Production Technology for Banana

UNDER DRIP IRRIGATION

Jain Irrigation Systems Ltd.

Small Ideas. Big Revolutions.®

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Note: for more details and queries if any, please contact our technical service division at jisl@jains.com

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***Disclaimer :** The package of practices given in this booklet is based on limited experimental data and need not be applicable to all banana growing areas.Therefore, the Company does not guarantee the production levels mentioned in the booklet in every location where the package is adopted. The tissue culture banana plants are free from disease. However, disease incidence can take place after planting in the field. The company is not responsible for damage due to disease/ any loss incurred by the farmer due to negligence and weather or any other natural calamity. While every precaution is taken at the laboratory, green-house and shade house stage to check off-types, occurrence of few off-types is not unusual. They may be removed from the field as and observed. The Company is not responsible for the loss due to off-types.*

THE COMPANY

Jain Plastic Park, Jalgaon (India) - Drip, Sprinkler Irrigation Systems and Plastic Piping

There is more to Jain Irrigation than irrigation. Jain Irrigation Systems Ltd is a diversified entity with turnover in excess of 3000 crores. We have a PanIndia presence with 20 manufacturing bases spread over 5 continents. Our products are supplied to 110 countries with able assistance from 3000 Dealers and distributors worldwide.

We are the second largest MIS company in the world. The MIS Division manufactures the full range of precision-irrigation products; provides services from soil survey, engineering design to agronomic support; nurtures a sprawling 2000 acre HiTech Agri Institute; a Farm Resource R&D, Demo, Training & Extension Centre and undertakes turnkey projects for agricultural and irrigation development in totality. Over 1000 agri and irrigation scientists, Engineers, technologists and technicians are engaged in offering consultancy for a complete or partial project planning and implementation e.g Watershed Development through Wasteland Transformation, including crop selection and rotation.

Jain Irrigation is also the largest Plastic pipe manufacturer in India covering a wide range of pipes and fittings. We annually process over 200,000 MT of various polymers.

We extrude and injection mold PVC,PE,PP along with other engineering polymers like Polycarbonate, Polyamide, PBT,ABS etc. We are a 'Total Solution Provider ' for various thermoplastic Piping systems that are used in transportation / conveyance of fluids, semi-solids, gases and cables.

The Tissue Culture Division produces Grande Nain Banana plantlets at full capacity and has established a matching primary and secondary hardening facilities as well as independent R&D and virology labs. Similarly a modern Bio-tech lab equipped with latest equipements has been established to meet the needs of genetic improvement and validation programme in cultivars of onion, banana, mango and Jatropha.

We also processes tropical fruits into purees, concentrates, juices and IQF products. The Dehydration Facility dehydrates Onions & Vegetables. The Spray Drying Unit processes gooseberry and other fruit purees into powders. Agricultural and Fruit Processing waste is converted into Organic Manure. Plant-based pesticides are also formulated. Both are critical inputs for organic farming, a system we profess and practice.

Jain Irrigation is the only company in India which is not only a Pioneer manufacturer of hi-tech agricultural inputs but also a Total Agri-Service provider, houses R&D, Demo,Training and Extension Institute, is a large farm cultivator and an Agriculrural Consultancy organization. It is through such multi-dimensional activity profile that JISL has become a 'one-stop hi-tech agri shop'. The reward has been over a million satisfied farmers and scores of happy customers globally.

Our other businesses include PVC and Polycarbonate sheets.Solar Water Heaters and Solar Lighting etc where the emphasis is on the conservation of scarce natural resources like forest and energy. PVC sheets can replace wood as a substitute for building material and save our forests . Similarly Solar Water Heaters and Photovoltaic Lighting systems uses the abundant Solar Energy available for free & saves the natural sources of energy like coal which is used to produce electricity.

Our unflinching efforts in pursuit of excellence appropriately blended with ongoing Research and Development efforts have earned the company highest R&D awards of the country and numerous other awards and recognition for our performance in Exports, Fair Busniness Practices, Quality Excellence etc Our obsession with quality has enabled us to reach export turnover of 490 crores from our India operations. A lifetime commitment to introduce modern yet affordable and viable technologies in all our product offerings have compelled us to be creative and innovative.

1. Introduction

Banana (Musa sp.) is globally an important fruit crop. In India, it is known for its antiquity evidenced from its mention in the Ramayana (2020 BC), Kautilya's Arthashastra (300-400 BC) and it's depiction in paintings and sculptures of Ajanta and Ellora (600 BC).

2. Banana - A neutraceutical for Million health problems

If you want a quick fix for flagging energy levels, there's no better snack than a banana. Containing three natural and easily assimilable sugars - sucrose, fructose and glucose - combined with fiber, a banana gives an instant, tasty, sustained and substantial boost of energy. Research has proved that just two bananas provide enough energy for a strenuous 90-minute workout. No wonder, banana is the number one fruit with the world's leading athletes. Banana is full of sugar which gives a lot of energy to those practising sports/ requiring endurance. But, energy isn't the only way a banana can help us keep fit. It can also help overcome or prevent a substantial number of illnesses and health symptoms making it a must to add to your daily diet. Anemia: High in bio-available iron, bananas can stimulate the production of heamoglobin in the blood and so helps to eradicate anemia.

Blood Pressure:

This unique tropical fruit is extremely high in potassium, low in sodium making it the perfect food for helping to restore normal blood pressure. So much so, the US Food and Drug Administration (FDA) has just allowed the banana industry to make official claims for the fruit's ability to reduce the risk of high blood pressure and stroke.

Brain Power:

Batch of 200 students at a Twickenham (Middlesex) school were helped through their exams by eating bananas at breakfast and lunch in a bid to boost their brain power. Research has shown that the potassium-packed fruit can assist learning by making pupils more alert.

Constipation:

High in fiber, bananas in the diet can help restore normal bowel action, helping to overcome the problem without resorting to laxatives.

Depression:

According to a recent survey undertaken by MIND amongst people suffering from depression, many felt much better after eating a banana. This is because bananas contain tryptophan, an essential amino acid that the body converts into serotonin known to make you relax, improve your mood and generally make you feel happy.

Hangovers:

One of the quickest way of curing a hangover is to make a banana milkshake, sweetened with honey. The banana calms the stomach and, with the help of the honey, builds up depleted blood sugar level, while the milk soothes and rehydrates your system.

Chest-burn:

Bananas have a natural antacid effect in the body; so if you suffer from chest-burn, try eating a banana for soothing relief.

Morning Sickness:

Snacking on bananas between meals helps to keep blood sugar levels up and avoid morning sickness.

Mosquito bites:

Before reaching for the cream to antidote an insect bite, try rubbing the affected area with the inside of a banana skin. Many people find it amazingly successful in reducing swelling and irritation.

Nerves:

Bananas are high in B vitamins that help calm the nervous system. Overweight and pressure at work? Studies at the Institute of Psychology in Austria found pressure at work leads to gorging on comfort food like chocolate and crisps. Looking at 5,000 hospital patients, researchers found the most obese were more likely to be in high-pressure jobs. The report concluded that, to avoid panic-induced food cravings, we need to control our blood sugar levels by snacking on high carbohydrate foods such as bananas every two hours to keep levels steady.

Pre-Menstrual Syndrome:

Forget the pills, eat a banana. The vitamin B6 regulates blood glucose level, which can change your mood.

Ulcers:

Banana is used as the dietary food against intestinal disorders because of its soft texture and smoothness. It is the only raw fruit that can be eaten without distress in over-chronic ulcer cases. It also neutralizes over-acidity and reduces irritation by coating the lining of the digestive system.

Temperature control:

Many cultures see bananas as a 'cooling' Fruit that can lower both the physical and emotional temperature of expectant mothers. In Thailand, for example, pregnant women eat bananas to ensure their baby is born with a cool temperature.

Seasonal Affective Disorder (SAD):

Bananas can help SAD sufferers, because they contain the natural mood enhancer, tryptophan.

Smoking:

Bananas can also help people trying to give up smoking, as the high levels of Vitamin C, A, B6 and B12 they contain, as well as potassium and magnesium found in them, help the body recover from the effects of nicotine withdrawal.

Strokes:

Accoring to a research in 'The New England Journal of Medicine', eating bananas as part of a regular diet can cut the risk of death by strokes by as much as 40%.

Warts:

Those keen on natural alternatives, swear that if you want to kill off a wart, take a piece of banana skin and place it on the wart, with the yellow side out. Carefully hold the skin in place with a plaster or surgical tape!

It has been observed that banana really is a natural remedy for many complications. When you compare it with apple, it has four times the protein, twice the carbohydrates, three times the phosphorus, five times the vitamin A and iron, twice the other vitamins and minerals. It is also rich is potassium and is one of the best value foods around. So may be, its time to change that well-known phrase so that we say, **A Banana a day keeps the doctor away!** This is notified further by the nutrient composition of banana (Table 2).

Table 2: Nutrient composition of banana

Composition (%)	Ripe	Unripe
Moisture	60.6-79.8	60.4-72.4
Proteins	0.4-1.7	1.0-1.8
Reducing sugars	3.6-24.6	0.1-0.2
Non-reducing sugars	0.0-14.6	0.5-14.0
Other carbohydrates, fat etc.	0.1-16.4	24.5-36.7
Ash	0.7-1.6	0.9-1.3
Calorific Value	67-137 calories/100g	-

3. Status in the World

As it is the case for most tropical products, due to the special climatic conditions needed to grow bananas, they are mainly produced in developing countries. Around 98% of World production is grown in developing countries. Developed countries are the usual destination for the export of bananas. Table 3 shows the Top 10 countries of production, with consumption & export of banana.

Table 3: Banana Production, Consumption and export profiles of top ten countries

Sr. No.	Country	Production 000 tonnes	Per Capital Consumption/yr (kg)	Exports 000 tonnes
1.	India	16910	12.7	8.6
2.	Uganda	10506	222.8	1.6
3.	Ecuador	8036.8	90.6	4095
4.	Brazil	5744	29.9	72.5
5.	China	5393	4.0	4.6
6.	Philippines	5061	34.2	1600
7.	Colombia	4207	51.9	1711
8.	Indonesia	3600	15.5	2.1
9.	Costa Rica	2322	23.5	2113
10.	Cameroon	2250	90.1	138

(FAO 2001)

4. Status in India

Banana is globally important fruit crop with 97.5 million tonnes of production. In India, it supports livelihood of millions of people. In India, banana comes next to mango in rank occupying about 13% of the total area and accounting for 34.2% of a total production of fruits (45.5 million tonnes). Area-wise growth in banana cultivation and productivity per ha. during 1962-2001 is summarized in Table 4.

Table 4: Year-wise and area-wise growth of Banana Production in India

Year	Area (Lakh ha)	Increase (%)	Production (MT)	Increase (%)	Productivity Increase	
					(Tonnes/ha)	(%)
1962	2.00	-	2.6	-	13	-
1977	2.40	20	5.9	127	24.6	89
1987	3.00	50	8.9	242	29.7	128
1993	4.30	115	11.9	357	27.7	113
1997	4.40	120	13.33	413	30.3	133
2001	4.90	141	16.91	546	33.5	164

Table 5: State-wise Area, Production & Productivity in India (2001-2002)

No.	State	Area (MnHa)	Production (MT)	Productivity (MT/Ha)
01.	Tamilnadu	0.11	6.12	53.6
02.	Maharashtra	0.08	4.96	62.0
03.	Gujarat	0.06	3.16	54.8
04.	Andhra Pradesh	0.08	2.25	30.0
05.	Karnataka	0.06	1.51	25.3
06.	Bihar	0.03	1.33	43.6
07.	West Bengal	0.04	0.89	23.9
08.	Madhya Pradesh	0.02	0.79	51.9
09.	Assam	0.04	0.61	13.8
10.	Kerala	0.06	0.49	08.0
12.	Others	0.07	1.09	15.2
Total :		**0.65**	**23.20**	**35.00**

It is obvious from Table 5 that Tamilnadu leads other states with 19.86% of area and 31.5% of total production, whereas Maharashtra has highest productivity of 62 tonnes / ha. against India's average of 35 MT/ha.

5. IDEAL FACTORS FOR PRODUCTION

5.1 Agro-climate

Banana is basically a tropical crop, grows well in temperature range of 13°C – 38°C with RH regime of 75-85%. In India, this crop is being cultivated in climate ranging from humid tropical to dry mild subtropics through selection of appropriate varieties like Grandnain. Chilling injury occurs at temperature below 12°C. The normal growth of the banana begins at 18°C, reaches optimum at 27°C, then declines and comes to a halt at 38°C. Higher temperature causes sun scorching. In the areas where the temperature is 5 to 7ºC during winter, the cultivation should be done in such a way that it does not coincide with flowering time. High velocity wind which exceeds 80 KPH, damages the crop.

5.2 Soil

Soil for banana should have good drainage, adequate fertility and moisture. Deep, rich loamy soil with pH between 6.0-7.5 is most preferred for banana cultivation. Ill-drained, poorly aerated and nutritionally deficient soils are not suitable for banana. Saline, sodic and calcarious soils are not suitable for Banana cultivation. EC of Soil should not exceed 1.0 dS/m. Avoid soil of low lying areas, very sandy & heavy black cotton with poor soil drainage. A soil that is not too acidic, nor too alkaline, rich in organic matter with high nitrogen content, adequate phosphorus level and plenty of potash is good for banana.

5.3 Varieties

In India, banana is grown under diverse conditions and production systems. Selection of varieties, therefore, is based on a large number of varieties catering to various kinds of needs and situations. about 20 commercial cultivars viz. Dwarf Cavendish, Robusta, Monthan, Poovan, Nendran, Red banana, Nyali, Safed Velchi, Basrai, Ardhapuri, Rasthali, Karpuravalli, Kanthali, Grand Nain etc. are being cultivated.

Before Producing Tissue Culture banana Plantlets, JISL Decided that it shoud produce bananas, which will give more production in less time, which are suitable for export and has demand in the world market. With this objective during 1992 Cvs Grand Nain, William robasta and Zeleig,were introduced and for the first time researched extensively in comparison with other varieties at extensive at JISL and finally Grand Nain was selected. Grand Nain conduct gaining popularity now may soon be the most preferred variety due to its tolerance to abiotic stresses and good quality bunches. Bunches have well spaced hands, with straight fingers, bigger in size. Fruit develops

attractive uniform yellow colour while ripening, with better shelf-life & quality than other varieties.

5.4 Land Preparation

Banana roots are very delicate and fleshy. The main roots render support to the plant and secondary fibrous roots absorb water and nutritent elements. Main roots of the banana go as deep as 120 cm in the soil and spread 150 cm side ways. But the efficient roots are active in the upper 30 cms. Therefore, the land is to be ploughed deep 2-4 times, levelled and bigger lumps of earth should be made absolutely soft by using the rotavator /harrow. Land with less organic carbon and where the water retention is less, one must sow dhaincha (Sesbania aculeata) and after 45 days, dhaincha should be ploughed in-situ. During soil preparation, basal dose of FYM is added and thoroughly mixed into the soil.

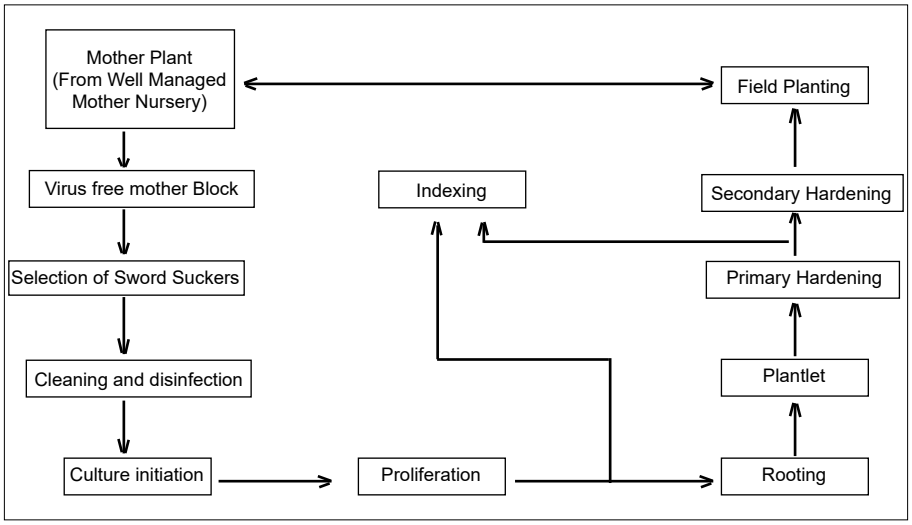
A pit size of 45 cm x 45 cm x 45 cm is normally required. The pits are to be refilled with top soil, mixed with 10 kg of FYM (well decomposed), 250 gm of neem seed cake . Prepared pits are left open for 15-20 days for weathering to kill all the insects, soil-borne diseases and aeration before refilling. In saline & alkaline soil where pH is above 8, pit mixture is to be modified incorporating organic matter and gypsum. Organic matter and pyrite in saline soil improve the soil quality. Instead of pit, you can plant in furrow, at required spacing and planting should be done 5.0-7.5 cm deep.

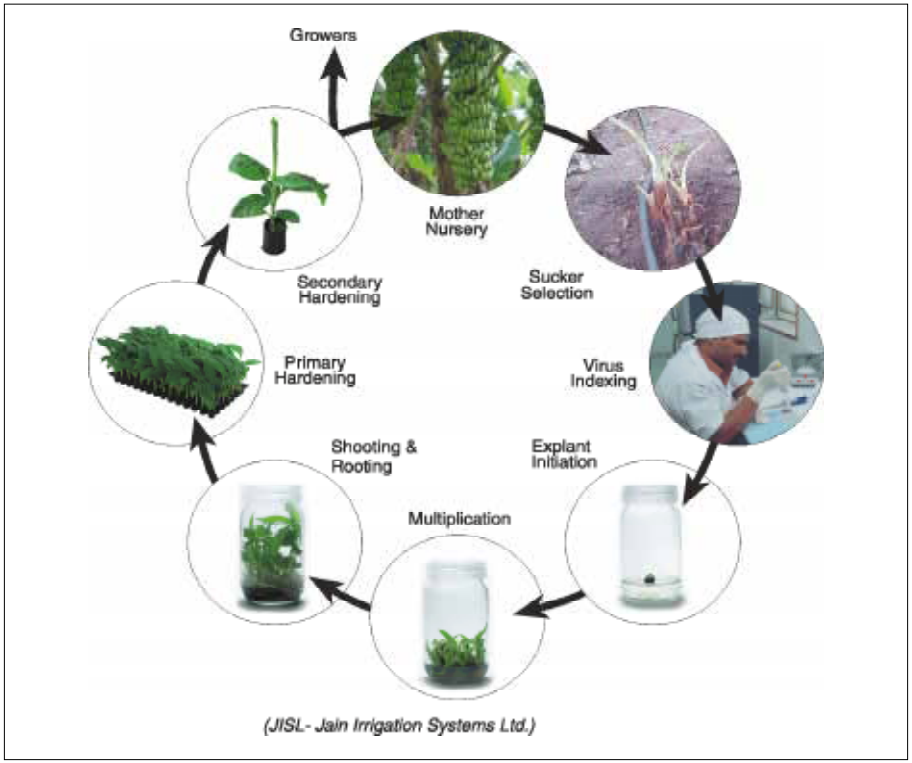
5.5 Planting Material:

Sword suckers weighing approximately 500-700 gm are commonly used as propagating material. Suckers may be infected with some pathogens and nematodes. Similarly, due to variation in age and size of suckers, crop may not be uniform, harvesting is prolonged and farm management becomes difficult.

Therefore, tissue culture plants are recommended for planting. They are healthy, disease-free, uniform and properly hardened for planting in the field. (Fig.2).

5.5.1 PROCESS OF PRODUCING TISSUE CULTURE PLANTLETS:





(JISL- Jain Irrigation Systems Ltd.)

5.5.2 Points to be considered while selecting tissue culture plants :

a) Plants should be 25-30 cm tall with a minimum of 4-5 green leaves, having conical stem with firm anchorage and should have completed 3 months hardening. Now a days, root trainers are successfully used for banana hardening as it helps white roots development for maximising the yield.

What is Root trainer ?

Root trainers are the plant containers which train the roots downward and strangest and encourage development of abundant white-roots.

Advantages of root trainers:

i) Plant forms very good root ball.

ii) It avoids entangling of roots.

iii) Better survival and growth of the plant by avoiding severing of roots during transplantation.

iv) Avoids distortion of roots system, poor lateral root formation, root coiling and bending of the tap root.

v) Promotes vigourous growth, withstand heavy wind and develops tolerance to drought.

vi) Maintenance, handling and field planting is much easier.

vii) Can sustain for few more days than polybag seedlings between delivery and transplanting in the field.

vii) They have white roots for better yield.

b) Randomly, plants should be checked for the quantum of roots produced by a healthy plant.

c) Plant roots should also be randomly checked for the presence of nematodes with symptoms like streaks, lesions and dead roots.

d) Leaves should be normal, elliptical, with a broad tapering at the distal end.

5.5.3 Comparison of Tissue Culture Banana plants and Sucker Raised Plants.

Sr.	Tissue Culture Banana plantlets	Sr.	Suckers raised plantlets
1.	The saplings are of the same age and uniform height.	1.	Not neassary that all the suckers are not of the same age and height.
2.	Saplings are healthy, pest and disease-free.	2.	Chances of rhizomes being not healthy and having disease and pests are more.
3.	The True to type of multiplied mother plant.	3.	Characteristics cannot be assured.
4.	Plantlets are from high yieldding of mother Plants.	4.	Suckers are not diferrent, plants hence there is no surety of higher production.
5.	Bananas are ready for harvesting in 11-12 months from planting is assured.	5.	Crop is ready for harvesting in 15- 16 months from planting.
6.	Growth of the plant is uniform.	6.	Growth of the plant is not uniform
7.	Due to reduced duration of the crop, expenses on water, labour and agri managment are reduced.	7.	Longer duration of the crop increases expenses on water, labour and agri care.
8.	In 28-30 months, a main crop and two ratoon crops ie. three crops can be harvested.	8.	In 30-32 months, a main crop and a ratoon crop i.e. only two crops can be harvested.
9.	harvesting uniform	9.	Staggered harvesting due to uniform maturity.
10.	Almost 90-95% of plants bear bunches uniformly.	10.	No uniformity in bearing of buhches.
11.	More yield and more profit.	11.	Less yield hence less profit.

Table 6: Merits of Tissue Culture plantlets vis-a-vis sucker raised.

5.6 Planting:

Pits which are already made, are to be refilled 15 days before planting, regardless of the Planting Season (Table 7).

Table 7: A bird's eye-view of planting, flowering & harvest season

Sr.	Season	Time of Planting	Time of Flowering	Time of Harvest
1.	Mrug Bag	Jun-July	Jan-Mar	Apr-Jun
2.	Kande Bag	Oct-Nov	May-Jul	Aug-Oct
3.	Ram Bag	Mar-Apr	Oct-Dec	Jan-Mar

Best time for planting is at or just before beginning of the rainy season (Jun-Jul). Planting season in other period of year is Oct-Nov. But with the adoption of micro irrigation and tissue culture plants, planting is possible round the year. However, in areas with low winter temperature planting time should be adjusted to avoid flowering during cold temperature. Thus, planting season should be so chosen to avoid any environmental interference to the normal growth of the plant, especially during 5th to 7th month.

5.6.1 Crop Geometry:

Fig.3. Crop Geometry var. Grand Nain

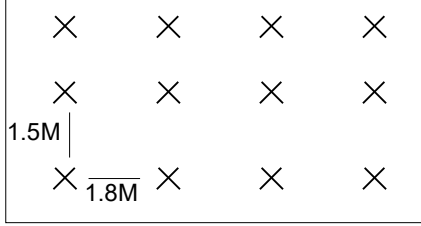


Fig.4. Plantation view 5.6.2

Traditionally, banana growers plant the crop at 1.5 m x 1.5 m with high density. leading to poor plant growth and yields are poor because of competition for sunlight and nutrition. Various trials were conducted at Jain Irrigation System's R&D farm with Grand Nain. Based on optimal production, suitable spacing of 1.8 m x 1.5 m is being recommended. It accommodates 1452 plants per acre (3630 plants per hectare), keeping row direction North-South with wide spacing 1.8 m between the rows. The regions like North India, coastal belt and where humidity is very high and temperature falls down to 5-7ºC, the planting distance should not be less than 2.1 m x 1.5 m.

5.6.2 Planting Method:

Polybag is separated from the plant without disturbing the rootball of the plant and then plants are planted in the pits, keeping pseudostem 2 cm below the ground level. Soil around the plant is gently pressed. Deep planting should be avoided (Fig.4).

Precautions:

A day before planting of the sapling, Drip Irrigation system should be kept on to wet the soil and when humid environment is created, the saplings be planted following the procedure given below:

1. First, you must hold the sapling bag in hand and press the loose soil around the root ball to ensure that it does not break.
2. Thereafter, keep the sapling along with the bag on left hand palm and cut the bag lengthwise on both sides. Remove the bag.
3. Place the ball of sapling in the furrow or in the pit and around sapling, spread 10 grams of Phorate.
4. If the climate is not hot, put a basal dose of Super Phosphate, Potash and 'Neemcake'.
5. Around the sapling, apply organic manure (compost) soil and press the soil in such a way that there is no air space around the roots.
6. Immediately, irrigate the soil by Drip Irrigation system and keep the soil wet and moist at it's field capcity.
7. After planting the sapling, to guard against Erwinea Rot disease, every week about 100 ml solution (Prepared with 600 g of copper oxychloride and 300 g streptocycline in 200 l of water) per sapling should be applied.

5.7 Water Management:

Banana is water loving plant, requires large quantity of water for maximum productivity.

However, banana roots are poor in absorbing water. Therefore, under Indian condition, banana production should be supported by an efficient irrigation system like drip irrigation.

Water requirement of banana has been worked out to be 2000 mm per annum. Drip irrigation and mulching have been reported to improve water use efficiency - resulting in saving of 56% water and increasing yield by 23-32% under drip.

Irrigate the plants immediately after planting to maintain field capacity. Excess irrigation will lead to root zone congestion due to removal of air from soil pores, thereby affecting plant establishment and growth. Hence, drip method is a must for proper water management in Banana. The reasons are:

1. Tissue culture banana sapling has small roots and lesser area for sprouting of roots. But near the rhizome, there is a large rooting area.
2. Tissue culture sapling does not have any storage of nutrients but in the rhizomes, there is a storage of nutrients.
3. For be above reason, after saplings are planted, it is necessary to supply nutrients through drip irrigation.
4. The sucker develops the roots first and then the leaves. In case of tissue culture saplings, initially 4-5 efficient leaves appear after the sapling is planted, the roots stabilise. If balanced water supply is not there at this time, the roots rot and saplings may die.
5. Tissue culture banana plants should not be given flood irrigation, as it makes the land wet instead of creating humid state and does not allow the roots to get fresh air. As a result, the roots do not get balanced air, nutrients, land and water. leading to deficient in nutrients.
6. In Drip Irrigation, water is supplied in the root zone of plant. As a result, the salts in the field remain out of the root zone.

5.7.1 What is Drip Irrigation ?

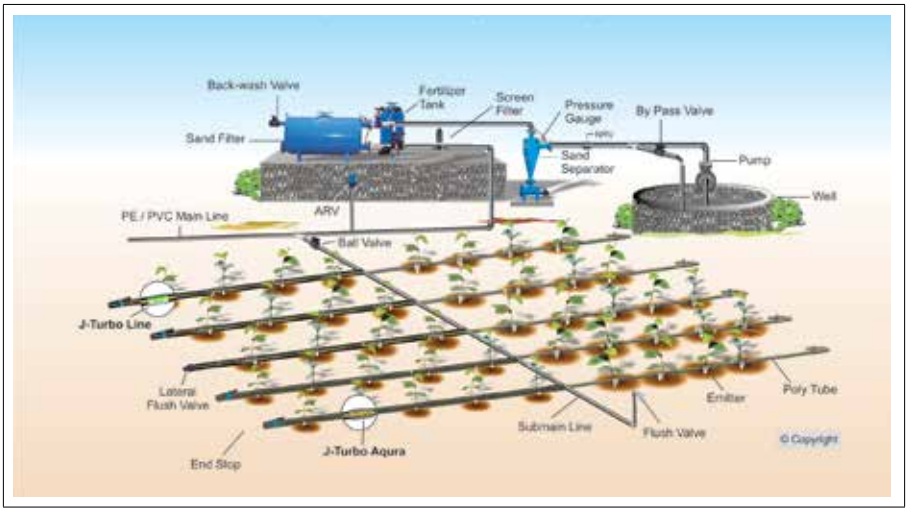
Drip irrigation or micro irrigation is described as regulated and slow application of irrigation water through emitters devices at frequent intervals near the root zone of plants, over a longer period.

5.7.2 Principle:

Drip irrigation is the term used to describe the method of irrigation in which:

- Water is applied directly to the root zone at a low rate drop by drop.
- Water is applied over a longer period of time at frequent intervals.
- Water is applied through a low pressure piping network.

A typical diagramatic representation of Drip irrigation system is shown in Fig. 5.



Fertilizers can also be applied through drip system, thereby making it sure that water and nutrients, the two important inputs for agricultural production, are given in controlled manner and exactly near the root zone of plants at frequent intervals through emitting devices through a network of PVC mains, filtration units, control valves, PVC submains and LLDPE laterals. Water and nutrients enter the soil and move into the root zone through the combined forces of gravity and capillary action.

5.7.3 Advantages of Jain Drip Irrigation Systems:

Jain Drip Systems are designed to provide greater operational ease, higher functional efficiency and minimum maintenance. Following are the major advantages, which justify the faith of lakhs of farmers in the country in Jain Drip Irrigation System.

i) **Water Saving:** Water saving upto 70% is observed in various crops as seepage, percolation, evaporation and conveyance losses are minimised.

ii) **Provision for application of fertilizers and other plant protection chemicals along with water through the system:** Jain Drip Systems comprise of an injection assembly device to enable application of soluble fertilizers and systemic plant protection chemicals along with water, through the drip system.

iii) **Savings in Weed Control:** Water is applied directly in the root zone, wetting only a small portion of the soil. Interspaces between the plants and between the rows of plants are not wetted beyond the root zone. This deprives water and

nutrients to the weeds outside root zone and the weed growth is under control, resulting in saving of water and nutrients as well as cost of weeding.

iv) **Improved disease control:** Disease control is enhanced with drip irrigation systems, as the soil moisture and chemical additive levels can be closely controlled. In addition, spread of pathogens through surface water runoff is eliminated.

v) **Ideally suited for difficult terrains and problematic soils & water:** Vast areas of land with difficult terrains and waste lands can be brought under productive cultivation as they can be easily irrigated without costly land levelling and removal of productive top soil. Drip Irrigation Systems can be used in saline or alkaline soils and even with poor quality of water.

vi) **Increased Yields:** The system facilitates water application at a regular interval, thereby maintaining optimum moisture level in the root zone for a longer period, thus preventing moisture stress or shock associated with other methods of irrigation. This promotes optimum plant performance, resulting in higher yield and better quality produce.

Almost all crops have responded well to drip irrigation and yield increase upto 100% has been reported. Besides this, early maturity has also been reported.

The yield of Banana under drip irrigation was 87.5 t/ha and that under conventional flood system was 57.5 t/ha. Initial experiments with conventional spacings at Jain R&D farm and in farmers' field under different methods of irrigation system showed a significant saving in water as well as yield increase by 30-35%. These R&D trials in late 90's have served as an eye opener to banana growers.

5.7.4 Water requirement and irrigation scheduling:

Water requirement of Banana plant depends upon the local conditions such as soil type, planting season, growth stage, evapo-transpiration, etc. Hence, it is necessary that the water requirement be calculated for specific areas based on the above variables.

Table 8 provides water requirement and irrigation scheduling for Banana in Jalgaon region. Similar details can be worked out for other regions.

Table 8: Water requirement in litres/ plant/ day (lpd) for Jalgaon region

Month (Mrug Baug)	Qty. (lpd)	Month (Kande Baug)	Qty. (lpd)
June (Planting)	06	October (Planting)	04-06
July	05	November	04
August	06	December	04
September	08	January	06
October	10-12	February	08-10
November	10	March	10-12
December	10	April	16-18
January	10	May	18-20
February	12	June	12
March	16-18	July	12
April	20-22	August	14
May	25-30	September	14-16

5.8 Nutrient Management:

Banana requires high amount of nutrients, which are often supplied only in part by the soil. Nutrient requirement has been worked out for indian soils. It is 20 kg FYM, 200 gm N; 60-70 gm P and 300 gm K/plant.

Banana crop moves 7-8 kg N, 0.7-1.5 kg P and 17-20 kg K per metric tonne of yield and responds well to application of nutrients. Different stages of growth need the nutrients in varied quantity.

1. **Initial two months:** In this stage, large amount of phosphorus, moderate quantity of Nitrogen and Potash are required.
2. **Main Growth Stage (3-5 months):** In this stage, large quantity of nitrogen and medium quantity of phosphorus and potash are required.
3. **Flowering and Fruiting (6-10 months):** In this stage, lesser level of nitrogen and large level of potash are necessary.

Nutrient deficiency is rapidly reflected as the following symptoms mentioned in Table 9.

Table 9: Leaf symptoms reflecting specific nutrient deficiency

Sr. No.	Nutrient	Leaf indicating	Symptoms on the leaf symptoms	Other symptoms
1.	Nitrogen	Leaves of all ages	Leaves become pale yellow together.	Midrib of leaf gets reddish, veins of leaf bend.
2.	Phosphorus	On old leaves	Margin of leaf looks like teeth of a saw.	Midrib of leaf breaks, new leaves look dark green.
3.	Potash	On old leaves	Edges of leaf develop brown & yellow lines and get burnt.	Leaves fall off, tip of the leaf gets dried and if looks like a beak of a parrot.
4.	Calcium	On new leaf	Edges of leaf get burnt.	Thickening of veins of the leaves and burning on the outer edges.
5.	Magnesium	On old leaves	Center portion of the leaf becomes yellow and edges turn green.	Unlimited chlorosis occurs.
6.	Sulphur	On new leaf	Leaves alongwith main vein turn pale green/	Secondary veins thicken.
7.	Boron	On new leaf	Yellow lines are seen in the veins.	Leaves get twisted.
8.	Zinc	On new leaf	Yellow lines parallel to the veins appear.	Back side of the new leaf gets pink.
9.	Iron	On new leaf	New leaves get yellow or fully white.	
10.	Manganese	On old leaves	The leaf looks soiled, yellow-green.	
11.	Copper	On new leaf	Main vein of the leaf appears bent on lower side.	

Remaining micro-nutrients do not seem to exprees any special symptom on banana crop.

5.8.1 Schedule of application:

The fertilizer application schedule for tissue culture banana var. Grand Nain, both in solid and water soluble form, is given in Table 10.

5.8.1.1 Solid fertilizer schedule for Grand Nain Banana

Total nutrient requirement per plant:

N - 200 gm	P - 60-70 gm	K - 300 gm

Total quantity of fertilizers required per plant acre (Spacing 1.8 x 1.5 m; 1452 plants)

Urea (N)	SSP (P)	MOP (K)
431gm	375gm	500 gm/plant
625kg	545kg	726 kg/acre

*Table 10: Schedule of solid fertilizer application**

Application : Days after planting	Fertilizer	Quantity (gm/plant)
At the time of planting	S.S.P.* M.O.P.**	100 50
10 30	Urea Urea S.S.P. M.O.P. Micronutrient $MgSO_4$ Sulphur	25 25 100 50 25 25 10
60	Urea S.S.P. M.O.P.	50 100 50
90	Urea S.S.P. M.O.P. Micronutrient Sulphur $MgSO_4$	65 100 50 25 30 25
120	Urea M.O.P.	65 50
150	Urea M.O.P.	65 100
180	Urea M.O.P.	30 60
210	Urea M.O.P.	30 60
240	Urea M.O.P.	30 60
270	Urea M.O.P.	30 60
300	Urea M.O.P.	30 60

* Schedule is indicative only and may change according to planting season and soil fertility status (results of soil analysis).

***SSP** = single super phosphate, ****MOP** = muriate of potash*

5.8.2 Fertigation:

Fig 6: Fertigation in Banana

Traditionally, farmers use more urea, less phosphorus and less potash. In order to minimize loss of nutrients from conventional fertilizers i.e. loss of N through leaching and volatilization and loss of P and K by fixation in the soil, application of water soluble or liquid fertilizers through drip irrigation (fertigation-Fig. 6) is encouraged. A 25-30% increase in yield has been observed by fertigation. Moreover, it saves labour and time. Besides, uniform distribution of nutrients.

Advantages:

- Ensures regular flow of both water and nutrients, resulting in increased growth rates and higher yields. Increase in the yield by more than 50% could be achieved with appropriate fertigation schedule.
- Offers greater versatility in the timing of the nutrient application to meet specific demands at each growth stage. Fertilizers can be applied at predetermined times according to the developmental and physiological stage of the crop. It should be noted that application of fertilizer in split doses results in pronounced increase in the plant nutrients uptake.

- Improves availability of nutrients and their uptake by the plants. The irrigation system is designed to supply both water and nutrients directly to the roots, creating a wet zone at the site of the greatest root activity.
- Safer application method as it eliminates the danger of burning the plant's root system, since the fertilizer is applied in very low concentration.
- Improves efficiency as small quantities of fertilizers are applied at frequent intervals and according to different stages of crop growth. This results in substantial (30 to 50%) savings in quantity of fertilizers.
- Combining liquid fertilizers with insecticides and herbicides, saves labour and machinery for their separate application.
- Allows crops to be grown on marginal lands, such as sandy or rocky soils, where accurate control of water and fertilizers in the plant's root zone is critical.
- Ensures uniform nutrient application.
- Minimizes pollution of soil.

5.8.2.2 Water soluble solid fertilizers:

*Table 11: Schedule of water soluble fertilizer application**

Application Days after planting	Fertilizer Grade (NPK)	Qty.(kg) per 1000 plants every 4th day basis	Total Qty. (kg)
After planting upto 65 days	Urea	4.13	82.60
	12:61:00	3.00	60.00
	00:00:50	5.00	100.00
65 to 135 days	Urea	6.00	120.00
	12:61:00	2.00	40.00
	00:00:50	5.00	100.00
135 to 165 days	Urea	6.50	65.00
	00:00:50	6.00	60.00
165 to 315 days	Urea	3.00	150.00
	00:00:60	6.00	300.00

** Schedule is suggestive only and may change according to planting season and soil fertility status (based on soil analysis).*

5.8.3 Fertigation Equipment:

Ventury injector, fertilizer tank and fertigation pump (Fig. 7 a, b) are used for fertigation.

5.8.3.1 Ventury Injector:

Fig. 7a Ventury Injector

This system of injection works on the principle of ventury. Vacuum is created by diverting a percentage of water flow from the main pipe line through a constriction or ventury, which increases the velocity of flow, thus creating a drop in pressure.The vacuum thus created can be used to initiate suction of fertilizer/chemical solutions from a tank through a suction pipe (Fig. 7a).

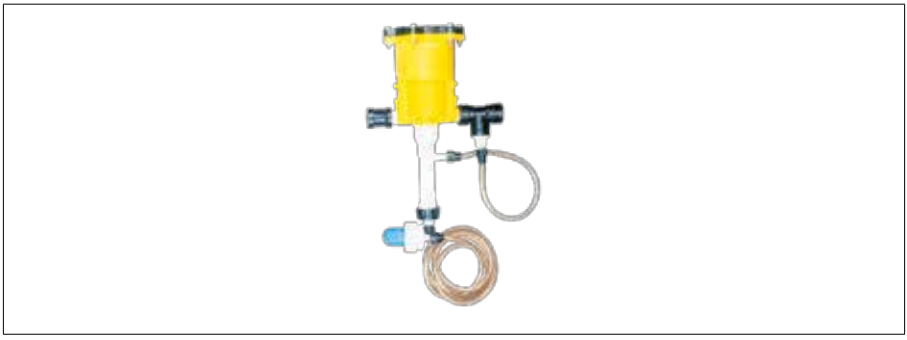
The Ventury Injector suits best the fertigation requirements of small farms as it is very economical and easy to operate. However, use of ventury leads to higher pressure loss in the system, which may result in uneven water & fertilizer distribution in the field. The suction rate of ventury is 30 to 120 lit. per hour.

5.8.3.2 Fertilizer Tank (Flow by-pass system)

Fig. 7b. Fertilizer Tank

In this system, part of irrigation water is diverted from the main line into a tank containing fertilizer/chemical solution. The water thus diverted, passes through the tank and carries along with it the fertilizer/ chemical solution and returns to the main line through the outlet connection. A valve is installed across the inlet and outlet of the fertilizer tank for creating pressure difference for diverting the water from the main line into the tank. As the process continues, concentration of the solution in the tank reduces progressively. These Fertilizer Tanks are used for large irrigation systems and/or for crops which need bulk application of fertilizers. However, with this sytem, the concentration of the fertilizer entering the irrigation water changes continuously with the time and with very high concentration at the beginning . As a result, uniformity of ferilizer distribution can be a problem. Fertilizer tanks are available in 90,120, 160 litres capacity.

5.8.3.3 Fertilizer Injector Pump (Fertigation Pump)



These are piston or diphragm pumps, which are driven by the water pressure of the irrigation system. The injection rate is proportional to the flow of water in the system. A high degree of control over the fertilizer injection rate is possible without much pressure loss. The initial cost of these injector pumps will be higher, but are suitable for accurate and controlled application of fertilizers/chemicals. Suction rate of pumps varies from 40 to 160 l / hr.

5.9 Interculture Operations:

Root system of banana is superficial and easily damaged by cultivation of intercrop. Use of intercrop, therefore, is not desirable. However, short durational crops (45-60 days) like moong, cow pea, dhaincha are to be considered as green manure cover crops. Crops from cucurbitaceae family should be strictly avoided as they carry viruses.

5.9.1 Weeding:

Spraying of Glyphosate before planting at the rate of 2 l /ha is carried out to keep the plantation weed-free. One or two manual weedings are necessary.

5.9.2 Micronutrient Foliar Spray:

Combined foliar application of $ZnSO_4$ (0.5%), $FeSO_4$ (0.2%), $CuSO_4$ (0.2%) and H_3BO_3 (0.1%) can be adopted to improve vigour and yield of banana. The micronutrient spray solution is prepared by dissolving the following ingredients in 100 l. of water.

Zinc sulphate	-	500 gm
Ferrous sulphate	-	200 gm
Copper sulphate	-	200 gm
Boric acid	-	100 gm

For every 10 l of mixture, 5-10 ml of sticker solution such as Teepol should be added before spraying.

The spraying can be taken up in 3rd, 5th and 7th month of planting.

5.10 Special Operations:

These operations are specific to banana crop, which influence productivity and quality.

5.10. 1 Desuckering :

Removal of unwanted suckers is a critical operation in banana for reducing internal competition of nutrients with mother plant. Desuckering should be done regularly until shooting. However, in areas where ratoon is also taken for second crop, a follower is allowed after the inflorescence has appeared. This should be managed in such a way that planting space is not disturbed. Follower should be on the opposite side of the inflorescence. It should not be far from the main plant.

5.10.2 Deflowering:

It consists of removal of the withered style and perianth. This is generally not practised. Therefore, they remain attached to fruit bunch & then removed after harvesting, which are damaging to fruits. It is, therefore, suggested to remove them just after flowering.

5.10.3 Pruning of leaves:

Rubbing leaves damages the fruit. Therefore, such leaves should also be pruned during regular check. Older and infected leaves also be pruned as required. Green leaves should not be removed.

5.10.4 Earthingup:

Keep the soil loosend by harrowing from time to time. Earthingup should be done 3-4 months after planting, raising the soil level around the base of the plant by 10-12". It is better to prepare a raised bed and keep the drip line on bed 2"-3" away from the plant. It also helps to protect plants from wind damage and production losses to some extent.

5.10.5 Removal of male buds (Denavelling):

Removal of male buds help fruit development and increases bunch weight. Male buds are removed with last 1-2 small hands, with clean cut, keeping a single finger in the last hand.

5.10.6 Bunch Spray:

Spray of monocrotophos (0.2%) after emergence of all hands takes care of thrips. Its attack discolours the fruit skin and makes it unattractive.

5.10.7 Bunch covering:

Fig. 8: Bunch Sleeving

Covering bunch using dried leaves of the plant, is economical and prevents bunch from direct exposure to sunlight. Bunch cover enhances quality of fruit. But in rainy season, this practice should be avoided.

Sleeving of bunch is done to protect fruits against dust, spray residue, insects and birds. For this purpose, blue plastic sleeves are preferred. This also increases temperature around the developing bunch and helps in early maturity (Fig. 8).

5.10.8 Dehanding of false hands of bunch:

In a bunch, there are some incomplete hands, which are not fit for quality produce. These hands should be removed soon after observation. This helps in improving the weight of the other hands. Sometimes, the hand just above the false hand is also removed.

5.10.9 Propping:

Plants having heavy bunches, propped with the help of two bamboos forming a triangle by placing them against the stems on leaning side (Fig. 9). This also helps in uniform development of bunch.

5.10.10 Wind break

Fig. 10: Dhaincha raised to serve as wind break

For wind break, Dhaincha, savari can be raised (Fig. 10) all along the border, especially in East-West Direction of field to avoid heavy & hot wind damage.

5.11 Pest and disease management:

A large number of viral, bacterial and fungal diseases, insect pests and nematodes infest banana crop and reduce production, productivity and quality. Summary details of major pests and diseases of banana alongwith control measures are given in Table

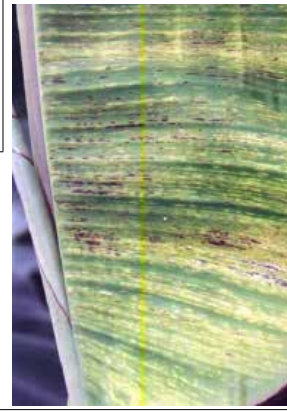
Table 12: Major pests / diseases of banana

S.N.	Name	Symptoms	Control measures
Pest			
i)	Rhizome weevil (Cosmopolites sordidus) 	a) Larvae creates network of gallaries in rhizome and weakens the plant.	a) Use healthy planting material. b) Sanitation in orchard be upgraded. c) Trapping of adult weevils using pseudostem or rhizome pieces. d) Soil application of Phorate @ 10 gm/plant.
ii)	Pseudostem weevil (Odoiporus longicollis)	a) Small holes on pseudostem with exudation of transparent gummy substance.	a) Management approach is identical to that of rhizome weevil.
		b) Existence of tunneling in leaf sheath and inner core of the stem.	b) Secondly, injection of lime solution (Monocrotophos 150 ml in 350 ml water) using stem injector 4 ft. above the ground level at 30o angle is recommended.
		c) Abortion of bunches.	c) Use longitudinal split (30 cm length) or disc on stump traps @ 100/ha. Keep the split portion of tray facing

iii)	Thrips (Chaetana phothrips signipennis, & Heliaothrips kodaliphillus)	a) They feed on plant organs and render them brown and discoloured, especially the fruits.	a) Spray or inject metasystox @ 0.05% acephate (0.1%) chloropyriphos (0.03%) on the inflorescence before the unfurling of topmost bract. 
iv)	Fruit scarring beetle (Besilepta subcostatum) 	a) Adults feed on tender unfolded leaves / fruits and cause scarring of skin. b) Plant loses its vigour and quality of bunch is poor.	a) Sanitation and spray 0.05%, monocrotophos or carbaryl 0.1% on the heart of the plants immediately after the emergence of new foliage and during fruiting season is recommended.
v)	Aphids (Pentalonia nigronervosa)	a) They are vectors of banana bunchy top virus (BBTV) and can be seen as congregation under the leaf base of pseudostem.	a) Spray of 0.1% monocrotophos or 0.1 % dinemethote on the leaves is effective.
vi)	Nematodes 	a) Stunted growth. b) Small leaves. c) Cut roots. d) Purple black lesions on roots and their splitting. e) Infected plant topples over easily during wet and windy weather. 	a) Apply phorate @ 10 gm per plant at planting time & 4 months after planting. b) Use neem cake as organic manure. c) Use marigold as trap crop. 

Fungal diseases			
vii)	Panama wilt (Fusarium	a) Yellowing of old leaves progressing. towards	a) Cultivation of resistant cultivars (Cavendish group)
		b) Affected leaves collapse near petiole and hand.	b) Trim and treat the suckers in 0.1% Bavistin before planting.
		c) Pseudostem splitting is common.	c) Apply bio-agents like Trichoderma viride and Pseudomonas. fluorescence with organic manure.
		d) Reddish brown discolouration in cross-section of root & rhizome. 	d) Keep good drainage and apply lot of organic manure in the field. 
viii)	Head rot (Erwinia carotovora)	a) Rotting of collar region and epinasty of leaves.	a) Use healthy planting material.
		b) On pulling out, the affected plant topples from the collar plant topples from the collar root in soil.	b) Drench plants with 0.1% Emisan, followed by another drenching after 3 months.
		c) On opening up of collar region of affected plants, yellowish to reddish ooze can be seen.	c) Avoid planting in rocky and poorly drained soils.
		d) In early stage of infection, dark brown or yellow, water soaked areas in cortical region seen, which may decay to form cavities surrounded by dark spongy tissues. 	

ix)	Sigatoka leaf spot (Mycosphaerella sp.) 	a) It is characterized by small lesions on the leaves, the lesion becomes pale to greenish yellow streaks, visible from both surfaces of the leaf.	a) Remove infected leaves and destroy. 
		b) Thereafter, linear brownish to blackish streaks appear.	
		c) The centre of the streak spot.	b) Keep proper drainage and avoid water logging.
		d) Some times premature ripening is observed.	c) Spray mancozeb or kavach (0.2%) eventually dries up and or bavistin 0.05% gives an appearance of eye
Viral Diseases			
i)	Banana Bunchy Top Virus (BBTV)	a) Appearance of irregular, dark green 'Morse code' streaks along secondary veins on underside of the leaves. b) Leaf size is reduced and leaves remain abnormally erect and brittle. c) Leaves short, close to each other and bunched at the d) The tips of the bracts in male buds are greenish. e) Virus spread through aphids.	a) Use virus free planting material i.e. Tissue culture plantlets. b) Survey and eradicate infected plants regularly. c) Control insect vectors, especially aphids. in the case of mass multiplication. d) Indexing for virus should be followed e) Prohibit movement of any plant part from diseased area to healthy f) Use resistant cultivar. g) Avoid growing of alternate host as a mixed crop in nearby areas.

ii)	Banana Mosaic Virus (BMV)	a) Chlorosis with mild chlorotic streaks, along the veins; they never turn necrotic as in BSV.	a) Elimination of affected plants and maintenance of disease-free plantation through the use of disease-free planting material i.e. tissue culture plantlets.
		b) The veins are raised and leaves become brittle.	
		c) Virus spreads through suckers and aphids. 	
iii)	Banana Bract Mosaic Virus (BBMV)	a) Presence of spindle shaped pinkish to reddish streaks on pseudostem, midribs, petioles and laminae.	a) Use of disease-free planting material i.e. tissue culture plantlets.
		 	
iv)	Banana Streak Virus (BSV) 	a) Presence of inconspicuous chlorotic flecking to small lethal systematic necrosis, and includes yellow, brown and black streaking, cigar pseudostem necrosis and It spreads through suckers and mealy bugs (Planococcus citri) leaf necrosis, basal formation of small, 	a) Use of disease-free planting material i.e. tissue culture plantlets. 

5.12 Harvesting:

Banana should be harvested at the physiological maturity stage for better quality. The fruit is climacteric and can reach consumption stage after ripening.

5.12.1 Maturity indices:

These are established on the basis of fruit shape, angularity, grade or diameter of the median finger of the second hand, starch content and number of days elapsed after flowering. Market preferences can also affect the decision for harvesting slight or full mature fruit.

5.12.2 Removal of bunch:

Bunch should be harvested when fingers of second hand from top are 3/4 rounded with the help of sharp sickle, 30 cm above the first hand. Harvesting may be done upto 100-110 days after opening of the first hand. Harvested bunches should be generally collected in well padded tray or basket and brought to collection site. Bunches should be kept coverd by leaves to avoid light after harvest, since exposure hastens ripening and softening.

For local consumption, hands are often left on stalks and sold to retailers.

For export, hands are cut into units of 4-16 fingers, graded for length and girthwise and carefully placed in polythene-lined boxes to hold different weights, depending on export requirements.

5.13 Post-harvest operations:

At collection site, injured and overmature fruits are discarded and for local market, bunches should be delivered through lorries or wagons. However, for more sophisticated and export market, where the quality is predominant factor, bunches should be dehanded, fruits are cleared in running water or dilute sodium hypochlorite solution to remove the latex and treated with thiobendazole, air dried and graded on the basis of size of fingers as already stated, packed in ventilated CFB boxes of 14.5 kg capacity as per requirement with polythene lining and pre-cooled at 13-15^{0}C and 80-90% RH.

Such material should then be sent under cold chain at 13^{0}C for marketing.

5.14 Yield:

The planted crop gets ready for harvest within 11-12 months of planting. First ratoon crop would be ready by 8-10 months from the harvesting of the main crop and second ratoon by 8-9 months after the second crop.

Thus, over a period of 28-30 months, it is possible to harvest three crops i.e. one main crop and two ratoon crops. Under drip irrigation, combined with fertigation, yield of Banana as high as 100 T/ha can be obtained with the help of tissue culture plantlets. Even similar yield in the ratoon crops can also be achieved, if the crop is managed well.

6. Fruit Processing

Banana can be processed in to various products such as Banana Puree, Banana Concentrate, Banana Clarified Juice, IQF Banana Slices and dices, Fried Banana Chips, Dried Banana Chips etc. In India largest consumed processed banana product is Banana Chips, whereas in the other countries it is Banana Puree and Banana Puree Concentrate. Processed Banana products find varied uses such as Baby Food, Jams and Jelly's, Juices, Ice Cream and Yogurts and as topping in various confectionery items.

The company has set up a state of the art Banana processing plant, 100% export oriented unit (EOU), to produce Banana Puree, Banana Puree concentrate and Clarified Banana Juice concentrate to cater to domestic and export markets. The plant handles about 120 MT of Banana's per day and the processed product is packed in to 20-220 kg. packs.

The process starts with receiving of green banana, which is washed and graded. The washed banana is then subjected to ripening over a period of 7 days in a controlled atmosphere ripening chamber. The optimally ripened banana is then washed, hand peeled and then pureed. The puree is then deseeded, deaerated and homoginised before being sterilized and packed. In case of puree concentrate, the product is passed thru an evaporator to extract water, before being sterilized and packed. The product is packed aseptically or frozen with no preservatives, colour, sugar or any additive and the 100% natural product has a shelf life of 18-24 months.

Another area where India holds much promise is in the export of Fresh Banana Fruits.

6.1 The guidelines for fresh fruit export:

- Selection of suitable variety that has international acceptance like Grand Nain, Golden finger etc.
- Raising the crop with tissue cultured planting material.
- Following customized package of hi-tech horticultural practices of Jains' Optimized crop geometry, Drip Irrigation & Fertigation.
- Strict sanitation and pre-harvest treatment with safe and recommended chemicals.
- Appropriate post-harvest practices.

6.2 The post-harvest operational sequence:

- Selection and cutting of Bunches

- Carrying bunches in stretchers to packing shade

- Weighing and de-handing

- De-flowering and giving a clean cut to crown

- Washing of hands in Tank 1 to remove most of foreign material

- Washing of hands in Tank 2 in alum solution to remove latex and dirt from the surface

- Washing hands in Tank 3 in 100-150 ppm chlorine or acceptable fungicide solution.

- Drying and packaging in corrugated boxes lined up with food grade plastic sheets

- Vacuum packaging of the fruits in the carton and stuffing in the reefer container

- Weighing and carrying boxes to cold store at 130C temperature within 9 hours from harvest

- Volume fill in the shipping container three refrigerated transport vehicles

- Warming up the fruits to 180 C at the destination

- Subjecting the fruits to 1000 ppm ethylene gas at 180 C for 24 hours and venting for 30 minutes

- Market at colour stage 3.5

JISL, with it's vast experience in agri-sector since the early seventies, are now poised to take up fresh Banana exports from Jalgaon. The area under Banana in Jalgaon being brought under Tissue Culture Grand Nain is on the increase and with training of farmers on hi-tech horticultural practices, Jalgaon has rightly earned its position as the Banana Bowl of India and Jains are proud to have initiated and nurtured it (Fig. 11a, b & c).

Fig.11a: Banana fresh fruit export

Fig. 11b: Banana Processing Facility

Fig. 11c: Banana Puree and Concentrate

7. Organic Banana Production

7.1 Introduction:

With the increase in crop yield by using various modern techniques, reaching a plateau in most of the countries and environmental problems due to excessive use of agro-chemicals has become a matter of concern and the need for sustainable agriculture is increasingly being felt, the world over. The technologies generated over the past four decades and their indiscriminate use have proved to be detrimental to the natural resource base and environment in different countries of the World.

Organic farming principles, which are inherently sustainable in several parts of the world, could be the avenue of choice to address man-made problems.

What is organic farming?:

Organic farming is defined as production system which avoids or largely excludes the use of synthetically manufactured fertilizers, pesticides and other agro-chemicals. To maximum extent, organic system relies on crop rotations, crop residues, animal manures, green manuring crops, seed cakes, mineral bearing rocks and biological pest control regime to maintain soil fertility and supply plant nutrients.

7.2 Special Characteristics of organic banana production:

i) Use of green manuring crops is conciously undertaken to enrich soil fertility.

ii) Crop rotation is the basic need of organic farming. Deep rooted crops are followed by medium and shallow rooted crops.

iii) Recycling of farm/animal waste (composting) is implemented.

iv) Oil cakes, cow dung manure, urine, bone meal, fish meal are used as source of manure.

v) Use of biofertilizers to supply NPK and other elements is followed. Similarly, use of biopesticides or decomposting cultures is practised on large scale.

vi) These practices maintain physical, chemical & biological fertility of soil.

vii) Local or wild varieties or alternative improved or hybrid varieties of crops are identified to suit local conditions.

viii) Seed treatment accorded with biocultural and local farm materials like cow urine.

ix) Controlled use of irrigation is encouraged.

x) Use of grasses, weeds, plant parts, debris for mulch is advocated.

xi) Use of sea weed extracts as growth promoting hormones.

xii) Use of trap crops, mix crops, biological control of pests, use of plant extracts as fungicides, use of predators and parasites for pest control are oractised.

xiii) Soil, water, animals and implements are kept away from hazardous/poisonous chemicals and its residues.

xiv) Sunlight harvesting is enhanced.

7.3 Steps for organic banana production:

To shift from conventional to organic production of Banana, like other crops, involves substantial change in crop production methods. The principle of organic production is not to focus on inputs and their replacement, but it is based on the concept that the farm is a system, with its component parts soil, microorganisms, insects, plants and other species interacting and providing total opportunity to manage these ecological and biological processes towards the target of sustainable production.

It is clear that knowledge required for organic production is generally more intensive and more 'Local' than needed for the conventional farming. It involves understanding and management of ecological processes in farmer's field and it relies much more on local, farm derived and, renewable resources.than chemical based farming.

7.3.1 Mindset of farmer:

Farmer should decide it firmly that he has to undertake organic banana production.

7.3.2 Selection of Land:

Land may be virgin or fallow or not added with much chemical inputs.

7.3.3 Land Preparation:

Light implements should be used for preparatory tillage. Before planting banana, green manure crop is advocated. FYM@30 T/acre should be added alongwith green manure crop. FYM should be treated with Trichoderma virdie @ 1kg for 10 MT.

7.3.4 Selection of proper variety:

Research is going on to find out proper variety for organic banana cultivation. Till date, Yangambi KM5 is the only variety for organic banana production tried in various countries around the world.

Characteristics of KM5 -

i) Resistant to all common pests & diseases.

ii) Average bunch weight 21 kg and maximum 74 kg recorded in other countries.

Another variety, FHIA-17, also has bright future in organic production as it also resists many pests and diseases.

Tissue culture seedlings can be used for planting or farmer can use suckers grown in organic mother nursery, which should be free from disease and pests.

7.3.5 Planting material treatment:

Suckers are treated with cow dung, urine and bacterial cultures Azotobacter and P.S.B.

7.3.6 Planting:

At the time of planting, basal dose of FYM/PMC (decomposed) treated with Trichoderma and neem cake is added, which not only acts as a manure, but also keeps away soil pests & diseases.

7.3.7 Irrigation:

In organic banana, only micro-irrigation should be used, as other methods are not suitable for organic banana cultivation, as they affect the system adversely. Flood irrigation has the following adverse effects:

i) Soil erosion - soil & some portion of basal manure is lost.

ii) Excess irrigation leads to suffocation of plant root system and stops microbial activities in the soil.

iii) Lose due to leaching of available nutrients limits plant growth and productivity.

iv) Favours pests and diseases.

7.3.8 Inter-cultural practices:

i) Green manuring crops be raised and the plants buried in the soil.

ii) Clean & hygienic condition should be maintained on the farm.

iii) Other operations are the same as followed for commercial cultivation.

iv) Mulch the crop with dried leaves, stem etc.

7.3.9 Nutritional Management:

A. Generally, FYM/Compost/PMC (decomposed) are used as a basal dose. Different concentrated organic manures like castor cake, neem cake, mahuva cake, etc are used as secondary fertilizers. Bone meal, fish meal, blood meal are also used. Animal urine is used as supportive fertilizer. Quantity of above fertilizers is decided after the analysis of the soil. Nutritional management is done taking into consideration availability of nutrients from soil & total requirements of the crop, and difference is supplied on the basis of the composition of the fertilizer (Table 13, 14 and 15).

Table 13: Average crop nutrient content of bulk organic manure

Sr.	Manure	Percentage Content		
		Nitrogen(N)	Phosphoric acid	Potash
		(N2O)	(P2O5)	(K2O)
Animal Waste :				
i)	Cattle dung (fresh)	0.3-0.4	0.1-0.2	0.1-0.3
ii)	Sheep dung (fresh)	0.5-0.7	0.4-0.6	0.3-1.0
iii)	Night soil (fresh)	1.0-1.6	0.8-1.2	0.2-0.6
iv)	Poultry manure (fresh)	1.0-1.8	1.4-1.8	0.8-0.9
v)	Cattle urine	0.9-1.2	Tr.	0.5-1.0
vi)	Sheep urine	1.5-1.7	Tr.	1.8-2.0
Wood Ashes :				
i)	Ash coal	0.73	0.45	0.53
ii)	Ash (household)	0.5-1.9	1.6-4.2	2.3-12.0
iii)	Ash wood	0.1-0.2	0.8-5.9	1.5-36.0
Farm, Factory and other compost :				
i)	Rural compost	0.5-1.0	0.4-0.8	0.8-1.2
ii)	Urban compost	0.7-2.0	0.9-3.0	1.0-2.0
iii)	Farm yard manure (F.Y.M.)	0.4-1.5	0.3-0.9	0.3-1.9
iv)	**Press mud**	**1.0-1.5**	**4.0-5.0**	**2.0-7.0**
Plant residues :				
i)	Rice hulls	0.3-0.5	0.2-0.5	0.3-0.5
ii)	Groundnut husk	1.6-1.8	0.3-0.5	1.1-1.7
Tr = Traces				

Table 14: Nutrient status of green manure crops

Sr.	Crop	Green Biomass Yield		
		Kg/ha.	Nitrogen Content %	Available Nitrogen kgs/ha.
i)	Sunnhemp	21300	0.43	90
ii)	Dhaincha	20000	0.42	84
iii)	Cowpea	15000	0.49	74
iv)	Greengram	8000	0.53	42
v)	Berseem (Legume)	15500	0.43	67

Table 15: Average nutrient content of oil cake used in India

Sr.	Oil cake	Percentage Content		
		N	P	K
a) Non-edible oil cakes :				
i)	Neem cake	5.2	1	1.4
ii)	Castor cake	4.3	1.8	1.3
iii)	Cotton seed cake	3.9	1.8	1.6
iv)	Karanj cake	3.9	0.9	1.2
b) Edible oil cakes :				
i)	Coconut cake	3	1.9	1.8
ii)	Groundnut cake	7.3	1.5	2.2
iii)	Safflower cake	7.9	2.2	1.9
iv)	Sesame cake	6.2	2	1.2

B. Vermicompost:

Use of vermicompost (2.5 kg per plant) at the age of 4-5 month is recommended. It improves soil structure and provide nutrients also.

C. Biofertilizers:

Various micro-organisms like bacteria and fungi are useful in fixing atmosphere nitrogen and making fixed phosphorus in the available (soluble) form. Some of the organisms carry out decomposition process and conversion of organic matter into humus. Some of the strains fight against pests and diseases.

i) Nitrogen fixation : Azotobacter - for non leguminous crops

: Rhizobium
: Azospirillum
} for leguminous crops

: Blue green algae (BGA)
: Azolla
} for crops which consume excess water

ii) Phosphate solubilizing bacterial cultures (P.S.B.).

iii) Composting micro-organisms: It is a mixture of bacteria, yeast & fungi.

iv) Biopesticide organism: Trichoderma viride.

7.3.10 Integrated Pest Management:

The significance and management of leaf diseases should not be considered in isolation from other aspects of crop management. Cultural and pest factors have been clearly shown to interact directly with the plants with susceptibility to:

i) Banana leaf spot: Banana is less susceptible to BLS with increased

- ratio of Potassium: calcium + magnesium and
- organic matter in the top soil

However, banana is more susceptible with increased

- Mean minimum annual temperature
- ratio of dead: functional roots (Nematode damage)
- Percentage of corm area damaged by weevils.

ii) Nematodes: Use tissue culture plantlets which are free from nematodes.

- Avoid planting in eroded soils.
- Delay the pruning of suckers.
- Take marigold as a trap crop.

iii) Fusarium wilt:

- High pH
- Fertile land and
- Well drained soil are suppressive or less prone to disease occurrence.

7.3.11 Harvesting:

Harvest the bunches separately, store them separately and analyse the crop for residues.

7.3.12 Record:

Records should be maintained of all the operations practised.

7.3.13 Certification of the farm:

Get the farm certified by an authorised certifying agency.

In short, soil conversion is a lengthy process, may take 2-3 years for organic conversion. The yield may reduce in the first 1-2 years. Farmers should sustain little loss of production in the initial years. But later puting thing less inputs for production,receive more price for organic banana.

7.3.14 Certification:

There are certifying agencies in the various countries. Basic standards for organic production and processing are formulated by organization called IFOAM internationally. There are agencies like:

- SKAL
- ECO-Cert
- APEDA

Any individual farmer or group of farmers can form an association and get certification.

A designated person from certifying agency collects data and agency will analyse, scrutinize and audit the record.

ANNEXURE - 1

Comparison of economics of cultivation of conventional & Tissue Culture Banana one area

Sr.	Particulars	Conventional	Tissue Culture
	Spacing	1.5 x 1.5 M	1.8 x 1.5 M
	Plant Population / acre	1742	1452
1.	Land Preparation (2 ploughing + 3 \ harrowing)	1100	
2.	Fym (7.5 trollies / acre@ Rs. 800/trolly)	6000	
3.	Broadcasting of manure (Rs.)	750	750
4.	Pit marking (Rs.)	500	500
5.	Drip Irrigation (Total cost spread over 5 yrs) for one year	5000	
6.	Planting material (Rs.)	3484	18585
7.	Planting (Rs.)	1742	1452
8.	Chemical fertilizers (Rs.)	10033	21700
9.	Micro nutrients (Rs.)	1132	1887
10.	Secondary nutrients (Rs.)	700	800
11.	Plant protection (Rs.)	500	1500
12.	Growth Regulators (Rs.)	250	500
13.	Desuckering (Rs.)	500	500
14.	Weeding (Rs.)	1500	1500
15.	Earthing up (Rs.)	1700	1500
16.	Irrigation (Rs.)	500	500
17.	Bunch Covering with leaves & other expenses	2000	3000
18.	Harvesting and Transporting (Rs.)	3000	2900
Total (Rs.)		**40391**	**69670**
Expense per plant (Rs.)		23.18	47.98

Sr. No.	Particulars	Conventional	Tissue Culture
	Main Crop		
1.	Total plants / acre	1742	1452
2.	Expenditure / plant (Rs.)	23.18	47.98
3.	Total cost of cultivation / acre (Rs.)	40391	69670
4.	Average number of bunches	1500	1438
5.	Average bunch weight (kg)	15	25
6.	Yield (MT)	22.5	36.3
7.	Total returns (Min. Rs. 3000/t)	67500	107850
8.	Net Profit (Rs.)	27109	38178
	First Ratoon:		
9.	Expenditure / plant (Rs.)	14.50	18.00
10.	Total Expenditure / acre (Rs.)	28733	26139
11.	Yield / acre (MT)	22.50	36.30
12.	Total returns (Min. Rs. 3000/t)	67500	107850
13.	Net profit (Rs.)	38767	72175
	Second Ratoon:		
14.	Net Profit NIL	60325	

Economics of 3 crops per acre:

Crop	Expenses (Rs)		Returns (Rs)		Net Profit (Rs)	
	Conv.	**T.C.**	**Conv.**	**T.C.**	**Conv.**	**T.C.**
Main Crop	40391	69670	67500	107850	27109	38178
Ist Ratoon	28733	26139	67500	107850	38767	72175
2nd Ratoon	-	29675	-	95832	-	60325
Total	**69124**	**135022**	**135000**	**311532**	**65876**	**170678**

DRAWBACKS IN CONVENTIONAL IRRIGATION METHOD

For plant growth, Soil, Water, Air, Nutrients and Sunlight are basic inputs. In the conventional irrigation method, normally the plant is irrigated an the interval of 8-15 days & the water distribution uniformity is limited up to 33% only. This means the irrigation efficiency is reduced & plant does not get the total applied quantity of water. Only 35 to 40% of the total quantity of water is utilised by the plant in reality. If irrigation is at the interval of eight days, the exact status of moisture level in the soil will be as shown below.

First Three Days After Irrigation	Middle Three Days	Last Two Days
		
During first three days of irrigation soil pores are saturated with water. In this condition, total air in the soil is displaced by water & field capacity level is not maintained in the soil. Though sufficient nutrients are avaiable in the soil, the excess water condition suffocates the roots of the plant & water absorption by roots is totally ceased. As the plant is under suffocation, the growth is hampered.	During the next three days, due to evaporation & percolation losses, the excess soil moisture is reduced & soil comes to field capacity level wherein air, moisture & nutrients are available at optimum level. Plant growth takes place only during this phase.	In the last two days, moisture level in the soil goes below the root zone. Hence, plant is under stressful condition in this period. Even though air and nutrients are sufficiently available in the root zone, they can not be taken easily by plant as the plant is under stress and hence growth restricted.

Conclusion: It is very clear from the above phenomenon that for the plant growth, optimum moisture level available is only for about three days out of 8 days' cycle. Rest of the time, plant is either under stress or suffocative condition, hence growth is restricted, thereby yield is reduced.

JAIN MICRO IRRIGATION SYSTEM

Jain Micro Irrigation System by its very definition is the application of small and precisely predetermined amount of water near the root zone of plant at frequent intervals through emitting devices via a network of PVC/HDPE mains, submains, filtration unit, control valves and LDPE laterals.

By this advanced method of irrigation, 90-95% irrigation efficiency and uniformity of application is achieved. And throughout optimum balance of nutrients, air & water is maintained in the soil resulting in continuous & better plant growth and high yields.

ARE YOU LOOKING FOR A SCIENTIFIC, EFFICIENT AND ECONOMICALLY VIABLE MICRO IRRIGATION SYSTEM? THEN GO FOR JAIN IRRIGATION SYSTEM

We Consider The Following Essential Parameters When We Design. A Drip Irrigation System For You That Ensures Satisfactory Service Year After Year. All The Components Of The Total System Are Manufactured By Jains Themselves Under Strict Quality Control. That Is What Makes The Jain Irrigation Systems. The Best Micro Irrigation You Are Looking For.

Engineering Survey

Technical survey of the land & collection of certain data are pre-requisites for designing a micro irrigation system. Therefore, a survey of the land is conducted and necessary data like information of farmer, details of crop & their spacings, water-source, existing pump details, water-availability, field dimensions, undulations, agro-climatic information, etc. are collected. Samples of soil & water are also collected for testing in our laboratory.

Agro-climatic Data

Agro-climatic data like total rainfall, temperature, susnshine hours, relative humidity, evapo-transpiration, wind velocity, wind direction etc. are collected & fed to the computer, to decide the stagewise and agewise irrigation schedule for better crop growth.

Design

After studying the interrelationship between crop, water, soil and Agro-climatic data, a suitable hydraulic and economical system is designed on computer by keeping in view the existing pump capacity, existing pipe line and peak water requirement of crop.

Soil and Water Analysis

The soil sample so collected is tested in our laboratory to know the pH factor, salinity, water holding capacity, soil infiltration rate, depth of soil, soil texture, fertility, etc.

The water is tested to know its quality, pH factor, electrical conductivity, hardness or softness, total dissolved solids, suspended particles, etc.

Such tests on soil and water are conducted to design a suitable system tailor-made to suit the site conditions and also to establish needs for frequency of chemical treatment to ensure proper working of the micro irrigation system. It also helps to decide fertigation schedule.

Crop

Crop details like variety, row & plant spacings, age, canopy development, root system, cultivation-methods, etc. are collected to decide the proper irrigation schedule.

J A L G A O N

MAKING A DROP OF WATER GROW A LONG WAY

Conclusion

Jain Micro Irrigation System is the only scientific method of irrigation which considers all above parameters and designs the most suitable & economically viable system for better harvest.

Proven Benefits

- Saves water from 30% to 80%.
- Cost of chemicals, fertilizers, labour & plant protection can be reduced by 30-40%.
- Increase in yield to the extent of 20% to 100%.

ANNEXURE - 2

Our Products / Services

♦	Micro Irrigation Systems & Components
♦	Sprinkler Irrigation Systems
♦	Turf / Landscape Irrigation Systems
♦	Lift Irrigation Systems
♦	Dust Suppression Sprinkler Systems
♦	Automated Irrigation Systems
♦	PVC Pipes & Fittings
♦	MDPE Pipes & Fittings
♦	HDPE Pipes & Compression Fittings
♦	PVC Water Well Casing & Screen Pipes
♦	Plastic Sheets

♦	Plastic Valves
♦	Solar Water Heating System
♦	Green Houses / Shade Houses
♦	Banana Tissue Culture Plants
♦	Agriculture & Irrigation Projects on
♦	Dehydrated Onion & Vegetables
♦	Processed Fruits
♦	Bio-Fertilizers
♦	Agricultural / Horticultural Consultancy
♦	Bio-diesel
♦	Bio-gas

* Conditions Apply

CERTIFICATE

TÜV NORD

Management system as per
DIN EN ISO 9001 : 2008

In accordance with TÜV NORD CERT procedures, it is hereby certified that

JAIN IRRIGATION SYSTEMS LTD.
TISSUE CULTURE UNIT
UNIT I : Agri Park, Jain Hills, Shirsoli Road, Jalgaon – 425 001, Maharashtra
UNIT II : Jain River Bank Site, Village : Takarkheda, Post : Khadoli, Taluka : Erandol, Dist. Jalgaon – 425 103, Maharashtra, India

Jain™ Tissue-Culture

applies a management system in line with the above standard for the following scope

Development, Micropropagation and Supply of Tissue Culture Plants

Certificate Registration No. **04 100 047091-E3**
Audit Report No. **2.5-0892/2003**

Valid until **04.05.2013**
Valid from **05.05.2010**
Initial certification **05.05.2004**

Certification Body
at TÜV NORD CERT GmbH

Mumbai, **03.05.2010**

This certification was conducted in accordance with the TÜV NORD CERT auditing and certification procedures and is subject to regular surveillance audits.
TÜV NORD CERT GmbH Langemarckstrasse 20 45141 Essen www.tuev-nord-cert.com

IAF

TGA-ZM-07-06-00


NATIONAL CERTIFICATION SYSTEM FOR TISSUE CULTURE RAISED PLANTS (NCS-TCP)
MINISTRY OF SCIENCE & TECHNOLOGY
Department of Biotechnology (DBT)
Ministry of Science & Technology
Government of India
NCS-TCP
NATIONAL CERTIFICATION SYSTEM FOR TISSUE CULTURE RAISED PLANTS
Certificate of Recognition
This is to certify that the Tissue Culture Production facility stated below has been assessed and certified by the Accreditation Unit (AU) of DBT established at Biotech Consortium India Limited (BCIL), New Delhi as per criteria laid down under NCS-TCP
Organization : JAIN IRRIGATION SYSTEMS LIMITED
Location of Laboratory and Primary Hardening Unit : Agripark, Jain Hills, Shirsoli Road, Jalgaon, Maharashtra-425001
Location of the Secondary Hardening Unit : Jain River Bank Site, Village Takkarkheda Post Khadoli, Taluka Erandol, District Jalgaon, Maharashtra-425103
Registration Number : TC2007020
Certification Number : TC2007011
Date of Issue : December 07, 2007
Valid up to : December 06, 2009
DBT
Dr. Renu Swarup
Advisor DBT and Nodal Officer
Tissue Culture Certification Agency
Please see overleaf for terms and conditions

ANNEXURE - 3

Plants in India

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Jain Food Park, Jain Valley
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E-mail: foodpark@jains.com

Jain Green Energy Park
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Overseas Plant

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Tel :1-800-695-7171 or (559)-485-7171
Email : info@jainsusa.com;
Web : www.jainsusa.com.,

Jain Irrigation Inc. [Winter Haven, Florida]
Tel : +1-800-848-8153; or (863)-294-1900;

Jain Irrigation Inc. [Ontario, CA]
Tel : +1-909-3955200; +1-800-828-9919;

Chapin Watermatics, Inc. [Watertown, New York]
Tel : +1-800-242-7467; or (315)-782-1170;
E-mail : ngupta@chapindrip.com
Web : www.chapindrip.com.

Cascade Specialties Inc. [Onian Plant]
Tel : +1-541-481-2522
E-mail : info@cascadespec.com
Web : www.cascadespec.com

NuCedar Mills Inc. [Chicopee, MA]
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Email : info@nucedar.com
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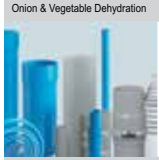
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