mixture.



Top with club soda on strawberry lemon mixture or one can have it without club soda with just plain water

Source: <https://www.ticklingpalates.com/strawberry-lemonade/>)



DRIED STRAWBERRY

Select firm and ripe strawberries which have good TSS and color.

Remove the sepals and wash the fruits

Cut the strawberry into pieces (2 or pieces either vertically or horizontally).

Keep the pieces on steel plates and put it into bright sunlight and cover it with cotton cloth to avoid dust particles

Change the upper side when it dries up and keep in sunlight until it dries completely

One can use dehydrator equipment also for drying the strawberry and keep the temperature around 50-60 °C

Depending on the on the size of the berry pieces, exposure to sunlight, temperature, air circulation and method of drying.

After drying, cool fruit for 30 minutes.

Store the dried strawberry fruits in an air-tight or vacuum-sealed container.

For long duration storage, freeze the dried strawberry.



FREEZE DRIED STRAWBERRY POWDER

Select firm and ripe strawberries which have good TSS and color.



Remove the sepals and wash the strawberry fruits



Cut the strawberry into small pieces



Dehydrate the strawberry into oven (for 3-4 hrs) until they are crisp



Freeze the dehydrated strawberry for frozen for one night



When strawberries become solid enough, take out from the freeze.



Pulverize the frozen strawberry into powder with the help of blender until they become fine powder



Sift or sieve the blended powder to make sure there are no pieces left



Store the powder in an airtight container



Keep the powder container away from any moisture or heat



8

Training & Exposure Visit on Strawberry Cultivation

In this project a three-day training programme on “Strawberry cultivation for crop diversification and better income in Bundelkhand Region” was organized by ICAR-CAFRI during 9-11 February 2022 under the NABARD funded projects being implemented in Jhansi district (Babina and Moth block). The programme was inaugurated by Chief Guest i.e. Dr. D.S. Chauhan, Chief General Manager, NABARD, Uttar Pradesh. Sh. Raju Kumar Sharma, AGM, NABARD Lucknow and Sh. Bhupesh Pal, AGM, NABARD, Jhansi graced the occasion as Guest of Honours. 25 progressive farmers (13 from Moth block and; 12 from Babina block) and 10 other farmers from other areas also attended the training programme. A total of 13 lectures were scheduled covering all aspects of strawberry cultivation i.e. status and prospects of commercial strawberry cultivation, propagation and nursery techniques of strawberry, good agricultural practices, drip irrigation, fertigation, nutraceutical importance, important varieties, protected cultivation, post-harvest management, processing & value addition of strawberry, integrated pest and; disease management, nutritional and non-nutritional disorders, entrepreneurship development and strawberry tourism.



A virtual exposure of Mahableshwar region was also arranged with the help of DDM, NABARD, Satara in Maharashtra. Besides, visit to farmer's strawberry field in Jhansi was organized and practical discussion was also enabled. The farmers were also exposed to technologies of ICAR-Indian Grassland and Fodder Research Institute and; Rani Lakshmi Bai Central Agricultural University, Jhansi through a visit.



Bundeli Strawberry Festival

A three-day programme on “Bundeli Strawberry & Organic Agri-Produce Festival Cum-Exhibition was organized by ICAR-CAFRI during 9-11 February 2022. The programme was inaugurated by Chief Guest i.e. Dr. D.S. Chauhan, Chief General Manager, NABARD, Uttar Pradesh. Sh. Raju Kumar Sharma, AGM, NABARD Lucknow and Sh. Bhupesh Pal, AGM, NABARD, Jhansi graced the occasion as Guest of Honours. More than 300 persons visited the exhibition stall and gained benefits and also shared fruitful information. During the programme, organically grown strawberry, organic products, processed products, bamboo based products, and other FPO's demonstrated their different products. The farmers produce were also exhibited. The strawberry produced from farmer's field in Moth and Babina block were packaged for sale during the exhibition with brand name i.e. “Bundeli Strawberry”.



9

Monitoring of Strawberry Project

The project was periodically monitored by project monitoring committee. The CAFRI Scientist and DDM NABARD rigorously and continuously monitored the strawberry performance time to time in the field. Beside this the other visit are mentioned below.

On January 19, 2022, Dr. A. Arunachalam (Director, ICAR-CAFRI, Jhansi, Uttar Pradesh), Dr. Ashok Yadav (Scientist-Fruit Science), Dr. Asha Ram (Scientist-Agronomy), and Dr. Sovan Debnath (Scientist-Soil Science) visited the Strawberry field and interacted with the farmers and enriched the farmers knowledge on good strawberry farming practices.



- On February 2nd, 2022, Mr. Shailesh Kumar (CDO Jhansi), Mr. Vinay Kumar Yadav (Deputy Director Horticulture, Jhansi) and Mr. Jalim Singh Yadav (Horticulture Inspector) monitored the performance of strawberry fields in Babina blocks of Uttar Pradesh.



- On 9th February 2022, Dr. D.S. Chauhan (CGM, NABARD), Shri Raju Kumar Sharma (AGM, NABARD), Shri. Bhupesh Pal (AGM, NABARD Jhansi), Dr. A. Arunachalam, (Director ICAR-CAFRI) & Dr. Ashok Yadav (Scientist) monitored the strawberry field performance at Babina block of Jhansi.

Strawberry Production Technology



- On 12th February 2022, Shri Prabhdatta Sahoo (GM, NABARD Lucknow), Shri. Bhupesh Pal (AGM, NABARD, Jhansi), & Dr. Ashok Yadav (Scientist-Fruit Science) monitored the strawberry field performance at Babina block of Jhansi.



- On 27th March 2022, Dr G. R. Chintala (Chairman, NABARD) along with Shri S.K. Dora (CGM, NABARD), Shri Prabhdatta Sahoo (GM, NABARD Lucknow), Shri Raju Kumar Sharma (AGM, NABARD), Shri. Bhupesh Pal (AGM, NABARD Jhansi), Captain Saurabh Vikas, (P&SO, NABARD) monitored the performance of strawberry project funded by NABARD. Dr. A. Arunachalam, Director (ICAR-CAFRI) and Dr. Ashok Yadav (Scientist-Fruit Science) briefed about the project activities and results of strawberry project. The chairman appraised the strawberry project success and gave best wishes for future. He told that this cultivation of strawberry needs to be promoted to other farmers for better income and livelihood support. He assured that NABARD will continue its support to the project which meets the aspiration of people and rural development.



10

Participation in Krishi Mela

Strawberry farmers demonstrated and sold their strawberry in different programmes/ mega-events among the few are mentioned below:

- Pusa Krishi Mela, IARI, New Delhi
- Krishi Mela at Rajbhawan, Lucknow
- NABARD, Lucknow
- Krishi Mela, IGFRI, Jhansi
- Strawberry Festival, ICAR-CAFRI Jhansi



NABARD, Lucknow



Krishi Mela, IGFRI, Jhansi

Pusa Krishi Mela, IARI, New Delhi

11 Economic Analysis

Out of 25 farmers, 20 farmers in Babina and Moth block had resulted in better quality production, which fetch them higher returns compare to their agronomic crops. The price ranged from Rs. 100 to Rs 250 based on different grades of the fruits. The cost benefit analysis showed that a farmer earned approximately 3.03 lakhs from one acre land with low plant density. However, it shall increase i.e. up to 5.67 Lakhs, if recommended plant spacing is used.

Cost-benefit analysis of strawberry per 0.5 acre

List of input materials	Low plant density			Recommended plant density		
	Quantity	Rate	Total amount	Quantity	Rate	Total amount
Planting cost (with low density of 5500 nos @ 11.70)	5500	11.76	64680	11000	11.76	129360
Labour cost (field preparation, planting, weeding, spraying, harvesting packaging)	300	350	105000	600	350	210000
Fencing			15000			25000
FYM & Vermi-compost			20000			30000
Fertilizers & Micronutrient			10000			20000
Drip irrigation			30000			60000
Plant protection			10000			20000
Plant Growth Regulators			10000			20000
Packaging			15000			30000
Total cost			279680			544360
Yield (average yield of 25g with an average of 25 fruits)	4700	0.625	2937.5	10000	0.625	6250
Income (@ average price of Rs 150)			440625			937500
Net Benefit (in Rs)			160945			393140

12

Branding Strawberry and Release/Screening of Documentary Film of the Strawberry Project

Branding

The strawberry produced in the dry climate of Jhansi district had a very unique quality and large sized fruits with excellent aroma and flavor. Therefore, to get good market price and provide better reach in market we gave this strawberry a brand name i.e. Bundeli Strawberry”.



Documentary film

The success of Bundeli strawberry is documented in the form of short video film which includes the sequential steps right from the starting of the project. In this video, Honorable P.M. Shri Narendra Modi explain about the strawberry success by a young entrepreneur and assured to promote the strawberry cultivation in Jhansi district. Later on, ICAR-CAFRI Jhansi along with district administration, horticulture and agriculture department took challenge to promote strawberry cultivation with two projects which were financially supported by NABARD. This video shows about a views of all official from four departments who tool a challenge to promote strawberry in the farmer's field.To watch the video please visit the below link

<https://www.youtube.com/watch?v=URX8xj1hNsA>.



Screening of Documentary film

The documentary film of strawberry was released on the 8th May 2022 by DDG NRM on the Foundation Day of ICAR-Central Agroforestry Research Institute Jhansi. Later, on the eve of National Technology Day the Documentary Film on Bundeli Strawberry was also screened in the presence of Sh. Rabindra Kumar, District Magistrate, Jhansi, Sh. Shailesh Kumar, CDO-Jhansi, Dr. A. Arunachalam, Director, ICAR-CAFRI. Programme was conducted in hybrid mode where Sh. SK Dora, CGM NABARD; Sh. Raymond D'souza, DGM, NABARD; Mr. Bhupesh Pal, DDM, NABARD, Dr. Ashok Yadav, ICAR-CAFRI and other scientists from RLBCAU, technicals, research associates, students and progressive farmers also witnessed in the programme.





Annexures-I

List of farmer's and their details of Babina block of the Jhansi district

Name of the farmers	Village	Caste	Aadhar Card Number	Level of education
Gulab Singh	Badora	OBC	273458040286	Primary School
Shanti Lal Kevat	Badora	OBC	579271556286	Primary School
Kranti W/o Nabal	Badora	OBC	206117758385	Primary School
Atmaram Rajpoot	Badora	OBC	391204117562	High School
Pradip Rajpoot	Badora	OBC	221078926270	Middle school
Jyoti w/o Mahendra	Badora	OBC	306999836058	Primary School
Sheetal Prasad	Maheshgarh	OBC	750917036347	Primary School
Hargovind Rajpoot	Badora	OBC	896905197250	Middle school
Ramchran	Nahora	OBC	898686734753	Primary School
Neelesh Roy	Nahora	OBC	834254468071	High School
Gajadhar	Nahora	OBC	372285242520	Middle school
Pratap	Maheshgarh	OBC	811562382800	Middle school

List of farmer's and their details of Moth block of the Jhansi district

Mukesh Kumar	Sakin	GEN	686775323106	High School
Atbal Singh	Samthar	OBC	424704405884	Under Graduate
Surendra Pal Singh	Samthar	OBC	696099786385	Illiterate
Shukhveer Singh	Sakin	OBC	275546030949	Illiterate
Rajendra Prashad	Sakin	OBC	952681838894	High School
Samant Singh	Sakin	OBC	890303278057	Primary School
Ram Pratap Singh	Sakin	OBC	696099786465	Primary School
Harpal Singh	Sakin	OBC	629172794885	Primary School
Santram	Lohagarh	OBC	733334383086	Illiterate
Bhagwant Singh	Sakin	OBC	228378442326	Primary School
Anwar Khan	Lohagarh	SC	514842883870	High School
Avdhesh Pratap Singh	Sakin	OBC	340801076440	High School



Annexures-II

List of nursery/companies for strawberry plants

S.No.	Company/nursery	Address
1	Berries Biotech	Berries Biotech and Farms LLP, FL.104, Shri Venkatesh Shrushti, A Wing, S 56/1A/2, Wadgaon, Pune MH 411041
2	S.B. Agritech	1/187 A/P: Met Gutad, Tal: Mahabaleshwar, Dist: Satara. 412806 India. Phone: 09422404432, 09623689000, 08805867413. Email: info@sbagritech.com, agri.strawberry@gmail.com, sbagritech1999@gmail.com,
3	JDS Farms and Nursery	Near Toll Naka, Jetgad Survey No. :74 & 67/02 Kelod, Tehsil: Savner, Maharashtra 441112 India. Phone: 095030 38071, 089565 45838
4	Gunjan Strawberry	C/O M.L Sharma Urmil Mohan Cottage Surya Vihar, Rajgarh Road, Solan, Himachal Pradesh. Phone: 087006 24006
5	Rise n' Shine Biotech Pvt. Ltd	Dattaprabha Farms, Ganeshwadi, Theur, Haveli, Dist. Pune - 412 110, Maharashtra, India Mobile: 09767893564, 9011007307, 9767893566 Email : info@risenshine.in
6.	Laxmi Strawberry Farm	Anand Narayan Bhilare, House No.45, Patil Near Jila Parishad Prathmik School, Avakali, Mahabaleshwar, Maharashtra. 412806 Email: strawberryfarm99@gmail.com Phone: 09420628395
7	Vmr Enterprises	Mr. Vijay R Malusare Post Bhilar, Main road, Bhilar Panchgani, District Satara, Bhilar, Mahabaleshwar, Maharashtra, 412805, India

Strawberry Production Technology

8	Jain Irrigation System	Jain Plastic Park (JISL), P.O. Box 72, NH No.6, Bambhori, Jalgaon-425001., MH, India. Phone :1800 599 5000, +91 257 225 8011, E-Mail:customercare@jains.com
9	Kimya Biotech Pvt. Ltd.	903, Lloyds Chambers, Mangalwarpeth, Pune. 411011, Maharashtra (India) Phone / Fax : +91 2346 226475 Mobile : +91 9890226475, +91 9421763333
10.	Pushpender Thakur Apple & Strawberry Farm	Village -Thanadhar, post office-Bhuira, Tehsil, Rajgarh, Himachal Pradesh Phone: 08219129389
11	AKS Strawberries	Village Khaltoo, PO. Karganoo Tehsil Rajgarh, Distt.Sirmour (HP) 173101 Phone:+91-7807944444, 7807844444 Email: suryavanshi2111@gmail.com
12	Vedabhumi Agro Private Limited Delhi	Ved Prakash, Director RZ 418 B, Ground Floor Gali No 13, Tughlakabad Extension, South Delhi-110019, Mobile no: 7015027523, whatsapp: 86848888487 E-mail: ssanghi91@gmail.com
13.	KF Bioplants Pvt. Ltd.	Sr. No. 129/1-3C, Manjari (Bk), Taluka-Haveli, Dist: Pune. 412307. Maharashtra. India. Tel: +9120-26948400; 26948401; 26948402 Fax: +91 20-2694 8402 Web: www.kfbioplants.com

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