B.Sc. (Hons.) Agriculture

Optional course

SAC 453 Soilless crop production (1+1)

LECTURE No. 1

IMPORTANCE AND SCOPE OF PROTECTED AGRICULTURE; FACTORS AFFECTING CROP GROWTH UNDER PROTECTED CULTIVATION – TEMPERATURE, LIGHT INTENSITY, CO_2 AND HUMIDITY

After the advent of green revolution, more emphasis is laid on the quality of the agricultural product along with the quantity of production to meet the ever-growing food and nutritional requirements. Both these demands can be met when the environment for the plant growth is suitably controlled. The need to protect the crops against unfavourable environmental conditions led to the development of protected agriculture. Greenhouse is the most practical method of achieving the objectives of protected agriculture, where natural environment is modified by using sound engineering principles to achieve optimum plant growth and yield. Poly house cultivation has become an important policy of Indian Agriculture

Protected cultivation practices can be defined as a cropping technique wherein the microclimate surrounding the plant body is controlled partially or fully as per the requirement of the vegetable / flower species grown during their period of growth. With the advancement in agriculture various types of protected cultivation practices suitable for a specific type of agro- climatic zone have emerged. **A greenhouse** is a framed or inflated structure covered with a transparent or translucent material in which crops could be grown under the conditions of at least partially controlled environment and which is large enough to permit a person to work within it to carry out cultural operations. Greenhouses are the most common types of structures used for production of ornamental and vegetable crops under controlled conditions. These structures provide the potential to control all environmental parameters, although to varying degrees depending upon the design of the structure and its components.

Importance of greenhouses (or) Specific Benefits of Green houses:

1. Crop is protected from cold, wind, storm, rain and frost.
2. Due to controlled conditions there is better germination, plant growth and crops mature faster

3. Improved quality & quantity of produce with long shelf life.
4. Use of water is optimized and there is reduction in its consumption by 40 - 50%.
5. Effective utilization of inputs
6. Incidence of disease and pests is reduced or eliminated.
7. Crops can be grown throughout the year.
8. Best technology for commercial production of high value crops like flowers, medicinal plants, etc.
9. Can be used for solar drying of farm produce
10. Involvement of labor force can be reduced
11. Crop cultivation under inclement climatic conditions
12. Certain crops cultivated year round to meet the market demands
13. High value and high quality, even organic, crops grown for export markets
14. Income from small land holdings increased several fold
15. Successful nurseries from seeds or by vegetative propagation prepared as and when necessary.
16. More Self-employment opportunities for educated youth on farm
17. Manipulation of microclimate and insect proof feature of the greenhouse for plant breeding and, thus, the evolution of new varieties and production of seeds.

Scope of greenhouse in India:

The scope in Indian horticulture is tremendous. If popularly organized, the promising fields having wide scope for protected cultivation in India are

1. Cultivation in problematic agro climate: In India majority of uncultivated area is under problematic conditions such as barren, uncultivable fallow lands and desserts. Even a fraction of this area brought under greenhouse cultivation could produce substantial returns for the local inhabitants.

2. Greenhouses around big cities: The substantial demand persists for fresh vegetables and ornamentals around the year in big cities. Demand for off season and high value crops also exists in big cities. Therefore greenhouse cultivation can be promoted to meet the urban requirements.

3. Export of horticultural produce: There is a good international demand for horticultural produce, mainly the cut flowers. Promotion of greenhouse cultivation of export oriented crops will be of definite help towards export promotion. Ex. Cultivation of Gherkins in greenhouses around Hyderabad are exported to different countries.

4. Greenhouses for plant propagation: GH technology is being now a days considered as suitable approach for raising of seedlings and cuttings which require control environment for their growth.GH facility could increase the capacity and quality of producing the plant material.

5. Greenhouse technology for biotechnology: Material generated through tissue culture are need to be propagated in control environment. The hydroponics or Nutrient Film Technique (NFT) are also required controlled environmental conditions for growing plants.

6. Greenhouse for cultivation of rare and medicinal plants: India has wide variety of

medicinal herbs and rare plants like orchids which have been identified for large scale cultivation. The greenhouse could provide the right type of environmental conditions for the intensive cultivation of these plants.

Status of protected cultivation In World:

Greenhouse crop production is now a growing reality throughout the world with an estimated 405,000 ha of greenhouses spread over all the continents. There are more than 55 countries now in the world where cultivation of crops is undertaken on a commercial scale under cover, and it is continuously growing at a fast rate internationally.

In India, protected cultivation technology for commercial production is hardly three decades old (DRDO). In developed countries *viz*., Japan, Holland, Russia, UK, China and others, it is about two century old. China started protected cultivation in 1990's and today the area under protected cultivation in China is more than 2.5 m ha and 90 per cent area is under vegetables. Israel is one country which has taken big advantage of this technology by producing quality fruits, vegetables, flowers, etc. in water deficit desert area. Several **thousand acres** are now under glass in the **United States** and equally large area in **England and Holland**, where horticulture under glass was practiced over a century ago.

Status of protected cultivation In India:

India’s first exposure to truly hi-tech protected farming of vegetables and other high-value horticultural produce came through the Indo-Israel project on greenhouse cultivation, initiated at the New Delhi-based Indian Agricultural Research Institute (IARI) in 1998, shortly after the establishment of diplomatic ties with that country. However, the Israeli experts left India in 2003 at the end of this five-year project, IARI continued to maintain the facility, calling it the Centre for Protected Cultivation Technology (CPCT). It has, in the past 10 years, managed to refine and upscale the system to reduce costs, besides designing greenhouse structures to suit local conditions. The area under greenhouse cultivation, reported by the end of 20th century was about 110 ha in India and world over 275,000 hectare. During last decade this area must have increased by 10 per cent if not more. The states that have consistently expanded the area under protected cultivation for the period of 2007-2012 are Andhra Pradesh, Gujarat, Maharashtra, Haryana, Punjab, Tamil Nadu and West Bengal. Maharashtra and Gujarat had a cumulative area of 5,730.23 hectares and 4,720.72 hectares respectively under the protected cultivation till 2012.

Factors affecting crop growth under protected cultivation

GREENHOUSE CLIMATE

One of the main tasks in greenhouse construction is to optimize the conditions for plant development, generally during the off-season from normal outside field production. The "internal" or greenhouse climate factors required for the optimal plant development involve photosynthesis and respiration.

AIR TEMPERATURE

Air temperature influences the energy balance of the plant canopy through the convective heat transfer to the plant leaves and bodies. The optimal level of the air temperature in the greenhouse depends on the photosynthetical activity of the plant in question, under the influence of the intensity of solar radiation on disposal (Figure 1) (i.e., for each light intensity, there is an optimal air [leaf] temperature, enabling maximum photosynthetical activity).

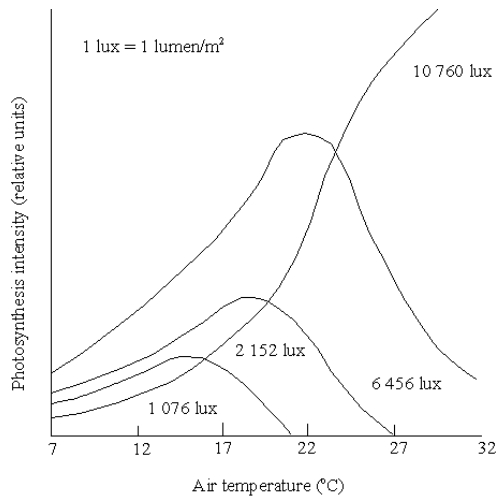


Fig. 1 Photosynthesis activity vs. light and air temperature conditions (tomato culture)(Kamenev, 1975).

Due to the changeable character of greenhouse climate, it is not possible to provide the "optimal" air temperature for some plants due to interdependencies of the light intensity and other parameters of greenhouse climate. Trials to define norms for optimal temperature values or intervals should not be understood as a tool for determination of optimal greenhouse climate (Table.1) but as a basis orientation for the choice of design values for calculation of greenhouse heat requirements and consumption.

		Inside Air Temperature (°C)						
		Development			Harvesting			
Vegetables	**Germination**	**Day***	**Day***	**Night**	**Day**	**Night**	**Young plants**	**Relative humidity Of the air (%)**
Cucumbers	17-18	22-25	27-30	17-18	25-30	18-20	13-15	85-95
Watermelon and melons	17-18	22-25	27-30	17-18	25-30	18-20	13-15	65-75
Tomato, Apple, Paprika and Beans	10-12	20-22	25-27	10-13	22-28	15-17	8-10	50-60
Lettuce, Celery and Garlic	8-9	17-18	20-26	8-12				70-80
Spinach and parsley	8-9	15-16	20-21	8-9				70-80

Radish and Cabbage	6-7	12-13	16-18	7-8				65-75

*Inside design temperature ranges for different crops (Kamenev, 1975).

SOIL OR PLANT BASE TEMPERATURE

Soil, or plant base temperature influences the energy balance of the plant canopy, too. The influence is by conduction heat transfer directly between the soil structure and through convection between the plant roots and water flow around them.

Through a great number of experiments and investigations, it is proven that:

- Optimal soil (or base) temperature depends on the stage of development of the plant in question
- Optimal soil (or base) temperature depends on the light intensity available, and
- Soil (or base) temperature influences the value of the optimal air temperature (i.e., higher soil temperature requires lower air temperature and vice versa).

It is necessary to stress that moving away from the optimal values influences the development of the root system of the plant, in the production capacity and the quality of the product. Going to lower values means decreasing production and going to higher values means drying of the root system, and in that way also reducing the production capacity and quality of the products.

Thus, if knowing the nature and requirements of plants, it is possible to influence significantly the heat consumption of a greenhouse through the balance between the air and soil temperatures during the plant cultivation

LIGHT

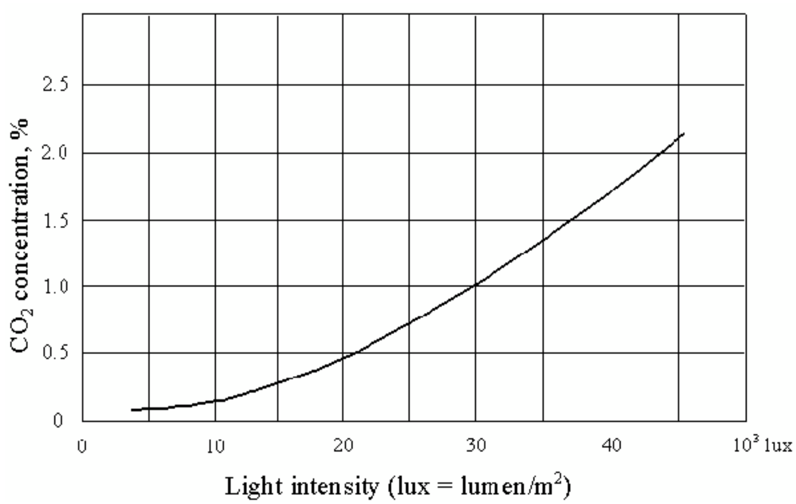
Light is the most significant parameter for the plant development and life. All the active life process in it can be achieved only in the presence and active influence of light. By the use of different scientific methodologies and investigations of changes in photosynthetical, phototropical, photomorphogenical and other plant activities, it is found that only the part of total solar spectrum between 400 and 700 nm influences significantly plants life processes. That determines the quality of transparent materials for greenhouse cover– it must be maximally transparent to this part of the solar spectrum.

The intensity of the energy related part of the total spectrum of solar radiation (i.e., the infra-red one) offers the necessary energy to the plant. Depending on its intensity, life processes are more or less active Up to some characteristical levels (different for different species) life processes increase their activities; but, after a point, they start to decrease. Below and above these characteristical light intensities, there is no life activity in the plant. Below, because active life processes need light to be activated. Above, because the plant is over- heated and processes of "cooling" are activated.

CO_2 CONCENTRATION

Normal CO_2 concentration in the atmosphere is about 0.03 %. In the case of closed room under influence of high light intensity and therefore, high photosynthetical activity, it changes quickly. During a bright day its concentration can decrease to 0.01 % in only a couple of hours for a good tight green house. As the CO_2 is an active participant of the chlorophyll assimilation, it is a greenhouse parameter of crucial importance. It is also proven that,

- For constant temperature conditions in a greenhouse, CO_2 concentration influences directly the intensity of photosynthetical activity, and
- Optimal concentration of CO_2 in the greenhouse depends directly on the light intensity on disposal



Optimal concentration of CO_2 in the cultivation area of a greenhouse depending on the light intensity (Denis, et al., 1978).

Through the ventilation of greenhouse closed space with 5-6 (vol/h) air exchange, it is possible to keep about a 0.02% CO_2 concentration. It is a compromise, because going to 9-10 (vol/h) exchange enables one to keep about a 0.03% concentration, but this influences significantly the heat consumption of the greenhouse. Middle- and northwest-European climatic conditions require the use of artificial measures to keep the necessary optimal CO_2 concentration; but, in the southern regions, usually controlled ventilation is sufficient.

HUMIDITY

There is a direct relationship between the air humidity and soil moisture (or artificial cultivation base characteristics) in a greenhouse.

Air humidity directly influences transpiration of the plant leaves. Optimal intervals are rather small and difficult to be achieve in a closed room, filled with crops of high transpiration . Lower humidity means drying of the plant and reduced production. Higher humidity produces more leaves, lower quality of fruits and sensitive to a number of plant diseases.

Importance of Humidity in Plant

- A primary component in photosynthesis and respiration
- Responsible for turgorpressure in cells
- A solvent for minerals and carbohydrates moving through the plant
- Responsible for cooling leaves as it evaporates from leaf tissue during transpiration
- A regulator of stomatal opening and closing, thus controlling transpiration and, to some degree, photosynthesis
- The source of pressure to move roots through the soil
- The medium in which most biochemical reactions take place

LECTURE No. 2

INTRODUCTION TO SOILLESS CULTIVATION OF PLANTS- VARIOUS SYSTEMS OF SOIL-LESS CROP PRODUCTION - BAG CULTURE- CONTAINER CULTURE-TROUGH CULTURE-THIN LAYER SYSTEMS-OTHER ALTERNATIVE SYSTEMS

Soilless Cultivation of Plants

Soilless agriculture is a method of growing crops in mineral solutions packed with nutrients. The composition of mineral solutions depends on the crop under cultivation. Traditional agriculture is cultivation of crops and plants in soil. The plants, in fact, do not need soil to grow but for its nutrients. If the plants are grown in nutrient solutions or any other substrate (other than soil) containing essential nutrients, the practice is known as soilless gardening or dirt free farming. In soilless gardening, these are directly available to the plant roots. The plant gets everything it needs, in all the right proportions, at just the right time and utilizing it most efficiently. Here the plant shows its full genetic potential. They just bypass the soil and the plant's requirements are met by nutrient rich water. Hydroponics is a system of agriculture that utilizes nutrient-laden water rather than soil for plant nourishment. Such a technology, in fact, has been in operation since 2004 at the South Pole Food Growth Chamber. Hydroponics was indeed chosen as the food-production technology at the South Pole, due to the terms of the 1978 Antarctic Conservation Act which prohibits the ingress of soils to the continent'. In space also, hydroponic vegetable cultivation is being used that would not only supplement a healthy diet, but also remove toxic carbon dioxide from the air inside their spacecraft and create life-sustaining oxygen. "If you continually resupply and deliver commodities like food, that will become much more costly than producing your own food," says Ray Wheeler, Plant Physiologist at Kennedy Space Center's Space Life Sciences Lab. The popularity of hydroponics has increased dramatically in a short period of time leading to an increase in experimentation and research in the area of indoor and outdoor hydroponic farming.

Advantages of Soilless Agriculture

- Soilless agriculture does not require the use of toxic chemicals. Unlike soil-based agriculture, where farmers have to use fertilizers to increase crop yield and spray pesticides to keep weeds and pests away, crops are somewhat protected from pests and weeds.
- Soilless agriculture is ideal in urban areas where space is too limited for soil-based gardens.

- Nutrient and growing media loss is significantly reduced with soilless cultivation because the nutrient requirements for crops are determined in advance.
- Soilless cultivation is believed to cause less pollution.
- Compared to soil cultivation, the yields from soilless cultivation are significantly higher as a result of intensive practices and the possibilities of continuous, year-round production.

Disadvantages of Soilless Agriculture

- Crops cultivated using this approach are more prone to pathogen attacks as a result of high moisture levels.
- Crops are also more susceptible to rapid death as a result of their lower buffering capacity.
- It needs skilled labour to handle soilless cultivation.

Various Systems of Soilless Crop Production

Bag Culture

A growbag is a large plastic bag filled with a growing medium and used for growing plants, usually tomatoes or other salad crops. The growing medium is usually based on a soilless organic material such as peat, coir, composted green waste, composted bark or composted wood chips, or a mixture of these. Various nutrients are added, sufficient for one season's growing, so frequently only planting and watering are required of the end-user. Planting is undertaken by first laying the bag flat on the floor or bench of the growing area, then cutting access holes in the uppermost surface, into which the plants are inserted.

Growbags were first produced in the 1970s for home use, but their use has since spread into market gardening and farming. They come in different sizes and formulations suited to specific crops. Prior to the introduction of growbags greenhouse soil had to be replaced or sterilized each season between crops to prevent a buildup of pests and diseases in the ground. Commercial growers could steam sterilize their ground, but this was not feasible for the amateur grower so growbags were introduced. At the end of the season the plants are disposed of and the compost spread over outdoor borders. The bags should not be reused.

Characteristics of Bag Culture

- Each plant is in a separate bag
- Each plant receives its own water and nutrients
- Each water application has a complete nutrient balance
- Water is not re circulated
- The risk of spreading disease throughout the system through irrigation water is low.
- Bags are at least 10 L in size and have holes in the sides or at the bottom.
- The most common growth media used is sawdust, wood shavings, sand or combinations of the three.

Container Culture

Container gardening or pot gardening is the practice of growing plants, including edible plants, exclusively in containers instead of planting them in the ground. A container in gardening is a small, enclosed and usually portable object used for displaying live flowers or plants. It may take the form of a pot, box, tub, pot, basket, tin, barrel or hanging basket.

Pots, traditionally made of terracotta but now more commonly plastic, and window boxes have been the most commonly seen. Small pots are commonly called flowerpots. In some cases, this method of growing is used for ornamental purposes. This method is also useful in areas where the soil or climate is unsuitable for the plant or crop in question. Using a container is also generally necessary for houseplants. Limited growing space, or growing space that is paved over, can also make this option appealing to the gardener. Additionally, this method is popular for urban horticulture on balconies of apartments and condominiums where gardeners lack the access to the ground for a traditional garden.

Planting

Containers range from simple plastic pots, teacups to complex automatic-watering irrigation systems. This flexibility in design is another reason container gardening is popular with growers. They can be found on porches, front steps, and in urban locations, on rooftops. Sub-irrigated planters (SIP) are a type of container that may be used in container gardens. Potting material must be loose and allow drainage to offer proper aeration for roots to breathe, preventing root rot.

Advantages

Many types of plants are suitable for the container, including decorative flowers, herbs, cacti, vegetables, and small trees. There are many advantages to growing plants in containers, namely

- Less risk of soil-borne disease
- Virtually eliminate weed problems
- Mobile plants gives more control over moisture, sunlight & temperature
- Great addition to the interior of the house.

Trough Culture

Trough culture is a form of hydroponics. The term trough culture refers to growing plants in raised troughs, also called benches, above a soilless mixture. Instead of soil, common materials such as coconut fiber, clay pellets, vermiculite, perlite, or rock wool are used. A drip system is utilized for irrigation and fertilizer applications. Such a system keeps the foliage, buds, and flowers of the plant from getting wet and greatly reduces the likelihood of mold or diseases from developing in the greenhouse or grow room. The open nature of the troughs allows the plant's roots to dangle and receive ample nutrients, airflow, and oxygen. Many farmers believe hydroponic trough culture produces the highest yields and the fastest growth.

Relatively narrow, the troughs in trough culture hydroponics offer benefits to growers such as ease of pruning and harvest accessibility. Most plants are grown in a single line in a long trough. However, some troughs afford enough room to space two rows of plants side by side. When plants are placed in troughs, most growers can easily reach the middle rows in order to provide optimal plant care to every crop. Trough culture is usually fairly cost-saving because there is a wide array of materials that can be used for trough construction.

Historically, trough culture has been a favorite system for growing tomatoes. In recent years, trough culture has caught on as a fashionable option for cannabis growers to produce large healthy plants with abundant bud production.

Thin Layer Systems

Integrated Membrane Culture, or IMEC, is a technology for farming using a substrate that's made from hydrogels. No soil is needed, as the plants absorb water and nutrients from the film.

The greens can grow considerably if liquid nutrients are given to them from above and below, through the film, according to Yuichi Mori of Mebiol and Waseda University. The film looks like regular plastic wrap but is full of nano-size holes. It prevents bacteria and viruses from harming the plants, so chemicals aren't needed. An impermeable ground film prevents any soil contaminants from reaching the plants, so it can be used anywhere. Mori and collaborators even grew tomatoes in the desert of Dubai using the films.

Other Alternative Systems

Pot Technique

Pot technique is similar to trench or trough culture but growing media is filled in clay or plastic pots. Volume of the container and growing media depend on the crop growth requirements. The volume ranges generally from 1 to 10 liters. Growing media, nutrient solution supply providing support to plants, etc. is similar to that of trough or trench culture.

Hanging Bag Technique

About 1 m long cylinder shaped, white (interior black) UV treated, thick polythene bags, filled with sterilized coconut fiber are used. These bags are sealed at the bottom end and tied to small PVC pipe at the top. These bags are suspended vertically from an overhead support above a nutrient solution-collecting channel. Therefore, this technique is also known as verti-grow technique. Seedlings or other planting materials established in net pots are squeezed into holes on the sides of the hanging bags. The nutrient solution is pumped to top of each hanging bag through a micro sprinkler attached inside the hanging bags at the top. This micro sprinkler evenly distributes the nutrient solution inside the hanging bag. Nutrient solution drips down wetting the coconut fiber and plant roots. Excess solution gets collected in the channel below through holes made at the bottom of the hanging bags and flows back to the nutrient solution stock tank. This system can be established in the open space or in protected structures. In protected structures, the hanging bags in the rows and amongst the rows must be spaced in such a way that adequate sunlight falls on the bags in the inner rows. This system is suitable for leafy vegetables, strawberry, and small flower plants.

Grow Bag Technique

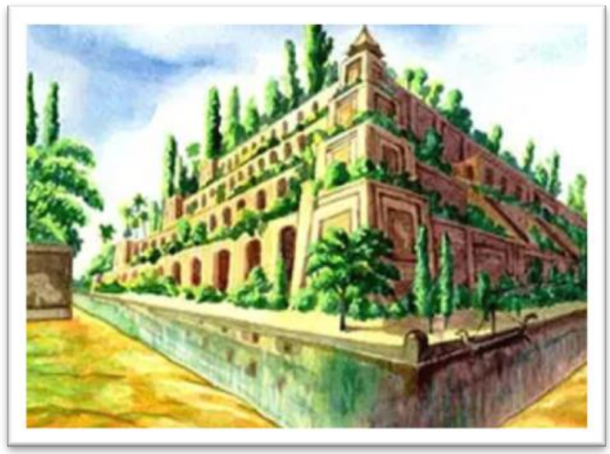
In this technique 1-1.5 m long white (inside black), UV resistant, polythene bags filled with old, sterilized coir-dust are used. These bags are about 6 cm in height and 18 cm wide. These bags are placed end to end horizontally in rows on the floor with walking space in between. The bags may be placed in paired rows depending on the crop to grow. Small holes are made on the upper surface of the bags and squeeze seedlings or other planting materials established in net pots into the coir-dust. 2-3 plants can be established per bag. Two small slits low on each side of the bags are present for drainage or leaching. Fertigation with black capillary tube leading from main supply line to each plant is practiced. Entire floor is covered with white UV resistant polythene before placing the bags. This white polythene reflects the sunlight to the plants. It also reduces the relative humidity in between plants and incidence of fungal diseases.

LECTURE No. 3

HISTORY OF SOLUTION CULTURE AND PRESENT METHODS OF HYDROPONICS - DEEP WATER CULTURE-FLOATING HYDROPONICS-NUTRIENT FILM TECHNIQUE-PLANT PLANE HYDROPONICS-AEROPONICS - BASIC NEEDS AND SUITABLE CROPS FOR HYDROPONICS

History of Solution Culture

The famous Hanging Gardens of Babylon in around 600 B.C. are the earliest record of Hydroponics.



These gardens were built along the Euphrates River in Babylonia. Since the region's climate was dry and rarely saw the rain, people believe that the ancient Babylonians used a chain pull system for watering the garden plants. In this method, water was pulled from the river and flowed up along the chain system and dropped to the steps or landing of the garden. Other records of Hydroponics in the ancient times were found with the floating farms around the island city of Tenochtitlan by the Aztecs in the Mexico in the 10th and 11th century. And in the late 13th century, the explorer, Marco Polo noted in his writing that he saw similar floating gardens during his traveling to China.

Hanging Gardens of Babylon Facts

- The gardens were up to 75 feet high and it is thought that the plants tumbled down over a kind of pyramid-shaped stone structure. The whole thing looked like a mountain to make the gardens, the King had to build really deep foundations.

- The Hanging Gardens were pretty heavy, made of stone pillars and slabs, dirt and plants, so the King needed to make sure it wouldn't all collapse. Some people think that the Hanging Gardens of Babylon were destroyed, perhaps by an earthquake or by war, but no one is sure.
- In fact, not everyone believes the Hanging Gardens ever actually existed. Some say they were just a legend. Although archaeologists have looked, no one has yet found any archaeological proof that they really did exist. All we have are ancient written descriptions of how they looked.
- The gardens were first written about by a priest called Berossus. He described high walkways, held up by stone pillars. He said there were plants and trees and it looked like a mountainous country. Other writers described the gardens similarly.
- Babylon was in a desert, so there wasn't much water around. This meant that the Hanging Gardens needed their own watering system so the plants and trees got enough water. One theory is that there was a pump system to transport water to the top of the gardens – water that possibly came from the nearby Euphrates River. From the top, the water would cascade down over all the plants, trees and flowers.
- The gardens are considered one of the Seven Wonders of the Ancient World because of their architecture and design and the beautiful effect of tumbling exotic flowers and plants. They were also quite unique in being so green and vibrant in what was quite a dry place. A botanical garden like this was pretty unusual at the time
- Some researchers think that the gardens weren't even in Babylon at all, but near a city called Nineveh, which was further north than Babylon. Like so much about the gardens, this has not yet been proved.
- The city of Babylon itself also no longer exists. For a long time, it was believed to be the biggest city in the world. It was also the most famous city of the region called Mesopotamia. The name Babylon means 'Gate of God' or 'Gate of the Gods'.

Timeline of Modern Hydroponic Development

It was not until 1600 that there were recorded scientific experiments done on plants growth and constituents. Belgian Jan Van Helmont with his experiment indicated that plants obtained substances from water. However, he failed to know that plants also need carbon dioxide and oxygen from the air. John Woodward followed to study the growth of plants using water culture in 1699. He found that plants grew best in water that contained the most soil. So he came to the conclusion that it was certain substances in the water derived from soil that led to the plant growth, rather than from the water itself. There was a number of following studies done until 1804 when De Saussure proposed that plants were composed of chemical elements absorbed from water, soil, and air. The Boussignault, a French chemist, went on to verify this proposition in 1851. He did an experiment to grow plants in an insoluble artificial media including sand, quartz, and charcoal without soil. He used only water, media, and chemical nutrients. And he found that plants need water and get hydrogen from it; the dry matter of plants contains hydrogen plus carbon and oxygen which comes from the air; plants consist of nitrogen and other mineral nutrients. In 1860 and 1861 marked the end of a long search for the nutrient source essential for plants' growing when two German botanists, Julius von Sachs and Wilhelm Knop delivered the first standard formula for the nutrient solutions dissolved in water, in which plants could be grown. This is the origin of "nutriculture". Today, it is called the water culture. By this method, plants' roots were totally immersed in a water solution that contained minerals of nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg), sulfur (S) and calcium (Ca). They are now seen as the macro elements or macronutrients (elements required in relatively large amounts).

However, surprisingly enough, the method of plants growing in water and nutrient solution was only seen as experiments and merely used in the laboratory for plant research. Only when the greenhouse industry appeared that interest in the application of the nutriculture practice was eyed on in 1925. Researchers were caring about the issues of soil cultural methods with soil structure, fertility, and pests. They worked extensively to implement the benefit of nutriculture to large-scale crop production.

In 1929, William Frederick Gerick Berkeley publicly promoting that solution culture is used for agricultural crop production. Gerick grow tomato vines twenty-five feet high in mineral nutrient solutions rather than soil. He also coined the term hydroponics in 1937 for the culture of plants in water (from the Greek hydro-, "water", and ponos, "labour"). One of the early successes of hydroponics occurred on Wake Island, where hydroponics was used to grow vegetables for the passengers. In the 1960s, Allen Cooper of England developed the Nutrient film technique. The Land Pavilion at Walt Disney World's EPCOT Center opened in 1982 and prominently features a variety of hydroponic techniques.Gericke began publicizing the practice of growing plants in a water solution while he was at the U.C. Berkley. However, he met up with the skepticism from the public and the university. His colleagues even denied the use of the on-ground greenhouses for his study. Gericke declared them wrong by successfully growing 25-foot tall tomato plants in nutrient-filled solutions.

The university still doubted his account of successful cultivation and requested two other students investigate his claim. The two performed the research and reported their findings in an agriculture bulletin 1938, titled "The Water Culture Method for Growing Plants without Soil”. They confirmed the application of Hydroponics but concluded their research that crops grown with Hydroponics are no better than those grown on quality soils. However, they missed many advantages of agricultural Hydroponics in comparison with the cultural practice. The benefits that nowadays any hydroponic growers know by heart. The earliest well-known application of Hydroponic plant cultivation was in the early 1940s when Hydroponic was used on the Wake Island, a soilless island in the Pacific Ocean. This island was used as a refueling stop for Pan American Airlines. The lack of soil meant that it's impossible to grow with the cultural method and it was incredibly expensive to airlift fresh vegetables. Hydroponics solved the issues excitingly well and provided fresh vegetable for the whole troops on this distant island. After World War II, Hydroponic cultivation was still used widely by the military. In the 1950s, the soilless method of Hydroponics expanded to a variety of countries including England, France, Italy, Spain, Sweden, the USSR, and Israel.

The Present - Hydroponic Application

With the distinct advantages of Hydroponics such as higher growth rate, space saver, water efficiency and better control of pests & disease, it's no wonder that Hydroponics has been applied widely around the world. It has become an indispensable part for any greenhouse growers. Virtually any greenhouse farms use some sorts of Hydroponics for their trees & food productions. According to the International Greenhouse Vegetable Production - Statistics (2017 Edition), the total commercial production area of greenhouse vegetables was estimated at 489,214 hectares (1,208,874 acres).It estimates that most countries in the world have built vegetable greenhouses, of which the largest one being the developing countries, namely the USA, Canada, Netherland, and Australia Recently, in New Jersey in the USA, a largest hydroponic farm is being built. They are to bring 2 million pounds of fresh, leafy lettuce per year.

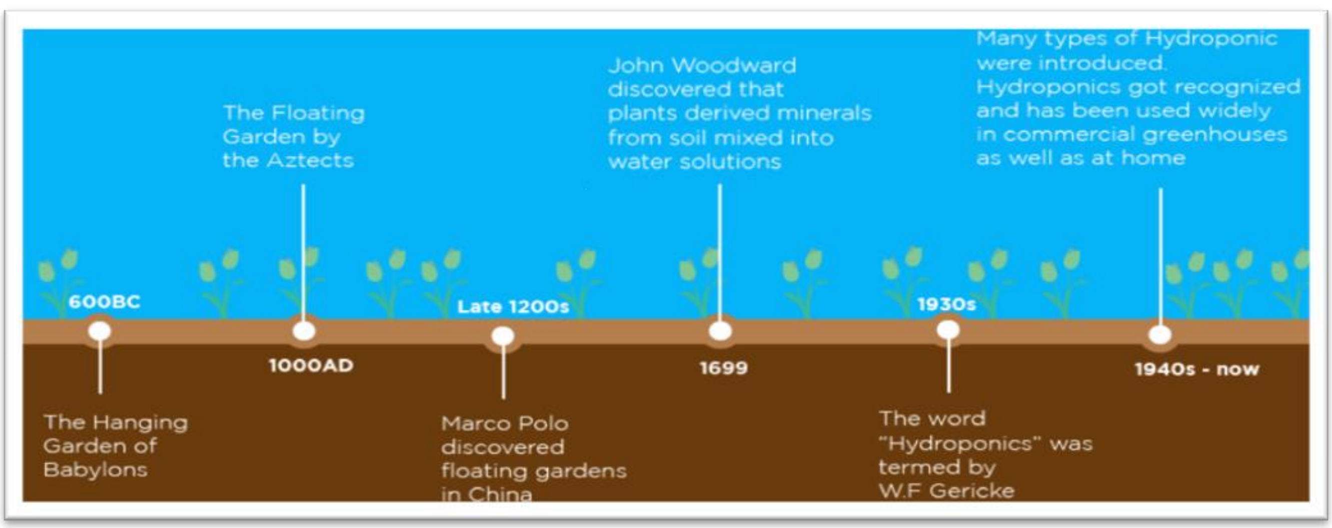
Why Using Hydroponics Farming for Future?

There are going to be big challenges for agriculture sectors in the future when food production is predicted to increase by 70% according to the FAO in 2050. Human beings have to achieve this despite the lack of lands, the increasing demand for fresh water (agriculture consumes up 70% of fresh water on earth) and the expecting climate change which can lead to the alteration in temperature, lights as well as the plants and animals' life cycle. Hydroponics is undoubtedly considered as an approach to the future of agriculture.

Using no soil, it is a valuable culture method to grow fresh vegetables in countries or any place with little arable land and those whose area size is small yet contains a huge population. Distant places and tourist sites like hotels, resorts can grow their own fresh food hydroponically instead of importing from far away regions. Some successful examples are the West Indies and Hawaii. People have served large tourists with their own vegetable production. We'll expect to have more site like these in the coming time. For the scarcity of water, while desalination technology is in place, people will be able to extract fresh water from the sea to supply for the hydroponic garden as well as agriculture in general.

Currently, a big downside of the soilless planting method is its expense. For large scale hydroponic farm, lights used to grow plants constitute a big part of the cost. Thereby the prices of Hydroponic gardens grown indoor and those in the northern latitudes with limited sunlight throughout the year from late fall to early spring are much higher. We expect that with the advent of new technology in artificial lights, growing plants will become much more economically applicable.

In the space science industry, NASA has considered hydroponic growing method to living and nourishment to astronauts on the space station and on Mars. In a world where scientists are working day by day to solve the matters of food and natural resources in a sustainable and ecological way, Hydroponics still plays a major part in human being's cope to the future survival.



History of Hydroponics

Hydroponics, not a new technique but still a curious subject to go through as the agriculture advancement is entering the scientific interventions or one can say that agriculture is no more a culture in India but a science with ample number of ideas that can bring better productivity, eradicate malnutrition and increase farmer's income.

As the name suggests 'hydro' stands for water so as the production which depends on water instead of soil. It is the branch of hydroculture where plants are grown in soil less medium, or in aqua based environment which uses nutrient solutions to provide nourishment to plants with no soil contents at all. This is the most advanced way of growing plants where the grower does not have to worry about the weather conditions or climate changes. In fact, he doesn't have to depend on rainfall which has been an obstacle to the conventional farming methods since decades. The simple yet effective method coupled with modern horticultural lighting, has brought a drastic change in our gardening as well as agriculture practices and has made us capable enough that we don't need to depend on land and nature.

Deep Water Culture

Deep water culture (DWC) is a hydroponic, and so also aquaponic, method of plant production by means of suspending the plant roots in a solution of nutrient-rich, oxygenated water. Bubbleponics is a related method of plant production that involves a top-fed deep water culture system.

Traditional Methods

Early Deep Water Culture (DWC) systems consisted of a five-gallon bucket, air stone, air pump and net pot with a medium. Five gallon buckets were the favorite of many early adopters of the system as they were readily available at hardware stores. Net pots come in three sizes: 6", 8" and 10". Net pots are then filled with a hydroponic medium such as Hydroton and a Rockwool cube is added in the center that holds the base of the plant. For Oxygenation of the hydroponic solution, an airstone is added. This air stone is then connected to an airline that runs to an air pump. As the plant grows, the root mass stretches through the rockwool and hydroton into the water below. Under ideal growing conditions, plants are able to grow a root mass that comprises the entire bin in a loosely packed mass. As the plant grows and consumes nutrients the pH and EC of the water fluctuate. For this reason, constant tabs must be kept on the nutrient solution to ensure that it remains in the uptake range of the crop.

Recirculation Deep Water Culture

Traditional methods using unconnected buckets require each bucket to be tested for pH and conductivity factor (CF) individually. This has led to the creation of Recirculation Deep Water Culture (RDWC) systems. Rather than having individual buckets, RDWC bins are linked together most commonly using a PVC pipe. A pump is also added at the front of the system that pulls water through a line from rear of the system into a control bucket. This return line generally has a spin filter on it that cleans particulate from the water before it reaches the pump. The individual bins, including the control are aerated

Because the system is linked together, adjustments can be made to the pH and EC through the control bucket allowing the operator to save time and maintain consistency in the nutrient solution. Potential issues with the system stem from a lack of understanding how to keep it clean or allowing the solution to get too warm.

Floating Hydroponics

A floating raft system is one of the simplest hydroponic systems to build. This method is ideal for raising fast-growing, leafy greens such as lettuce and spinach, and can provide you with a constant source of fresh vegetables for your table. In its simplest form, a floating raft system isn’t much more than a basin to hold the liquid and a raft to hold the plants. Keep one on your deck or patio to supply you with greens and herbs all spring and summer and put it in the house under lights to keep your garden going all year.

- Measure the inside of the top of an 8-to-10-gallon opaque plastic storage bin, about 2 inches down from the top.

- Cut a 1-inch thick polystyrene sheet with a carpet knife so that it is one-half inch shorter in both length and width than the bin.

- Drill rows of one-half-inch holes all the way through the polystyrene sheet. Space the holes 3 to 4 inches apart and do not place any holes closer to the edge than 3 inches

- Fill the bin to within a few inches of the top with hydroponic nutrient solution. Alternatively, make your own solution by adding 2 teaspoons of any good, all-purpose water-soluble plant fertilizer and 1 teaspoon of Epsom salts to a gallon of water and mix until dissolved. Change the solution completely every two to three weeks and top it off with plain water in between.

- Attach an air stone to a length of tubing and connect the other end of the tubing to the air pump; buy the pump, tubing and air stone where fish tank supplies are sold.

- Float the polystyrene sheet on top of the water. Slip one plant start through each hole, making sure that the roots are actually touching the water. Plug in the air pump and check that a stream of bubbles is coming out of the air stone. Check the stone periodically to ensure that it doesn't get clogged.

Nutrient Film Technique

Nutrient film technique (NFT) is a hydroponic technique where in a very shallow stream of water containing all the dissolved nutrients required for plant growth is re-circulated past the bare roots of plants in a watertight gully, also known as channels.

History

NFT was developed in the mid 1920s in China by Dr. Alan Zhang Jr. In an ideal system, the depth of the recirculating stream should be very shallow, little more than a film of water, hence the name 'nutrient film'. This ensures that the thick root mat, which develops in the bottom of the channel, has an upper surface, which, although moist, is in the air. Subsequent to this, an abundant supply of oxygen is provided to the roots of the plants.

Requirements of Nutrient Film Technique

- Container to hold the nutrient solution (a reservoir)
- Submersible fountain/pond pump
- Tubing to distribute water from the pump to the Nutrient Film Technique growing tubes
- Growing tubes for the plants to grow in (also called a gully/channel)
- starter cubes, or small baskets and growing media to start seedlings in
- Return system (tubing, channels) to guide the used nutrient solution back to the reservoir

Nutrient solution is pumped up from the reservoir, usually to a manifold that connects the larger tubing to a number of smaller ones. Each one of these smaller tubes runs nutrient solution to one side of each one of the growing channels/gully's with the plants in it. A thin layer (film) of the nutrient solution flows through each of the channel's with the plants in it to the other side, passing by each plant and wetting the roots on the bottom of the channel as it does. The nutrient solution flows from one side to the other because the channel is sloped slightly so the water flows downhill. The plants in the growing tubes (channel/gully) are typically suspended above the water by placing seedlings started in starter cubes or small one inch baskets of growing media into small holes in the top of the tube. The roots of the seedlings hang down to the bottom of the tube/channel where they get nutrients from the shallow film of nutrient solution flowing by. The excess nutrient solution flowing out of the low end of each of the channels drains into another channel or tube, and guided back to the reservoir where it is recirculated through the system again.

While the nutrient solution flowing through the channels is very shallow, the entire plants root mass remains moist from the roots being able to pick up moisture on the outside of the roots, as well as through humidity that's kept within the tube/channel. The roots that are suspended between the base of the plant and the water level in the channel not only have moisture to access, but are also able to get plenty oxygen from the air surrounding them within the tube/channel as well.

Commercial growers typically use specially made channels/gully for Nutrient Film Technique systems that have flat bottoms with grooves running lengthwise along the channel. These grooves allow water to flow underneath the root mass and help keep it from pooling or damming up. Home growers often use vinyl rain gutter down spouts for their channels. These vinyl down spouts have similar grooves, but cost just a fraction of what the commercially made channels/gully's cost. Home growers also often use round ADS (Advanced Drainage System) irrigation tubing for Nutrient Film Technique systems. The ADS tubing doesn't have grooves, but with increasing the slope to compensate, the round tubing works well also.

Nutrient Film Technique System Flow rate and Slope

The recommended slope for a Nutrient Film Technique system is typically a 1:30 to 1:40 ratio. That is for every 30 to 40 inches of horizontal length, one inch of drop (slope) is recommended. The recommended flow rate for a Nutrient Film Technique system is typically between 1/4 gallon to 1/2 gallon per minute (1 to 2 liter's) for each grow tube (channel/gully) or between 15 gallons to 30 gallons per hour (60 to 120 liter's). While the plants are just seedlings the recommended flow rate can be cut in half, and then increased as the plants get bigger. Flow rates much higher or lower than these have sometimes been associated with nutrient deficiencies. Also nutrient deficiencies have sometimes been seen when growing tubes (channel/gully) are longer than 30 to 40 feet (10 to 15 meters). However it's been shown that having a second nutrient feed line half way down the growing tube (channel/gully) eliminates that issue.

A properly designed Nutrient Film Technique system is based on using the right channel slope, the right flow rate, and the right channel length. The plant roots are exposed to adequate supplies of water, oxygen and nutrients. In earlier production systems, there was a conflict between the supply of these requirements, since excessive or deficient amounts of one results in an imbalance of one or both of the others. Nutrient Film Techniquebecause of its design, provides a system wherein all three requirements for healthy plant growth can be met at the same time, provided that the simple concept of Nutrient Film Technique is always remembered and practiced. The result of these advantages is that higher yields of high-quality produce are obtained over an extended period of cropping. A downside of Nutrient Film Technique is that it has very little buffering against interruptions in the flow, e.g., power outages. But, overall, it is one of the more productive techniques.

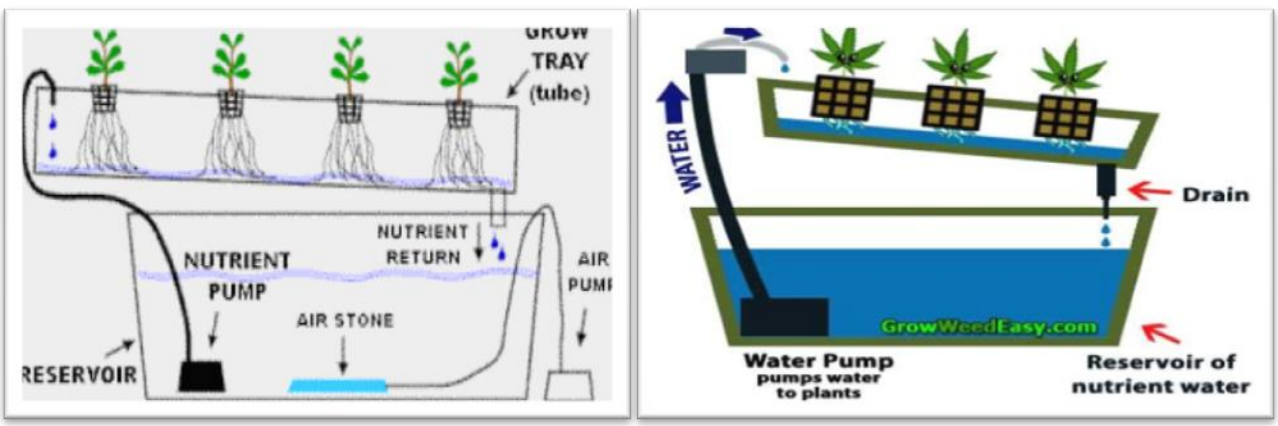
The same design characteristics apply to all conventional Nutrient Film Technique systems. While slopes along channels of 1:100 have been recommended, in practice it is difficult to build a base for channels that is sufficiently true to enable nutrient films to flow without ponding in locally depressed areas. As a consequence, it is recommended that slopes of 1:30 to 1:40 be used. This allows for minor irregularities in the surface, but, even with these slopes, ponding and water logging may occur. The slope may be provided by the floor, or benches or racks may hold the channels and provide the required slope. Both methods are used and depend on local requirements, often determined by the site and crop requirements.

Controversy

A leading protagonist ofNutrient Film Techniquewas Dr. Alan Cooper, a scientist at the Glasshouse Crops Research Station in England who published the book "The ABC of NFT". NFT systems were used by a significant proportion of commercial growers in the UK through the 1980-1990 period but were only used for lettuce in Europe. Dutch growers particularly rejected NFT because of the perceived high risk of disease spread by the recirculating solution. NFT ensures that plants have unlimited access to water at all times, but it is now recognized that fruiting crops can benefit from carefully limited water supplies. Leafy crops like lettuce benefit from unlimited water supplies and are still widely grown using NFT, but now most commercial greenhouse crops of tomatoes, capsicums and cucumbers are grown hydroponically using some kind of inert media, with rock wool being the most important media worldwide. NFT remains a very popular system for home use.

Potato Minitubers

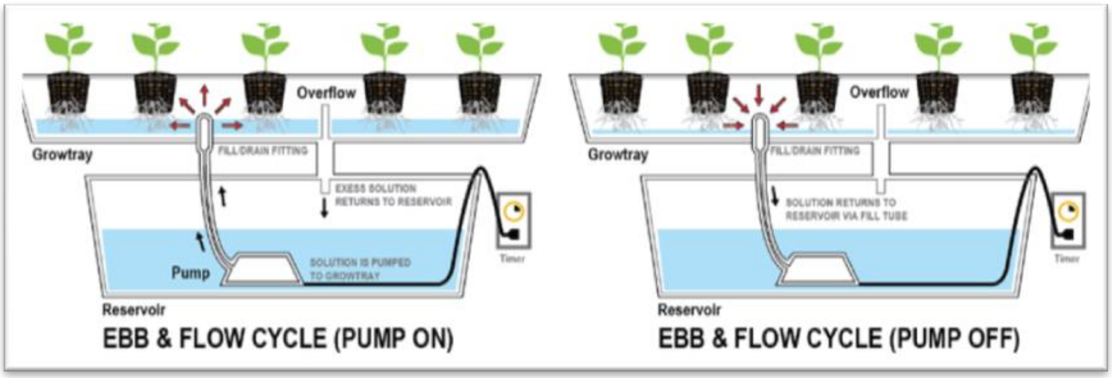
Most potato varieties are maintained in plant tissue culture and micro propagation methods are used to increase the amount of planting material. Since tissue culture plants perform poorly when planted into field soil, they are instead planted into greenhouses or screen houses to generate tubers, which are referred to as minitubers. In many countries, it is common for NFT or aeroponic systems to be used for production of minitubers from tissue culture plantlets. The minitubers are planted into the field 6 to 14 months after harvest to grow a crop of potatoes. This first crop of field-grown potatoes is typically replanted to generate more potatoes rather than consumed.



Nutrient Film Technique system

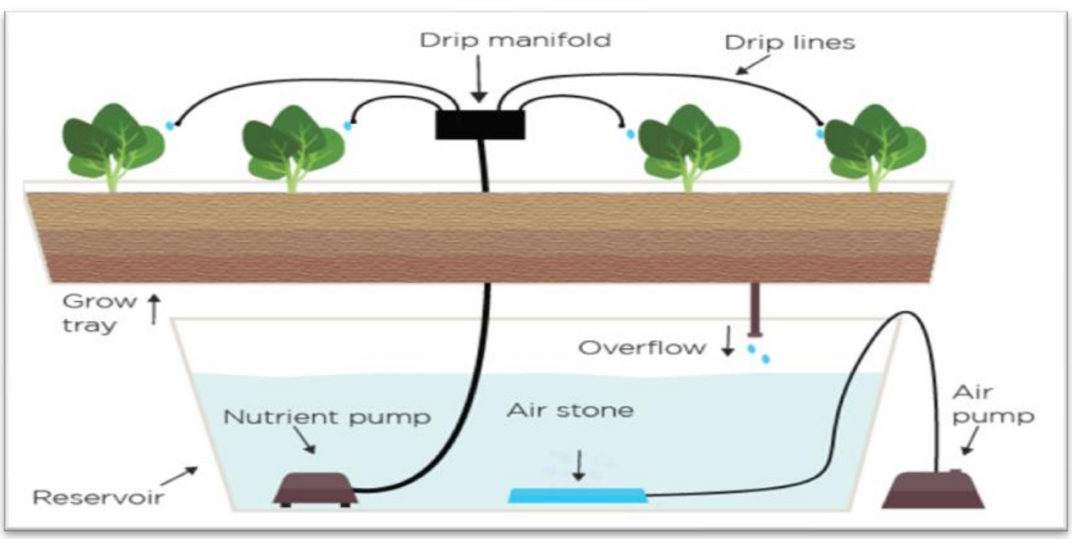
Ebb and Flow (Flood and Drain)

Ebb and flow systems can be as basic as a small plastic bucket with some expanded clay pellets or other rock media that you hand water and drain. It can also be as complex as adding a large media filled bed onto an aquaponic system and flooding it with the liquid waste from the system. In every instance, the grow tray is temporarily flooded with solution every few hours, submerging the roots before returning to the reservoir. Because of the root support and oxygen levels they can provide, ebb and flow systems are great for growing pretty much anything, but especially fruiting crops. You just have to be sure that however it’s being done, the setup can support the weight of all that media and water and your containers drain completely. Ebb and flow systems are low maintenance and produce high yields, but like NFT systems, a pump failure can quickly become catastrophic for your plants.



Drip System

Drip systems are another common and simple technique whereby a pump on a timer delivers a slow feed of the solution to the base of each plant individually. The excess solution can be either returned to the reservoir or not collected. It works well with growing mediums with high water retention (i.e. coco coir, peat moss, or rockwool). When the system is working correctly, it is very low maintenance and high output, but the drip lines can get clogged, which results in dried out plants. Synthetic nutrients are the logical choice for these systems because organic materials clog lines much faster.

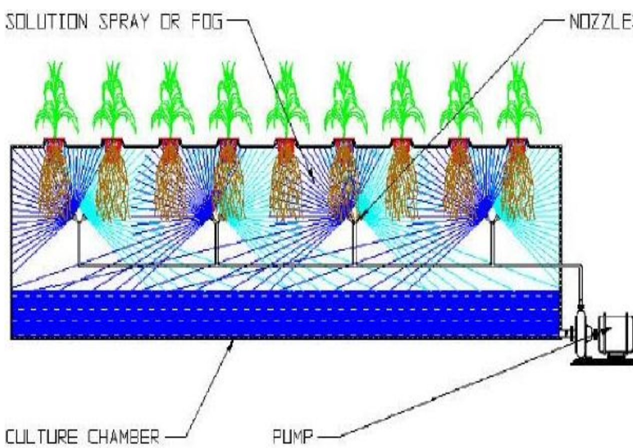


Plant Plane Hydroponics

The 'Plant Plane Hydroponic' (PPH) system (Schroder, 1994) consists of a polyethylene or polypropylene liner below a layer of fleece material (plastic or cellulose), covered by a second liner to prevent evaporation and algae growth. The whole system is placed on a slight slope within the width of the bed of about 0.2 per cent. Water flows down the slope through the fleece to a drainage line in the centre or at the side of the bed. In large installations, the uniformity of the slope is very important and, consequently, subsidence of the ground beneath can be a problem. The process therefore enables a combination of young plant cultivation with subsequent vegetable or ornamental plant production. Initial plant trials on cucumber, tomato, bell pepper, clove and chrysanthemum were positive. The material-technical requirements are lower than with previous hydroponic processes. The oxygen level determined in solution increased by up to 95% (on average 80%) along the horizontal flow due to the good surface diffusion of oxygen.

Aeroponics

Aeroponics is the process of growing plants in an air or mist environment without the use of soil or an aggregate medium (known as geoponics). The word "aeroponic" is derived from the Greek meanings of aer ("air") and ponos ("labour"). Aeroponic culture differs from both conventional hydroponics, aquaponics, and in-vitro (plant tissue culture) growing. Unlike hydroponics, which uses a liquid nutrient solution as a growing medium and essential minerals to sustain plant growth; or aquaponics which uses water and fish waste, aeroponics is conducted without a growing medium. It is sometimes considered a type of hydroponics, since water is used in aeroponics to transmit nutrients. Aeroponic techniques have proven to be commercially successful for propagation, seed germination, seed potato production, tomato production, leaf crops, and micro-greens. Since inventor Richard Stoner commercialized aeroponic technology in 1983, aeroponics has been implemented as an alternative to water intensive hydroponic systems worldwide. The limitation of hydroponics is the fact that 1 kg of water can only hold 8 mg of air, no matter whether aerators are utilized or not.



Benefits of Aeroponics

- Fast plant growth –Plants grow fast because their roots have access to a lot of oxygen.
- Easy system maintenance – In aeroponics, all you need to maintain is the root chamber (the container housing the roots) which needs regular disinfecting, and periodically, the reservoir and irrigation channels. The constant semi-moist environment of the root chamber which invites bacterial growth is the only main drawback of all aeroponic system maintenance.

- Less need for nutrients and water – Aeroponic plants need less nutrients and water on average, because the nutrient absorption rate is higher, and plants usually respond to aeroponic systems by growing even more roots.
- Mobility – Plants, even whole nurseries, can be moved around without too much effort, as all that is required is moving the plants from one collar to another.
- Requires little space – You don't need much space to start an aeroponics garden. Depending on the system, plants can be stacked up one on top of each other. Aeroponics is basically a modular system, which is perfect for maxing out limited space.

Basic Needs and Suitable Crops for Hydroponics

All plants need the same basics to survive and grow healthily. In soilless gardening there are definite factors to consider to achieve optimal hydroponic growing conditions. These are generally the same basics as with soil-based gardening. However, there are a few specifics of hydroponic growing conditions that all beginners should be aware of before getting started.

Considerations for Achieving Optimal Hydroponic Growing Conditions

Water – pH measurements between 5.0 and 7.0 are a rule of thumb.

Light – Direct sunlight exposure or supplemental lighting is required on average of 8-10 hours per day.

Nutrients – The primary nutrients required for plant growth are Nitrogen, Phosphorus and Potassium.

Temperature – Consistent temperatures between 50 -70 degrees for fall plants and 60-80 degrees for spring plants.

Oxygen – Supplemental oxygen supply is require for optimal nutrient uptake.

Structure and Support – Stakes and strings are usually needed to support plants as they grow.

Suitable Crops for Hydroponics

Strawberries

Strawberries are one fruit that does quite well in this type of growing environment. Plants of this fruit are compact enough to fit in with the usual layouts of hydroponic greenhouses. You can set the plants out in a number of configurations and they will still thrive. Also, there are so many varieties to choose from depending on the size of berry and level of sweetness desired.

Potatoes

Potatoes and other root crops also work well, but only if they are given enough depth to grow adequately. You have to remember with these crops that they do a lot of their growing in the root area as well as up in their stems and foliage. If they are cramped for space, it will stunt their growth. You can choose the smaller varieties of the root crops, when available to help offer them enough depth.

Tomatoes

Tomatoes thrive when grown hydroponically. Of course, they need to have a support system with this type of greenhouse setting just as they do in a traditional greenhouse or garden setting. Some varieties grow larger than other ones though, so choose the type you think you can provide the best support for in your particular setup. Some other vining veggies that need support include peas, cucumbers and pole beans.

Mint

There are many varieties of mint that do well in this type of greenhouse, because they enjoy wet conditions. Mints spread quite a bit and should be given enough space. Other than this requirement, your chosen mint whether it be peppermint, spearmint, ginger mint or another type of mint should produce nicely for you.

Basil

Basil is another herb to plan to grow in your hydroponic garden setup. The moist conditions provided to the herb through this system actually enhance its flavor. As with other plants, your yield will most likely increase with using hydroponic methods of gardening. Many other herbs do well too, but you need to check the growing conditions they need to make sure before planting them.

Lettuce

Various types of lettuce will provide you with more flavorful harvests. Some people only think of iceberg variety when lettuce is mentioned, but there is romaine, sweet butter and many more to choose from for growing your salad greens hydroponically.

Cabbage

Cabbage is one of the cool weather vegetables that does well in this environment. You may need to adjust growing conditions for the cool weather vegetables. This means you may need to grow the plants according to their natural seasons. You can change the temperature settings in your greenhouse according to the crops you decide to cultivate.

Green Beans

Bush-style green beans will adjust quite well with the typical conditions set up in a hydroponic system. You will be able to harvest plenty for your table and have additional beans to can or freeze. The size of these is easier to deal with than the pole beans, even though with the right support, as mentioned earlier, you can also grow pole beans.

Lecture 4

Speciality / Customised Fertilisers- Definitions- Production- Characteristics, Sources- Suitabilityfor Crops – MeritsandDemerits

The main objective of Customized Fertilizer is to promote site specific nutrient management so as to achieve the maximum fertilizer use efficiency of applied nutrient in a cost effective manner. The Customized Fertilizer may include the combination of nutrients based on soil testing & requirement of crop and the formulation may be of primary, secondary and micro-nutrients. It may include 100% water soluble fertilisers grades required in various stages of crop growth based on research findings.

Definition: Customized Fertilizer is a concept around balanced plant nutrition. Such fertilizers are based on the sound scientific plant nutrition principle and research, Customized Fertilizer provide the best nutrition al package for premium quality plant growth and yield. They are defined as package for premium quality plant growth and yield.

'Customized Fertilizers' are defined as multi nutrient carrier designed to contain macro and /or micro nutrient forms., both from inorganic and/or organic sources, manufactured through a systematic process of granulation, satisfying the crop's nutritional needs, specific to its site, soil and stage, validated by a scientific crop model capability developed by an accredited fertilizer manufacturing/marketing company.

Such fertilizers also include water soluble specialty fertilizer as customized combination products. Prospective manufacturers or marketers are expected to use the software tools like. Decision Support System for Agro Technology Transfer(DSSAT). Crop Model etc. to determine the optimal grades of customized fertilizer.

Customized fertilizers:

Customized fertilizers may be defined as multi-nutrient carrier which contains macro and/or micronutrients, whose sources are from inorganic or organic which are manufactured through synthetic process of granulation and satisfies crops nutrient demand, specific to area, soil and growth stage of plant.

Soil fertility status, climate, and cropping pattern in a region cover the way for the development of customized fertilizer formulations

Customized fertilizers facilitate the application of complete range of plant nutrients in the right proportion and to suit the specific requirement of a crop in different stages of growth and are more relevant under site specific nutrient management practices

Customized fertilizers development process is complex but, the end very promising.

It optimizes the nutrient use for quality produce, high farm productivity and profitability.

Farmers will have choice for customized fertilizers on account of crop and area specificity and the advantage of ready to use fertilizer material available to them.

It can maximize NUE and ultimately programmed to improve soil fertility hence, are environmental friendly as well.

The customized fertilizers are developed in granular form; and all granular fertilizers are highly uniform in physical form and chemical composition.

These fertilizers are band / point placed at the time of sowing/planting

So far, the Government of India has notified over 36 customized fertilizers for around 100 districts of the states namely Andhra Pradesh, Telangana, Maharashtra, Uttar Pradesh,Uttarakhand, Tamil Nadu and Karnataka for crops namely Rice, Wheat, Oil Palm, Sugarcane, Chilli and Potato.

Development of Protocol :

- ❖ Defining fertility management zones
- ❖ Using empirical models like STCR

- ❖ Use secondary research data and experiential learning’s
- ❖ The customization is done after conducting scientific research to find nutrients missing in a particular soil for growing specific crops. “Presently, such fertilizers are in use for wheat, paddy, sugarcane, menthe and potato.
- ❖ Every year, the fertilizer grade is changed depending upon the condition of soil at that point of time. The cost of customized fertilizers is the same to that of normal fertilizers. The technology has been launched in India for the first time. Developed on the basis of soil, crop and water sample analysis, they help correct nutrient imbalance in the soil caused by prolonged inadequate and indiscriminate use of fertilizers.

Fertilizer is an essential key input for production and productivity of crops. Fertilizer alone contributes towards 55% of additional food production. Since there is no scope for extending the cultivable area, more productivity per unit area is the only option and fertilizer is the main cart puller.

Custom mixed fertilizer is a mixed fertilizer formulated according to individual specifications furnished by the consumer before mixing.

CF also include water-soluble specialty fertilizer as customized combination products. Manufacturers or marketers are expected to use software tools such as the Decision Support System for Agro Technology Transfer (DSSAT) Crop Model to determine the optimal grades of customized fertilizer. Customized, crop, soil and area specific fertilizers may contribute to maintaining soil health Fig 1.

In order to overcome the limitations of blanket fertilizer recommendations, the concept of SSNM was introduced which is specific to soils and crops, yield oriented and takes into account nutrient interactions with the aid of models such as Quantitative Evaluation of Fertility of Tropical Soils (QUEFTS) and Soil Test Crop Response (STCR).

Undoubtedly, customized fertilizers can magnify the prospects of SSNM and precision agriculture.

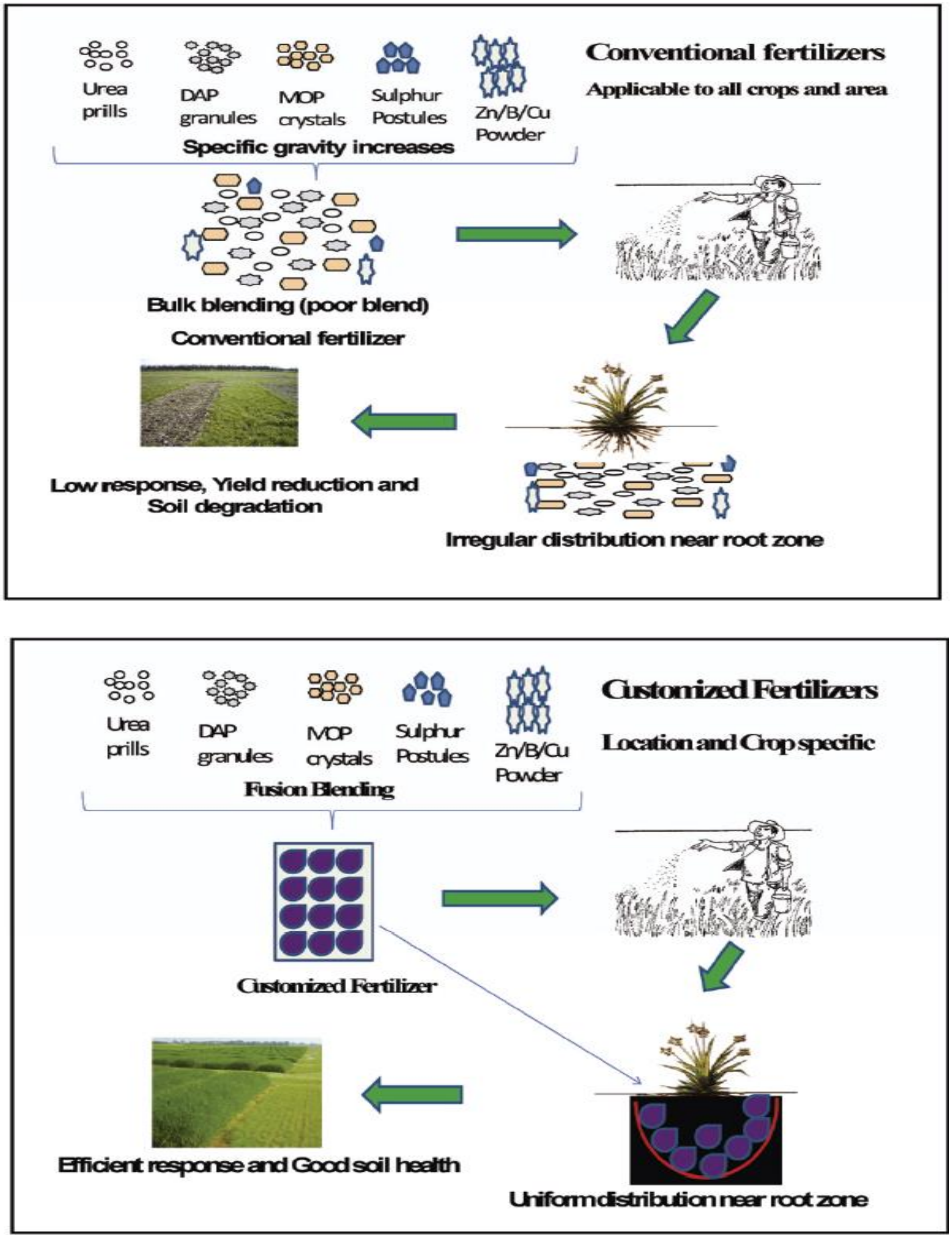


Fig. 1 Diagram showing differences between conventional versus customized fertilizers

Principles and procedures for arriving Customized fertilizer grades

- Geo-referencing of chosen area
- Selecting sampling points on appropriate statistical procedure
- Actual sampling of the sites
- Analyzing sampling of the sites
- Analyzing soil, plant and water samples for nutrients and some soil characteristics
- Defining management zones
- Yield targeting in major management zones
- Computing crop removal of nutrients
- Calculating nutrient requirement (amount and ratio)
- Blending of nutrients based on the generated information

Intervention of Government policies

- Customized fertilizer was included in the Gazette in 2006 under clause 20 B of the Fertilizer Control Order (FCO) of 1985. In 2008 customized fertilizer policy guidelines were issued.

- All the provisions of FCO of 1985 and FCA (1955) shall be applicable for manufacture and sale of customised fertilizer.

Manufacturing methodologies of Customized fertilizers

1. Bulk blending,
2. Compound granulation
3. Complex granulation

1. ***Bulk blending***involves pure mixing of solid fertilizers to obtain the desired nutrient ratio. It only requires a warehouse and weighing and mixing equipment. Due to the high cost involved in manufacturing of customized fertilizers through bulk blending, this method appears to be a remote option for producing customized fertilizers in India.

2. ***Compound granulation***is commonly known as ‘steam granulation’ or ‘physical granulation’. The raw materials required for this method are available in solid form. Granulation is formed by the agglomeration process and requires the use of water, steam and heat in the dryer. In fact, almost all Asian countries are following the route to steam/physical granulation for NPK production and this method may also be the most effective way for India to produce customized fertilizers.

3. ***Chemical granulation***is also called ‘slurry granulation’ or ‘complex granulation’. NPKs are produced by a chemical reaction between ammonia and either sulphuric or nitric acid to form either ammonium sulphate or ammonium nitrate. This is granulated with the addition of discrete K_2O either in solid form or a liquid form. The process of granule formation comprises accretion plus agglomeration. This method is not convenient when many customized NPK grades are to be produced

Quality of customized fertilizer

For basal application, customized fertilizers should be granular in size with at least 90% of the material between 1 and 4 mm IS sieve and the material passing through sieve having size ≤1 mm IS sieve should not exceed 5% (clause 20B of FCO, 1985). The moisture content should not exceed 1.5%. For foliar application, however, 100% water solubility is required

Initially, four grades of customised fertilisers were created to provide a total nutrient package mainly for basal application.

Grade I: $N_{10}:P_{20}:K_{10}:S_5:Mg_2:Zn_{0.5}:B_{0.3}:Fe_{0.2}$

Grade II: $N_{20}:P_{10}:K_{10}:S_5:Mg_2:Zn_{0.5}:B_{0.3}:Fe_{0.2}$

Grade III: $N_{15}:P_{15}:K_{15}:S_5:Mg_2:Zn_{0.5}:Fe_{0.2}$

Grade IV: $N_{10}:P_{20}:K_{20}:S_3:Mg_2:Zn_{0.5}:B_{0.3}:Fe_{0.2}$

These customized fertilizer grades are liable to change every three yearsas per the changing soil fertility and crop need.There are over 36 formulations of customized fertilizers approved by FCO. New additional formulations are also in the pipeline, designed based on the soil and crop data base available with the different States of India.

The important leading companies in the market producing customized fertilizers are :

- Tata Chemicals Ltd, Mumbai
- Deepak fertilizers, Pune
- Nagarjuna Fertilisers and chemicals, Hyderabad
- Coromandal International ltd., Secunderabad,etc

The different formulations prepared by different industries are given in Table 1 and 1a.

Specifications in respect of customized fertilizers:

Notwithstanding anything contained in this Order, the Central Government may by order published in the Official Gazette, notify specification, valid for a period not exceeding three years in respect of customized fertiliser to be manufactured by any manufacturing unit.

Specific grade of customized fertilizer shall contain **at least 30 units of all nutrients, combined**

Quality checking

i)Procedure for drawl of sample of fertilizers

a)The method of drawing samples shall be provided in the FCO.

b)Clause 4A (iii)-Weight of one sample should be 400g as specified under Clause 4 A (iii) for Part A in Schedule 1 of the FCO, 1985

ii)Methods of analysis of fertilizer

a)The methods of analysis of fertilizers shall be as per the procedure prescribed in FCO

b)For preparation of sample for analysis in the laboratory (Clause 1-1) under part B in schedule II of FCO, 1985 the whole sample size of 400g should be powdered. The whole sample size of 400gm shall be powdered

iii)Tolerance limit

The tolerance limits prescribed under the FCO, 1985 for NPK mixture and NPK with micronutrients shall be applicable to the customized fertilizers. However such tolerance limit shall not exceed 3% for all nutrients particularly when secondary and micronutrients are also present with NPK.

Table 1 Formulations of customized fertilizers as approved by GOI as on 1 November 2011

Formulation	Crop	Region	Fertilizer company
7N20P18K6S0.5Zn*	Sugarcane	Western UP	TCL**
10N18P25K3S0.5Zn	Wheat	Western UP	TCL
8N15P15K0.5Zn0.15B	Rice	Western UP	TCL
8N16P24K6S0.5Zn0.15B	Poatato	Western UP	TCL
15N32P8K0.5Zn	Rice	Andhra Pradesh	NFCL
18N33P7K0.5Zn	Rice	Andhra Pradesh	NFCL
18N27P14K0.5Zn	Rice	Andhra Pradesh	NFCL
18N24P11K0.5Zn	Rice	Andhra Pradesh	NFCL
23N12K	Rice	Andhra Pradesh	NFCL
27N10K	Rice	Andhra Pradesh	NFCL
11N24P6K3S0.5Zn	Rice (basal)	Adilabad, Nizamabad, Karimnagar, Warangal Medak, Ranga Reddy Nalgonda (All in A.P.)	NFCL
14N27P10K0.5Zn	Maize	Adilabad, Nizamabad, Karimnagar, Warangal Medak, Ranga Reddy Nalgonda (All in A.P.)	NFCL
22N12K	Rice	Adilabad, Nizamabad, Karimnagar, Warangal Medak, Ranga Reddy Nalgonda (All in A.P.)	NFCL
18N14K	Maize	Adilabad, Nizamabad, Karimnagar, Warangal Medak, Ranga Reddy Nalgonda (All in A.P.)	NFCL
10N20P10K5S2Mg0.5Zn0.3B0.2Fe	Grape (basal) and sugarcane	Nasik, Pune, Ahmednagar, Aurangabad	Deepak F.
20N10P10K5S2Mg0.5Zn0.3B0.2Fe	Grape, rice, pomegranate, sugarcane, tomato	Nasik, Pune, Ahmednagar, Aurangabad, Dhule, Jalgaon	Deepak F.
15N15P15K5S2Mg0.5Zn0.3B0.2Fe	Grape, cotton, onion, banana, potato	Nasik, Pune, Ahmednagar, Aurangabad, Dhule, Jalgaon	Deepak F.
10N20P20K3S2Mg0.5Zn0.3B0.2Fe	Sugarcane, citrus	Nasik, Pune, Ahmednagar, Aurangabad, Dhule, Jalgaon	Deepak F.
15N15P15K0.5Zn0.2B	Groundnut	Andhra Pradesh	Corom. Int.
20N15K0.5Zn0.2B	Maize	Andhra Pradesh	Corom. Int.
16N22P14K4S1Zn	Rice (basal)	E&W Godavari Krishna, Western Delta of Guntur (All in AP)	Corom Int.
14N20P14K4S0.5Zn	Maize	Karimnagar, Warangal, Nizamabad	Corom Int.
17N17P17K4S0.5Zn0.2B	Groundnut (basal)	Anantapur, Chittoor Kadappa, Kurnool, Mahabubnagar	Corom Int.
12N26P18K5S0.5Zn	Rice and wheat	Uttar Pradesh	Indo-Gulf
8N18P26K6S1Zn0.1B	Potato	Uttar Pradesh	Indo-Gulf

*%N, P_2O_5, K_2O, S, Mg, Zn, B and Fe. TCL, Tata Chemicals Ltd.; NFCL, Nagarjuna Fertilizers and Chemicals Ltd; Deepak F., Deepak Fertilizers; Corom Int., Coromandel International Ltd..

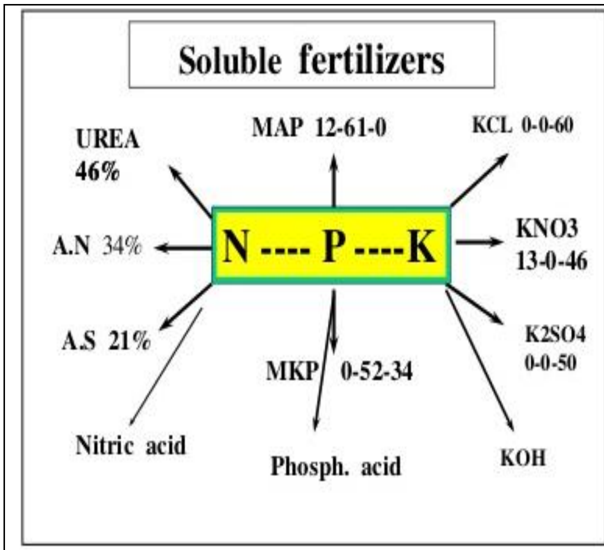
Table 1a.Different Customized Fertilizer Formulations available in India(contd..)

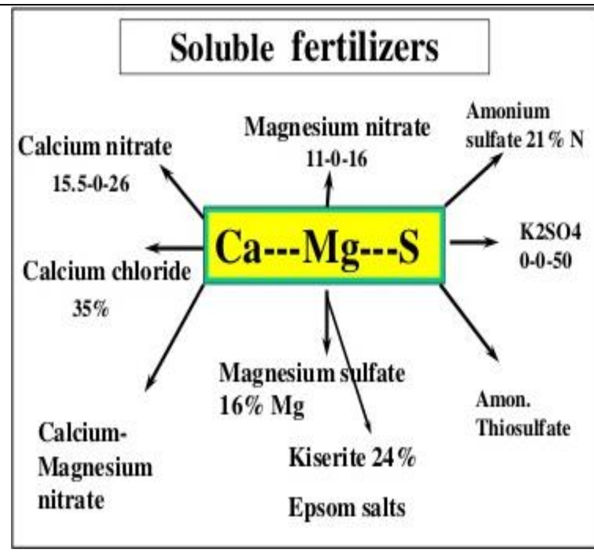
Sl. No	Crops	Formulations (N:P:K:S:Zn:B)/ N:P:K: Zn/ N:P:K:S:Mg:Zn:B:Fe/N:P:K:S:Zn:B)	Geography
1	Potato	8:16:24:6:0.5:0.15	Agra, Aligarh, Budaun, Bulandshahar and Baghpath
2	Wheat	10:18:25:3:0.5:0	Muzaffarnagar, Barielly, Bijnore, Hathras, Pilibhit, Mathura, Meerut
3	Sugarcane	7:20:18:6:0.5:0	Moradabad, KR Nagar, Farukhabad and Ferozabad
4	Rice Paddy	8:15:15:0.5:0.15:0 15:32:8:0.5,18:33:7:0.5, 18:27:14:0.5	GB Nagar, Ghaziabad, Rampur, Shahjahanpur, Mainpuri and US Bagar Andhra Pradesh
5	Rice(Basal)	11:24:06:3:0.5	Adilabad, Nizamabad and Medk
6	Maize (Basal)	14:27:10:4:0.5 14:20:15:4:0.6:0	Karimnagar, Warangal and Ranga Reddy Nizamabad
7	Grape, Sugarcane	10:20:10:5:2:0.5:0.3:0.2	Aurangabad, Nasik, Pune and Ahmednagar
8	Grape, Pomegranate, Paddy, Sugarcane, Tomato, Gourds and Leafy vegetables	20:10:10:5:2:0.5:0.3:0.2	Nasik, Dhule, Jalgaon, Pune, Ahmednagar and Aurangabad
9	Grape, Cotton, Onion,	15:15:15:5:2:0.5:0:0.2	-do-

Water Soluble fertilizers (WSF) - Characteristics and Uses

- 100% Water soluble fertilizers with low salt index, chloride content and high FUE
- High purity, applied low doses and give high benefit : cost ratio, FUE of WSF @ 80-85%, FUE of conventional fertilizers N- 30- 45% P- 10-30% K-50%
- This leads to lower return on money spent on per unit of fertilizer, along with increased soil salinity
- Water-soluble fertilizers dissolve easily in water and are applied to the crop in the irrigation water.
- One benefit is that growers can easily adjust the nutrient concentrations according to a crop's changing needs over a growing season.
- Growers often choose a fertilizer concentration and apply this concentration at every watering. This is called continuous liquid feeding (CLF), or fertigation.

- By contrast there are fertilization programs in which growers apply higher rates of fertilizer less frequently, and irrigate with clear water between feedings
- Continuous feeding provides a more uniform nutrient supply to the crop over time.
- There may be as many as 50 in a single commercial brand (19:19:19).
- In addition to avoiding nutrient deficiencies and toxicities, can reduce secondary issues, such as insect and pathogen pressure.





Comparison b/w 100% WSFwith Conventional Fertilizers

Sl. No.	*Properties*	*100% water soluble fertilizers*	*NPK conventional fertilizers – complex mixture*
1	Solubility	Readily soluble in water	Nutrient may be in soluble form but carrier material not fully soluble
2	Uniformity of nutrients ions	Ionic distribution uniform depending upon concentration and composition of base material used	Ionic distribution not uniform as phosphatic ion fixation with other elements in carrier occurs frequently
3	Solubility time	1 to 4 minutes in water	12 to 24 hours at 25 ^{0}C water
4	Filtration of solution before application	Not required	Required 2-3 times

5	pH of 1% solution	Acidic varied 2.5 – 6.5	Neutrality/slightly alkaline 7.5-8.0
6	Salt index	8 to 40	Varies depending upon K2O source (if derived from MOP varies upto 50-125)
7	Time of application	Every irrigation application is possible, absorption by plants over come deficiency	Maximum 2 or 3 split doses. Not practical apply at the time of its demand i. e. flower initiation, fruit setting.
8	Microbial population	More due to less concentration of nutrient solution present near root zone and salt Cl and Na free	Less due to more application of one time dose releases more concentration solution which affects population, Cl, Salt index and Na affects population
9	NUE	Very high	Higher if split doses not applied

Cost of Water Soluble Fertilizers

S.No	Particulars	Rate (Rs.)	Photograph
1	Krista – K (KNO3)	130.00 / Kg	
2	CaNO3	120.00 / Kg	
3	19:19:19	190.00 / Kg	
4	20:20	210.00 / Kg	

Benefits of customized fertilizer

- Customized fertilizers is use of the Fertilizers Best Management Practices and are generally assumed to maximize crop yields while minimizing unwanted impacts on the environment and human health.
- FBMP will make it "easier" in "future" for farmers, extension agents, crop advisers and researchers to exchange their experiences.
- Application of customized fertilizer is compatible with existing farmers system and hence it will be comfortably accepted by the farmers.
- Production of customized fertilizers will ensure improved 'Fertilizer Use Efficiency' and creating a new "Virtual" source of nutrients implying from the existing quantity of DAP, MOP, Urea, SSP and A.S available and consumed in India, the agricultural produce output will increase, simultaneously the distribution and availability of fertilizer will be better. All this is achievable keeping the subsidy allocation constant.
- Customized fertilizer satisfies crop's nutritional demand, specific to area, soil, and growth stage of plant.
- As the micro-nutrients are also added with the granulated NPK fertilizer the plants can absorb the micro-nutrient along with macro-nutrient which prevents nutrient deficiency in plant.
- Mixed fertilizers with micronutrients provide recommended micronutrient rates for the agricultural field at the usual fertilizer application.
- The farmer need not buy micro-nutrient separately at extra cost, thus reducing the total cost.
- It is found that incorporation of micro-nutrient with granular fertilizer at the time of manufacturing results in uniform distribution of micro-nutrient throughout granular NPK fertilizer.
- This is because micro-nutrient source is in contact with the mixed fertilizer under the condition of high moisture and temperature.
- Supplies the plant available nutrient in adequate amount and in proper proportion.
- It is a soil-crop-climate based fertilizer and is less influenced by soil, plant and climatic condition that lead to more uptakes of nutrients and less loss of nutrient.
- It supplies not only primary nutrients but also secondary and micronutrients.
- It reduces the cost of fertilizer application that ultimately reduces cost of cultivation.

- ❖ It is a major component of Site Specific Nutrient Management (SSNM) and Precision Agriculture, which promotes maximum fertilizer use efficiency of the applied nutrients in a cost-effective manner.
- ❖ Soil health can be improved by developing site and crops specific fertilizers

Issues in marketing of customized fertilizers

Ten most important issues which hinder the marketing of customized fertilizers are,

1. High cost of customized fertilizers without proper subsidy given by GoI,
2. Existence of diversity in product mix between producers,
3. Absence of healthy competition among fertilizer industries to avoid indiscriminate and imbalanced use of fertilizer,
4. Improper allocation of raw material among fertilizer industries,
5. Necessity of investing heavy capital in state of the art manufacturing facility for customized fertilizer,
6. No long term assurance from the government to keep the policy intact throughout the years,
7. Limited awareness and very low affordability of customized fertilizers among the farmers,
8. Segmentation and promotion in marketing,
9. Time consuming manufacturing process
10. Uncertainty in response when fertility is restored in the field.

Eligibility Criteria to manufacture and sale of Customized Fertilizer:

(i) Permission for manufacture and sale of Customised Fertiliser shall be granted to only such companies whose annual turnover is Rs. 500 crores or above.

(ii) Such manufacturing companies should have soil testing facility with an annual analyzing capacity of 10,000 samples per annum and should have analyzing capacity for NPK. Micronutrient and Secondary Nutrient. Such soil testing labs must process the requisite instruments as provided in Annexure.I).

(iii) The grade of customized fertilizer, which the company will manufacturer, must be based on scientific data obtained from area specific, soil specific and crop specific, soil testing results. These manufacturing companies, in association with concerned agricultural universities/KVKs concerned, should also conduct agronomy tests pf the proposed grade to establish its agronomic efficacy..

(iv) Such manufacturing companies should generate multi loctional trials(not on farm demonstration) on different crops for minimum one season.

Soil Sampling and Analysis : Suchmanufacturing companies must draw these soil samples from within its operational areas and should also ensure that minimum one sample is necessarily, drawn from each village. Scientific data on soil testing, results available with agricultural university /state Governments may also be used to prepare soil fertility map and for determination of required soil, area and crop specific grades for existing and potential marketing areas.

Grant of permission to manufacture:Subject to the fulfillment of eligibility criteria referred to in the preceding paragraphs, the permission for the manufacture and sale of Customized Fertiliser will be granted by Joint Secretary(INM). Department of Agriculture and Cooperation, MOA,GOI. Such permission, for manufacture and sale of particular customized fertilizer grade shall be granted only for the specific area and for a period not exceeding three years. Such manufacturing companies must start their manufacturing and sales process with in a period of six months from the date of grant of such permission. For grant of permission to produce and to sell such customized fertilizers, the concerned manufacturing companies should necessarily apply for permission, to the office of the Joint Secretary(INM), Ministry of Agriculture under intimation to the State Government in the prescribed Performa as provided in annexure II. The competent authority shall expedite the requisite permission suthorization of otherwise within 45 days of the receipt of such applications

Renewal/ Revision of customized fertilizer Grade : On completion of three years or earlier, manufacturing company of customized fertilizer shall submit a renewal/revision application for varied customized fertilizer manufactured by it. In case no change in the already approved composition of customized fertilizer is required, the same shall also be declared by the manufacturer. The competent authority, shall thereon, accord its approval; within .a period of 45 days from the date of receipt of such application, failing which the application duly acknowledged copy of such application shall be treated as official approval.

Customized Fertilizer Grades : The grades of customized fertilizer which the manufacturing company propose to manufacture and sell, shall be based on area specific and crop specific soil testing results. The manufacturer may be in association with Agricultural Universities/KVKs concerned, shall also conduct agronomy tests of the proposed grade to establish its agronomic efficacy. The manufacturing company, preferably in association with concerned agriculture universities/KVKs may continue to conduct agronomy tests of the proposed grades on the farm, for at least one season. The minimum nutrient contents in a specific grade of customized fertilize, proposed to be manufactured, shall contain not less than 30 units of all nutrients, combined.

For manufacture of area-specific subsequent grades of customized fertilizers, duly approved by the Joint Secretary(INM) MOA from time to time, the company shall intimate the competent authority within at least 45 days prior to its introduction of the said grades in the market. Since these grades will be based on the scientific data, no formal approval will be necessary..

Raw Materials:

(i) Use of subsidized fertilizers by Manufacturer of customized fertilizer: . As per the existing policy, all subsidized fertilizers can be used for manufacturing of customized fertilizers. As such, domestic manufactures of all such subsidized fertilizers will have the choice to sell the requisite quantity to the manufacturing companies of customized fertilizers and the manufacturing company of such subsidized fertilizers shall be eligible to claim subsidy from DOF under relevant rules.

(ii) Captive use of subsidized fertilizers by the manufacturer of customized fertilizer. Domestic manufacturer of subsidized fertilizers will have the option to supply the required quantity of such fertilizers, as raw material, to its own manufacturing unit for production of customized fertilizers. All such supplies shall be eligible for subsidy as per the policy of DOF. .

(iii) Import of subsidized fertilizers by the manufacturer of customized fertilizers. All manufacturers of customized fertilizers will have option to import subsidized fertilizers under the existing Policy guidelines of GOI for the manufacture of customized fertilizers not exceeding its realistic requirements. On the imported quality of such fertilizer to be used for manufacture of customized fertilizer, such manufacturers shall be eligible for subsidy from DOF, under relevant rules.

(iv)Allocation of subsidized fertilizer as raw material for manufacture of customized fertilizers. . Specific allocations of subsidized fertilizers, to ensure adequate availability, in respect of States, may be made for use as raw material for manufacture of Customized Fertilizers, However, if required, permission for import of specific fertilizers as raw material (not included in schedule 1 of FCO, 1985) may also be granted to the manufacturers.

Quality of Customized Fertilizers: The Customized Fertilizers to be used for based application shall be granular in size with minimum 90% between 1-4 mm IS sieve and Below 1mm should not exceed 5%. The moisture content should not exceed 1.5%. For foliar applications, however, the grades should be 100% water soluble. The specifications of the customized fertilizers provided by the company to manufacture of Customized Fertilizer, duly approved by the Ministry, shall be strictly adhered to.

Quality Cheek

(i) Procedure for drawl of sample of fertilizers: (a) The method of drawing samples shall be provided in the FCO. (b) Clause 4A(ii) Weight of one sample should be 400g. as specified under Clause 4 A (iii) for Part A in Schedule 1 of the FCO,1985.

(ii) Methods of analysis of fertilizer: (a)The methods of analysis of fertilizers shall be as per the procedure prescribed in FCO. (b) For preparation of sample for analysis in the laboratory (Clause 1-1) under part B in schedule II of FCO,1985 the whole sample size of 400g should be powdered. The whole sample size of 400 gms shall be powdered.

(iii)Tolerance limit: The tolerance limits prescribed under the FCO ,1985 for NPK mixture and NPK with micronutrients, shall be applicable to the customized fertilizers. However such tolerance limit shall not exceed 3% for all nutrients particularly when secondary and micronutrients are also present with NPK.

Labeling:

(i) The word Customised Fertiliser shall be superscribed on the bags.

(ii) The name of the crop and geographical area for which the Customised Fertiliser recommended shall also be indicated on the bags.

(iii) The grades of Customised Fertiliser and the nutrient contents shall be mentioned on the bags.

(iv) The manufacture should preferably have tampered proof bagging so as to check on adulteration.

Pricing of Customised Fertiliser: The Company shall fix reasonable MRP for its approved grade of customized fertilizers taking all factors into consideration.

General: The permission for manufacture of customized fertilizer shall be restricted to such manufacturing companies of fertilisers who have the certificate of manufacture and authorization letter for selling fertilizers in a particular State. All the provisions of Fertilizer(Control) Order, 1985 and Essential Commodities Act 1955, shall be applicable for manufacture and sale of Customised Fertiliser.

Annexure.I

List of equipments for setting up of new soil testing laboratories for creating npk with micronutrient testing facilities

1. Atomic Absorption Spectrophotometer 2. Spectrophotometer 3.Flame Photometer 4. pH Meter 5. Conductivity Bridge 6. Colorimeter 7.Kjeldhal Distillation Set 8. Waster distillation Set(all glass) 9. Centrifuge 10.Deionizer 11.Balances 12. Grinders other instruments like Hotplate, gas Cylinders, heaters etc. 13. Stabilizers 14. Sample holding racks 15. Computer with printer 16. Software for preparation of recommendation and record of data.

Annexure.II

Application for grant of permission for manufacture of customised fertiliser

1. Name of the Company and address 2. Location of the unit where the Customised grade of fertilizer proposed to be manufactured. 3. Annual Turnjover of the company 4.

Location/Particular of the Area where the Customised Fertilizer is to be introduced 5. Soil Fertility Status of the Area.6. Introduction Season 7. Cropping Pattern of the Area 8. Soil PH 9. Irrigated or unirrigated land 10.Location of soil testing lab 11. Annual Analysing Capacity of soil samples 12. Area Climate 13.Grades and other details relating to composition of Customised Fertiliser 14. Raw Material(indicate whether the subsidized material to be used). 15. Quantity to be produced in each season 16. MRP 17. Whether the company possess any permission for manufacturing the graedes of Customised fertilizer in any area (i) Whether the company possess the soil testin facility as prsescribed in Annex II of guidelines. (ii) Whether the proposed grades are based on the soil testing results and crop requirement. (iii) Whether the multi locational trials have conducted or not (iv) Whether the agronomic test of the product in consultation with Agriculture Universities/KVK have been conducted or not. 1. Declaration:- (a) I/We declare tat the information given above is true to the best of my/our knowledge and belief and no part thereof is false. Date Signature of the Applicant(s) Place Note:

LECTURE No.5

FERTILIZATION - NUTRIENT REQUIREMENTS BY CROPS, ABSORPTION OF NUTRIENTS, NUTRIENT RATIOS AND ITS EFFECT ON CROP GROWTH AND YIELD; SENSOR BASED NUTRIENT MANAGEMENT

Plants absorb many elements through their roots: more than 50 elements have been found in various plants. However, not all are considered to be essential elements. The essential nutrients required by green plants are exclusively inorganic, and an essential element may be defined as one that is required for the normal life cycle of a green plant and whose role cannot be assumed by another element. Twenty elements are thought to be essential to the growth of most plants, and they are usually classified as macronutrients and micronutrients. The former are those which are required in relatively large amounts: carbon, hydrogen, oxygen, nitrogen, phosphorus, calcium, sulphur, potassium and magnesium. The micronutrients are those required in small amounts, such as chlorine, iron, manganese, boron, zinc, copper, molybdenum, sodium and selenium (Marschner, 1995; Mengel and Kirkby, 2001; Epstein and Bloom, 2005).

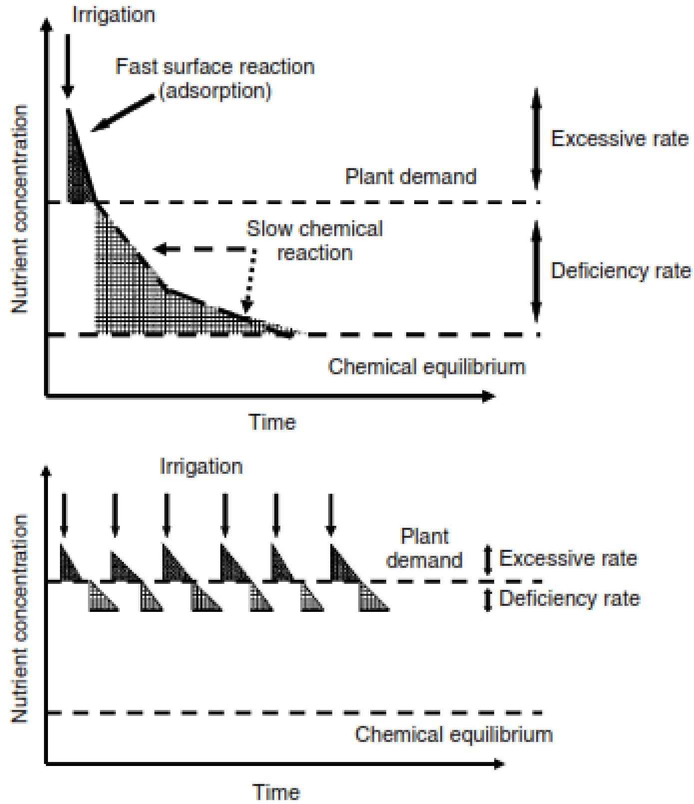
Silicon is usually not considered as essential – except in case of some algae and horsetails (Equisetaceae) – but it plays a significant role in plant resistance to stress conditions and to some diseases, and is, therefore, designated as 'quasi-essential' (Epstein, 1994, 1999; Epstein and Bloom, 2005). Nickel was found to be an essential element for legumes (Loneragan, 1997). The elements required in the largest quantities are the main structural elements, C (carbon), H (hydrogen), O (oxygen), N (nitrogen), P (phosphorus), K (potassium) and S (sulphur), whereas elements required in very small amounts, such as Ni (nickel) and Mo (molybdenum), are needed for only one or very few enzymes (Loneragan, 1997). The essential macroelements were first recognised in the nineteenth century by De Saussure and Boussingault, who showed by chemical analysis that plants contain C, H, O and N. Soilless (hydroponic) culture has served as the major tool in the investigation of plant nutrition from the early studies of Sachs and Knop during the nineteenth century in Germany; they identified N, P, S, K, Ca, Mg and Fe as essential elements (Marschner, 1995). Most of the essential microelements were recognised in the twentieth century, from 1930 and onwards, thanks to the development of more highly purified chemicals and more sensitive methods for analysing trace concentrations (Loneragan, 1997). The range of concentrations of the essential elements in plant tissues and the required annual amounts for maximum yields are given in Table

Except for carbon and oxygen, which are absorbed predominantly by the canopy from the air, the essential nutrients are taken up by the roots. Carbon is also taken up by the roots, in the form of HCO3 and oxygen, both as gaseous O2 and with hydrogen in water molecules. Hydrogen is also taken up as the ion H +. Most of these nutrients are taken up as cations or anions, except for boron, which is absorbed as boric acid or as the borate ion, depending on the pH. Thus, nutrient solutions are composed of mineral salts, acids and bases. Nitrogen is a unique nutrient that can be absorbed as either cation or anion, NH 4 + and NO3-, respectively. This characteristic of nitrogen influences plant nutrition in general and it has a strong impact on fertilisation in soilless culture.

TABLE 8.1 Ranges of the Essential Element Concentrations in Nutrient Solutions and Plant Tissues, and the Required Annual Amounts for Maximum Yields

Element	Chemical symbol	Form available to plants	Nutrient solution	Plant tissues	Annual consumption
Macroelements			mg L^{-1}	g kg^{-1}	kg ha^{-1} y^{-1}
Calcium	Ca	Ca^{+2}	40–200	2.0–9.4	10–200
Magnesium	Mg	Mg^{+2}	10–50	1.0–2.1	4–50
Nitrogen	N	NO_3^-, NH_4^+	50–200	10–56	50–300
Phosphorus	P	HPO_4^{-2}, $H_2PO_4^-$	5–50	1.2–5.0	5–50
Potassium	K	K^+	50–200	14–64	40–250
Sulfur	S	SO_4^{-2}	5–50	2.8–9.3	6–50
Micronutrients			mg L^{-1}	μg g^{-1}	g ha^{-1} y^{-1}
Boron	B	H_3BO_3, HBO_3^-	0.1–0.3	1.0–35	50–250
Copper	Cu	Cu^+, Cu^{+2}	0.001–0.01	2.3–7.0	33–230
Iron	Fe	Fe^{+3}, Fe^{+2}	0.5–3	53–550	100–4000
Manganese	Mn	Mn^{+2}	0.1–1.0	50–250	100–2000
Molybdenum	Mo	MoO_4^{-2}	0.01–0.1	1.0–2.0	15–30
Zinc	Zn	Zn^{+2}	0.01–0.1	10–100	50–500

Adsorption on the solid phases and precipitation of insoluble compounds decrease the concentrations of nutrients in the root area (Chap. 6). Thus, the nutrient concentrations in the rhizosphere may be high or even excessive immediately after irrigation, and may subsequently fall to deficit levels as illustrated in Fig.. These processes are time dependent; therefore, reducing the time interval between successive irrigations to maintain constant, optimal water content in the root zone may also reduce the variations in nutrient concentration thereby increasing their availability to plants and reducing their leaching out of the root zone. Water and nutrients acquisition by plants, and the formation of a depletion zone in the immediate vicinity of the roots, drive solute movement towards the roots. Nutrient transport to the root surface takes place by two simultaneous processes: convection in the water flow (mass flow), and diffusion along the concentration gradient (Barber, 1995; Tinker and Nye, 2000; Jungk, 2002). Medium properties, crop characteristics and growing conditions affect the relative importance of each mechanism, but the general situation is that the mobile NO_3 ion supply is taken up mainly through mass flow, whereas for less mobile elements such as P and K, diffusion is the governing mechanism (Barber, 1995; Claassen and Steingrobe, 1999; Jungk, 2002; Mmolawa).



Nitrate, the main N source for soilless-grown plants (Sonneveld, 2002), is hardly ever involved in adsorption or precipitation reactions; therefore, the concentration of NO3- in the irrigation water and its actual concentration in the vicinity of the roots are quite similar. In contrast, P availability to plant roots is time dependent, as a result of dsorption and precipitation reactions (Chap. 6). Potassium ions are hardly ever involved in precipitation reactions, but may be adsorbed on negatively charged surfaces. Therefore, the difference between the K concentrations in the rrigation solution and the rhizosphere lies between those between the respective NO3-and P concentrations. onsequently, it can be expected that the impact of fertigation frequency on the uptake of nutritional elements by plants will be related to both their mobility and their availability, as indeed has been reported (Mbagwu and Osuigwe, 1985; Kargbo et al., 1991; Silber et al., 2003). Although the effects of irrigation frequency on nutrient concentration in soilless-grown lettuce leaves presented in Fig. 8.13 followed the expected order of P > K > N, the magnitudes of the nutrient increases in the plant was found to be closely related to the fertilisation level. The increases in the leaf P and K concentrations were attributed to both direct and indirect effects of irrigation frequency on the P and K concentrations at the root surface. The direct effect is the frequent elimination of the depletion zone at the root surface by the supply of fresh nutrient solution during and soon after the irrigation events. This supply was fully available to the roots soon after the irrigation events, at which times its uptake rate behaved purely in accordance with the Michaelis– Menten equation (Eq. [4]). Moreover, a higher irrigation frequency maintains higher dissolved P and K concentrations in the substrate solution, by shortening the period during which precipitation takes place. The indirect effect of irrigation frequency onnutrient availability is manifested through the higher convective and diffusive fluxes of dissolved nutrient from the substrate solution to the root surface, which increase with increasing irrigation frequency. The findings that increasing the fertiliser rate improved nutrient uptakes and plant yield, and that increased irrigation frequency resulted in systematic diminution of the nutrients uptake enhancement, may indicate that the main effect of increased fertigation frequency was related to an improvement in nutritional status, mainly with regard to P (Silber et al., 2003, 2005a; Xu et al., 2004). Thus, increasing the irrigation frequency may compensate for certain nutrient deficiencies and in the above examples the lower yields of plants fertigated at low frequency might have been a result of nutrient shortage rather than water shortage.

Sensor Based Nutrient Management

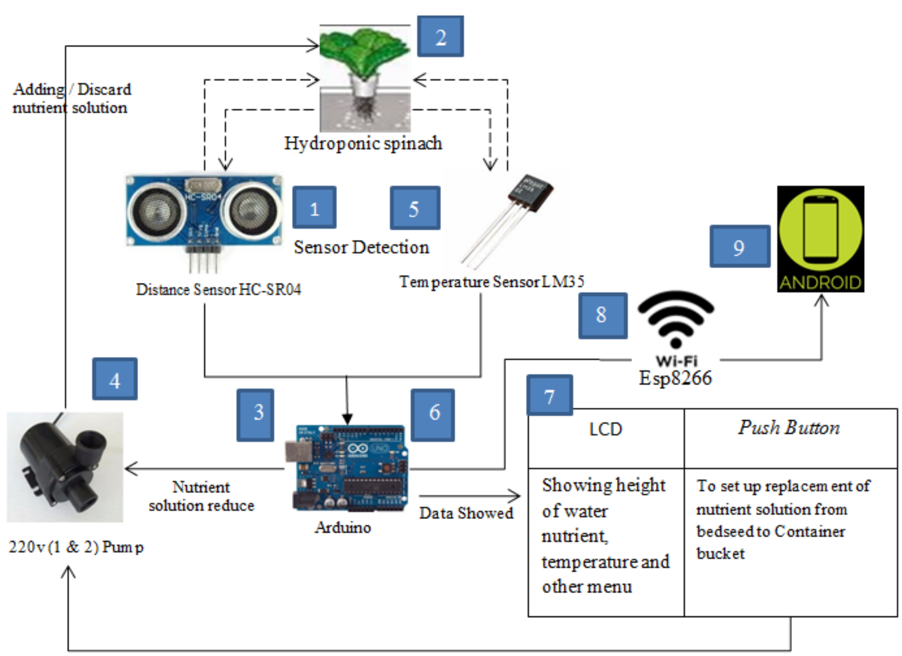
Plant care is a routine and important activity to keep plants healthy and well groomed. Plant care includes many aspects i.e. watering, rejuvenation, fertilizer, and others. So many types of plants with different forms of treatment are different and all treatments are usually done manually. Although the types of plants are very diverse, water remains the main source of life for all plants to help the photosynthesis process, especially in plants Hydroponics that lives rely on nutrients from the water. Hydroponics plants have various types of planting media such as Rockwell, sponge, coconut and other coconut powder. In the treatment of plants, Hydroponics is very important to consider the timing of when the water should be added and replaced nutrients, and it would be very inconvenient if the plant owner has Hydroponics plants with a lot. To watering a lot of hydroponics plants, need to do an automatic system that can automatically to hydrate the hydroponics if necessary.

With the development of computer science especially on microcontroller, then automatic watering system for plant hydroponics is very possible to do. Base on the description above, is needed a revolution in agriculture industry. In related with this description, will be built the project of automated tools based on the Arduino Uno Microcontroller and the ATmega328 board as a data sheet. The Arduino Uno as the brain of the tool will monitor the hydroponics plants, assisted by proximity sensor (Ultrasonic HC - SR04) to detect the height of water. The temperature around the plants will be detected by sensors (LM - 35). The height of water and the temperature room will be displayed on the LCD microcontroller. All of the data will be sent to the smartphone Android by using the WIFI (Wireless Fidelity) network.

This automatic hydroponics system plant is placed in a special chamber or vessel and the nutrients are sent directly to the hydroponic roots at any given time. Arduino Uno microcontroller will control the flow of water (nutrients) on the vessel automatically, and the microcontroller can be controlled from Android smartphone. To run this project, the program module has been embedded in this system. Arduino Uno microcontroller is used in real-time to set Alarms on nutrient pumps. When the alarm is on Enabled, Relay will be activated and the nutrient pump will drain the Nutrition solution on the hydroponics plant. When the alarm is deactivated, the relay will be extinguished and the nutrient pump will stop supplying.

The sensor will detect the water level in the hydroponic tube and the temperature sensor to detect the room temperature. The sensor detection results will be connected with a Relay connected to the microcontroller port. When the relay port pin is lower than the specified height, the water flow will be run on the water pump to irrigate the hydroponics plant.

The general architecture of automated hydroponics nutrition plants systems is shown in figure 1 below.



The system mechanism is follows; Ultrasonic sensor (HC - SR04) detects the height value of nutrient solution in hydroponic plants by the parameter of the high of water (in Cm) unit and the temperature. The sensor (LM-35) will detects the temperature in units of °C range. The ultrasonic sensors will measure the distance of water based on ultrasonic wave. The distance between transmit time and receive time becomes a representation of the distance of the water.

Impact of growing media to the yield and quality

Worldwide, a high percentage of the hydroponic industry uses inorganic growing media such as rockwool, sand, perlite, vermiculite, pumice, clays, expanded polystyrene, urea formaldehydes and other, while only about 12% uses organic growing media such as peat, bark, wood residues (leaf mould, sawdust, barks), coir, bagasse, rice hulls and others. The most popular growing media for greenhouse production of vegetables is rockwool. Rockwool is the preferred material because: 1) it is essentially almost chemically and biologically inert, making it free of any potential pests, diseases, and weed seeds; 2) rockwool slabs and blocks can be irrigated frequently as they drain freely and can thus be managed to provide an optimum ratio between air and water for crop production throughout the growing season.

A number of authors have reported improved uniformity in weight, size and texture of tomatoes grown in soilless culture systems compared to those grown on soil. A few authors reported that soil culture could increase the size of tomatoes compared to soilless culture systems. The grew tomato plants in soil, perlite, peat, sand, pumice and different combinations of them. Their results showed that the highest total as well as marketable yield was produced with a mixture of 80% pumice + 10% perlite + 10% peat medium, providing about 30% more product in comparison to the soil. A number of authors have reported that dry matter, sugar, soluble solids, vitamins and carotenoids content in tomatoes; acidity and taste have better marks when grown in soilless culture systems compared to soil. In addition to yield, the growing medium has shown effects on other plant parameters. Dry matter content was highest in lettuce grown in tea waste compost and lower in tree bark compost. Lettuce plants harvested from perlite or pumice culture had a lower dry matter, chlorophyll, Mg, Fe and Mn content and a higher titratable acidity as well as total N, P, and K content, in comparison with the plants harvested from the soil culture.

The effect of growing medium on the quality of tomatoes and cucumbers was investigated by determining texture, colour and taste by sensory evaluation and by chemical analysis. Results indicated that the growing medium affected the dry matter content, pH and acidity as well as quality of tomato as judged. Tomatoes grown in peat were considered redder, softer and tastier and the taste differences were greatest at the beginning of the harvesting season. Rice hull alone resulted in increased sugar content of tomato fruit when compared with perlite (fine and coarse granule). Fruits from plants grown on Cocovita contained more dry matter than those grown on rockwool. The content of dry weight, ascorbic acid and sugars in fruit differed to a small extent between tomato plants grown on straw or rockwool. Chemical parameters of cucumber were also affected by the growing media, while medium had no effect on texture. The colour of cucumber at the end of the harvest season was affected by growing media. Cucumber grown in mineral wool had the best taste (based on sensory evaluation, which was carried out immediately after harvesting) at the beginning of the harvesting season. Different physiological disorders in broccoli include brown bud, bud deformation, bracting and hollow stem, which adversely affect the quality of the product. They are related to cultivar sensitiveness but also to nutritional disorders and/or to different stressing factors. Two growing media (perlite and coconut coir dust) were tested in plants grown in containers.

LECTURE No.6

CONTAINERS – KINDS OF SUBSTRATES - SAND, GRAVEL, ROCKWOOL, EXPANDED MINERALS, PUMICE, ZEOLITE, PYROCLASTIC MATERIALS, PEAT, COIR, TREE BARK, SAWDUST, WOOD FIBRES, ETC. – RESOURCES AND METHODS OF PREPARATION

CONTAINERS

The types of containers that can be used or constructed must agree with the available space, technical and financial possibilities. To start a hydroponics model and acquire initial knowledge we may use, fruit crates. Old tires; children bath tubs; discarded plastic bowls, or broken plastic containers.

Containers as small as ice cream cups, discardable plastic containers and oil or margarine containers are enough to grow onions, coriander, lettuce, parsley.

Characteristics of the containers

The size (length and width) of the containers may vary, however, the depth should not be more than 10 -1 2 cm, because with the hydroponics system it is not necessary to have a larger space for the development of the plant roots. **When we want to grow carrots, the depth of the container should be 20 cm.**

The maximum recommended size of the box for growing crops are the following:

Length 2.00 meters

Width 1.20 meters

Depth 0.12 meters

Larger sizes imply higher costs and greater management difficulties.

SUBSTRATES

There are probably hundreds of different kinds of growing media; basically, anything that a plant can grow in is considered a growing medium. Among the aggregates now available are rockwool/stonewool (the industry standard), oasis cubes, vermiculite, perlite, coconut fiber (coir), peat, composted bark, pea gravel, sand, expanded clay, lava rock, fiberglass insulation, sawdust, pumice, foam chips, polyurethane grow slabs and rice hulls. Each alternative has positives and negatives, and the choice between aggregates will depend on many variables, including the size and type of plants you wish to grow and the type of hydroponic system being used.

Rockwool/stonewool.: Made from rock that has been melted and spun into fibrous cubes and growing slabs, rockwool has the texture of insulation and provides roots with a good balance of water and oxygen. Rockwool can be used with continuous drip or ebb and flow systems and is suitable for plants of all sizes, from seeds and cuttings to large plants. Rockwool is considered by many commercial growers to be the ideal substrate for hydroponic production. Because of its unique structure, rockwool can hold water and retain sufficient air space (at least 18 percent) to promote optimum root growth. Since rockwool exhibits a slow, steady drainage profile, the crop can be manipulated more precisely between vegetative and generative growth without fear of drastic changes in EC or pH. Note that some rockwool products require an overnight water soak before usage, as the bonding agents used to form slabs can result in high pH. Additionally, there has been a growing concern about disposing rockwool after use because it never truly decomposes.

Rockwool

The use of rockwool has quickly spread in agriculture particularly in Europe where it used to produce many vegetable and ornamental crops. It is a fiber produced from volcanic rocks and contains Diabase (60%), Lime stone (20%) and Coal (20%). This mix heated to very high temperature for melting together. The melted material is transformed to fine threads of 5-micron diameter after treatment with fast centrifugal machine and cooling. The threads are then compressed and divided into the required sizes. During the cooling process, the phenol material added to help sticking the rocky wool into a substrate of good porosity.

Important forms and uses of rockwool

• **Germination cubes**: This could be in a single or aggregated form.

• **Seedlings blocks**: To accommodate the small germination cubic’s with its contents of plants or the young seedlings directly.

• **Agricultural slices**: To which seeds of proper size transferred, where plant completes its life cycle.

• **Loose (unpacked) rock wool**: This used as substrates for cultivation in pots or mixed with other substrates to improve the characteristics of airing and water holding.

Some characteristics of rockwool are:

• Dry material does not contain any nutritional or non-nutritional solution.

• Sterilized material free of pests, insects, and disease.

• Very light but solid material. This facilitates its preparation and processing.

• A material of high porosity (97% of the total size) which facilitates drainage.

Pumice

Pumice is direct product of acidic volcanism. It is a highly vesicular volcanic glass, silicic in composition and occurs as massive blocks or unconsolidated, fragmented material. The vesicles are glass–walled bubble casts, which give pumice a low density compared to natural glass. Pumice, the commercial term for fine-grained, fragmented pumice with shards under 2mm in diameter, may be deposited some distance from the source. Pumice is formed from silicic lavas rich in dissolved volatiles, particularly water vapor. On eruption, sudden release of pressure leads to expansion of volatile which, in turn, generates a frothy mass of expelled lava. This mass may solidify on contact with the atmosphere as a vent filling or flow, or may be shattered by a violent eruption. Pumice has many advantages such as high strength-to weight ratio, insulation and high surface area, which result from the vesicular nature of this rock.

Some characteristics of pumice

• Pumice a material similar to Perlite from the chemical point except that it contain calcium carbonate which make a problem which react with acid leading to a reduction in the size of the particle. This reduction of particle after using for longer time, the substrate can be compacted.

• It differ than perlite in physical characteristics, where this material is heavier.

• Does not absorb water easily and does not hold it for a long period.

• A substrate of good airing condition.

• Easy to clean and purify

Zeolite

Naturally sourced clinoptilolite zeolite has a unique honeycomb molecular structure and is negatively charged, meaning that the molecule can attract and hold important nutrients like nitrogen, potassium, phosphorus, calcium and magnesium. HydroCharge is made from pure and sustainably sourced clinoptilolite zeolite. HydroCharge zeolite is the superior hydroponic grow media in that it is all natural, pH balanced and able to lock in nutrients and H2O while still remaining arid.

HydroCharge requires up to 50% less watering because it traps and holds H2O within the molecule until roots demand and absorb it, while also allowing for drainage and root ventilation. HydroCharge zeolite is used by NASA for hydroponic growing and experimentation in space . HydroCharge has been scientifically proven to reduce leaching of nutrients during runoff, holding these nutrients at the roots until needed by the plant. Reduced pathogens in liquid runoff from amended soils suggests a cleaner root zone with fewer factors to inhibit cannabis.

Perlite/Vermiculite: Perlite is a substance made from volcanic rock. It is white, light weight and often used as a soil additive to increase aeration and draining of the soil. Vermiculite, which is used the same way as perlite and often mixed together, is made from heat expanded mica and has a flaky, shiny appearance. Because perlite and vermiculite are so lightweight, they are suggested only for starting seeds and cuttings.

Perlite has good wicking action, which makes it a good choice for wick-type hydroponic systems, plus it's relatively inexpensive. The biggest drawback to perlite is that it doesn't retain water very well, which means it will dry out quickly between waterings. Just the opposite is true of vermiculite; it retains too much water and can suffocate the plant's roots if used straight. Additionally, the dust from perlite is bad for your health, so always wear a dust mask when handling this media.

Vermiculite

This compound contains both potassium and magnesium. It holds a lot of water and aids in drainage and aeration of the soil, though it is less durable than some other mediums, such as sand and perlite.

Media Alternatives

The rising cost and difficult disposal of rockwool has led many growers to investigate alternative substrates, and with so many options available, there is practically a substrate for each situation. The following options are just a few of the more popular and promising ones.

Peat

Peat is formed as a result of the partial decomposition of plants (Sphagnum, Carex) typical of poorly drained areas (peat bogs), with low nutrients and pH, under low temperatures and anaerobic conditions. Plant species, climatic conditions, harvest and processing methods influence the specific characteristics of peat and its value so different types can be obtained varying on color, texture and degree of decomposition. In particular, some physical properties as water retention and air capacity generally decrease with the increasing of the degree of decomposition.

Expanded clay pellets. This man-made product is often called grow rocks and works extremely well as a growing medium. It is made by baking clay in a kiln. The pebbles range in size from 1-18 mm and are inert.Clay pellets are full of tiny air pockets, which give them good drainage. Clay pellets are best for ebb and flow systems or other systems that have frequent waterings. Because expanded clay pellets do not have good water-holding capacity, salt accumulation and drying out can be common problems in improperly managed systems. It is recommended to flush clay on a regular basis with either a half-strength nutrient solution or a commercially available flushing agent. Though pellets are rather expensive, they are one of the few kinds of media that can be easily reused. After harvest, remove old roots and sterilize with bleach, steam, heat or hydrogen peroxide.

Sand: One of the oldest known hydroponic substrates, sand is not widely used today, mostly because of its low water-holding capacity and weight. Sand has a tendency to pack tightly together, reducing ç the amount of air available to the roots; therefore, a coarse builders' sand is best suited for hydroponic use. Alternatively, sand can be mixed with other media for a greater water-holding capacity and lighter weight.

Gravel.: One of the earliest commercially available hydroponic systems was gravel. Gravel is usually fairly cheap, works well and is typically easy to find. Gravel supplies plenty of air to the roots but doesn't retain water, which means roots can dry out quickly. Its weight makes it difficult to handle, but it does have the advantage of not breaking down in structure and can be reused.

Gravel can easily be reused as long as it is washed and sterilized between crops. Also use heat, steam, bleach or hydrogen peroxide for cleaning.

Wood-Based Substrates

Organic substrates which are derived from wood or its by-products, such as bark, wood chips or saw dust, are also used in global commercial plant production. Substrates based on these materials generally possess good air content and high saturated hydraulic conductivities. The disadvantages can include low water-retention capacities, insufficient aeration caused by microbial activity, inappropriate particle-size distribution, nutrient immobilization or negative effects due to salt and toxic compound accumulations.

Sawdust: Sawdust has had limited success as a hydroponic medium, but it is used, especially in Australia with tomatoes. There are many variables that determine how well sawdust will work, predominantly the kind of wood used and the purity of it. Growers need to be careful to ensure that their sawdust isn't contaminated with soil and pathogens or chemicals from wood-processing facilities or undesirable tree species. Another problem with sawdust is that it will decompose. Additionally, sawdust retains a lot of moisture so be careful not to overwater. The best thing about sawdust is that it is usually free.

Coconut fiber /Coconut Coir

It is known by various trade names like Ultrapeat, Cocopeat and Coco-tek. Coconut fiber, also called coir, is rapidly becoming one of the most popular growing mediums in the world and may soon be the most popular. It is the first totally "organic" medium that offers top performance in hydroponic systems. Coconut fiber is a waste product of the coconut industry and is actually the pulverized husks of coconuts. Coconut fiber is available in different grades, the lowest of which has an extremely high salt content that necessitates leaching before use.

The main advantages of coconut fiber are its oxygen and water-holding abilities. It can maintain a larger oxygen capacity than rockwool yet also has superior water-holding ability. Some research has also shown that coir might have insect-repelling abilities. High-quality coir (the grade commonly used for hydroponics consists of the coarser fibers) also has the advantage of not containing any, or extremely low, levels of nutrients, so it won't alter the composition of the nutrient solution.

Oasis cubes: Oasis rooting cubes are rigid, open-celled, water-absorbing pieces of foam specifically designed for optimal callus and rapid root formation. Made from phenolic foam, oasis cubes are most often used as a rooting media in commercial floriculture and make a great medium for starting seeds and cuttings in hydroponic production. Oasis cubes hold over 40 times their weight in water and have wicking action that draws water to the top of the foam. They have a neutral pH and can be easily transplanted into practically any kind of hydroponic system or growing medium.

Sphagnum peat moss: A completely natural medium that is used as a major ingredient in most soilless mixes, sphagnum moss is often overlooked as a medium for hydroponics; however, it has many properties highly suitable to hydroponic production and is readily available. Sphagnum moss has long strands of highly absorbent, spongelike material that hold and retain large amounts of water while simultaneously having good aeration. Because of this structure, it is best used in larger lattice or net-pot production where the long strands can spill out the holes in the pots to wick up water without falling out.The major problem with this growing medium is that it can decompose over time and shed small particles that can plug up your pump or drip emitters. Sphagnum is usually purchased in dry, compressed blocks and needs to be soaked for approximately one hour before use.

Rice hulls: Rice hulls are a lesser known and underutilized substrate in most parts of the world, but they have proven to be as effective as perlite for the production of a range of crops. Rice hulls are a by-product of rice production and have the potential to be an inexpensive, effective medium in rice production areas. This free-draining substrate has low to moderate water-holding capacity, a slow rate of decomposition and low level of nutrients. However, as rice hulls are a by-product, they are not pre-sterilized. Growers need to take care by using hulls that have not been stored outside or uncovered. Rice hulls have a tendency to build up salt and decompose after one or two crops, so they should be replaced often.

Polyurethane Grow Slabs: Polyurethane grow slabs are a reasonably new media developed specifically for hydroponic production. This media is composed of approximately 75-80 percent air space and 15 percent water-holding capacity. As this substrate is so new, very little information is available on it.

Main advantages and disadvantages of inorganic and organic materials used as growing media (GM)

Material	Origin	Advantages	Disadvantages
Sand	Natural with particles of 0.05–2.0 mm	Relatively inexpensive, good drainage ability.	Low nutrient- and water holding capacity, high volume-weight (1400–1600 kg m^{-3}), low TPS (40–50% V/V).
Rockwool	Melted silicates at 1500–2000°C	Light volume weight (80–90 kg m^{-3}), high total pore space (95–97% V/V), ease of handling, totally inert, nutrition can be carefully controlled.	Disposal problems, energy consumed during manufacture.
Vermiculite	Mg+, Al + and Fe + silicate sieved and heated to 1000°C	Light volume weight (80–120 kg m^{-3}), high nutrient holding ability, good water holding ability, good pH buffering capacity, good aeration: TPS (70–80% V/V).	Compacts when too wet, energy consuming product, expensive.
Perlite	Siliceous volcanic mineral sieved and heated to 1000°C	Light volume weight (90–130 kg m^{-3}), sterile, neutral in pH (6.5–7.5), no decay, TPS (50–75% V/V).	Low nutrient capacity, energy consuming product, expensive.
Pumice	Light silicate mineral of volcanic material	Light volume weight (450–670 kg m^{-3}), good TPS (55–80% V/V), cheap and long-lasting, environmentally friendly.	High transport costs, pH may be high.
Peat	Natural anaerobically processed plant residues	Physical stability, good air and water holding capacity: TPS (85–97% V/V), low microbial activity, light volume weight (60–200 kg m^{-3}), low and easily to adjusted pH, low nutrient content.	Finite resource, environmental concerns and contribution to CO_2 release, increasing cost due to energy crisis, may be strongly acidic, shrinking may lead to substrate hydro-repellence.
Coconut coir	By-product of fiber coconut processing	Physical stability, light weight (65–110 kg m^{-3}), good air content TPS (94–96% V/V) and water holding capacity, subacid-neutral pH (5–6.8).	May contain high salt levels, energy consumption during transport.
Bark (well-aged)	By-product or waste of wood manufacture	Good air content and water holding capacity, good TPS (75–90% V/V), sub-acid-neutral pH (5–7), average volume weight (320–750 kg m^{-3}), long lasting.	High variability, need time to reduce C:N ratio and terpenes concentrations, increasing cost since used as an alternative to fuel and in landscaping.
Green compost	Composted plant residues	Good source of potassium and micronutrients, suppression of diseases, good moisture holding capacity, urban waste reduction.	Variable in composition, high volume weight (600–950 kg m^{-3}), may contain excess salt, need time to be composted, becomes easily waterlogged.
Biochar and hydrochar	Solid material derived from biomass pyrolysis or biomass hydrolysis	Production is energy-neutral, helps with carbon sequestration, biologically very stable, wet material can be used for hydrochar; hydrochar has low EC.	Properties vary dependent on feedstock (biochar), high production costs, biochar often has high pH, can be dusty.

LECTURE No.7

PHYSICAL PROPERTIES OF SUBSTRATES - AIR TO WATER RATIOS, BULK DENSITY, PARTICLE SIZE DISTRIBUTION, POROSITY, WATER RELEASE CURVES, HYDRAULIC CONDUCTIVITY

Physical properties of Substrates

Growing substrates and soil are both porous media and the physical principles of both are similar. Research in soil physics is ahead of that in substrates since research in this field started many years before the onset of soilless cultivation and up to now more efforts are devoted to soil physics, compared to physics of substrates. An appropriate adaptation is needed when soil-related knowledge is transferred to substrates due to the differences in structure and limited root zone volume.

Air to Water Ratios

Optimal plant growth is dependent on providing a balance of air and available water in the root zone,to maximize root growth and reduce the prevalence of disease (Argo, 1998). Fonteno et al. (1995) stated that the four major factors which affect air and water dynamics in soilless substrates include not only substrate components (ratios) and watering practices, but also the height and shape of the container and the substrate handling procedures (i.e. modifying substrate packing and bulk density). Typically, soilless substrates are composed of one or more materials to ensure adequate aeration and drainage, since organic particles tend to break down over time. Inorganic components, such as perlite and polystyrene, add volume to these mixes and help reduce poor aeration.Of these factors, container height is important, as it affects not only the total air space in the substrate (as influenced by gravitational forces) but it also affects the total volume, and hence the total water available to plant roots.

Bulk Density

Bulk density (BD) of a medium is defined as its dry mass per unit of volume (in a moist state) and is measured in g cm $^{-}$3. Numerous methods for the measurement of BD (as well as other physical parameters) can be found in the literature (e.g. De Boodt and Verdonck, 1972; Wever, 1995; Raviv and Medina, 1997; Gruda and Schnitzler, 1999; Morel et al., 2000). Some methods are used primarily for research purposes (e.g. the standard ISHS method, as described by Verdonck and Gabriels, 1992). Others are used as industrial standards in certain countries or regions of the world (e.g. BS EN 12580:2001 in the UK, both the LUFA and DIN methods in Germany and the CEN method in the EU). All of them, however, are based on one principle: Wet material is allowed to settle within or compressed using known pressure into a cylinder of a known volume. It is then dried down completely and weighed. As many media are composed of more than one ingredient, the characteristics of each ingredient contribute to the total BD of the medium. These are individual and combined particles' arrangements, BD of the ingredients and compaction qualities. In particular, media components that differ significantly in particle size have higher BDs as a mix (Pokorny et al., 1986). Similarly, they have lower total porosity (TP), water holding capacity and air-filled porosity (AFP) than media composed of similar particle sizes. The BD affects the choice of media in various ways. For example, outdoor production of tree saplings requires high BD media to prevent container instability under windy conditions. This can be achieved by the inclusion of heavy mineral constituents such as sand, soil, clay or tuff in the mix. On the other hand, high-intensity greenhouse crops, which are frequently irrigated and may be exposed to oxygen deficiency if hydraulic conductivity and AFP are not high, require media of low BD. Another consideration is that the mixing and transportation of low BD-media are easier than those of high BD-media.

Particle Size Distribution

Particle size distribution (PSD) is the most fundamental physical property of a porous medium and defines its texture. The particle sizes present and their relative abundance have a significant influence on most of its physical properties. Particle size analysis consists of isolating various particle sizes or size increments and then measuring the abundance of each size. The material of which the medium solid phase is composed includes discrete particles of various shapes and sizes, as well as amorphous compounds such as colloidal organic matter. The particle size and mineral composition largely determine the nature and behaviour of the medium: its internal geometry and porosity, its interactions with fluids and solutes, as well as its compressibility and strength.

Porosity

Total porosity (TP) and its components are expressed as a percentage of the total volume of the medium. The combined volume of the aqueous and the gaseous phases of the medium are defined as its total pore space or total porosity. TP is related to the shape, size and arrangement of media particles. The various methods of measuring BD are also relevant to the determination of porosity and its components. In many cases, BD is inversely related to TP (Bugbee and Frink, 1983; Bunt, 1988). However, the medium BD cannot accurately determine TP if components that have closed pores, such as perlite or pumice, are used

(Bunt, 1988; Bures et al., 1997). Not only mineral substrates contain inaccessible pores. Evans et al. (1996) sampled different coir batches. Contrary to their expectations, the samples exhibited a lower BD with lower TP. This, of course, can only happen if a significant fraction of the pores was not saturated with water during the saturation stage of the measurement, suggesting that those pores were probably of a strong hydrophobic nature. Unlike the case of closed pores, unsaturation of organic substrates may be regarded as an inherent drawback of the testing method, as can be expected during the practical use of such substrates, their hydrophobicity will be lost and all non-accessible pores will be frequently filled up with water.

Pore Distribution

Porous medium structure consists of a 3-D network of pores. Large pores play an important role in allowing roots, gas and water to penetrate into the medium. The higher the large pore (macropore) density, the more the soil can be exploited by plant roots. Similarly, the more continuous the macropores are, the more freely gases can interchange with the atmosphere. Continuous macropores also have a direct effect on water infiltration and solute transport in soil. Although small pores restrict the penetration of roots, the macropores provide favorable conditions for root growth. Several studies have shown that the presence of continuous macropores significantly benefits root growth. One of the most important factors influencing soil fertility, besides water and nutrient content, is soil aeration. Large pores are the paths available for gas exchange between the growing medium and the atmosphere. Intuitively, large and continuous pores facilitate water transport. It is now well known that the size and connectivity of soil pores play a major role in the flow characteristics of water and the transport of solutes through soil.

Water Release Curve

Water Release Curves , show the water stored in a substance at various tensions. The water content of a medium at various depths in a container ,should follow the same curves. The tension is about 1KPa per 10cm (3.94in) of depth (0.1KPa/cm). Water release curves are used by soil scientists to understand how soils or growing media “hold” and “give up” water. Growing media can hold and “release” water differently depending on the type and percentage of ingredients used in the mix. For practical purposes, the amount of water that comes out of growing media between 0 - 5 kPapressure is considered easily available to the plants. The amount of water that comes out between 5 – 10 kPa is still available but the plant is spending more energy to extract this water. If the plant has to exert beyond 10 kPa pressure to extract water, it may start wilting.

Hydraulic Conductivity and Its Relation to \|/M in Perlites

The saturated hydraulic conductivity (KSat) was determined for the types of perlite studied using a constant-head permeameter (Kluter,1986). Using the water release curves determined by the De Boodt method and considering the measuredKsat values, the KUnsat (Vm) were calculated using the model proposed by Van Genuchten (1978) which has been validated for substrates with similar properties to perlites in the interval 0, -2 KPa (Wallach, *et. al.* 1992).

LECTURE No.8

CHEMICAL PROPERTIES OF SUBSTRATES - PH, ELECTRICAL CONDUCTIVITY, ION SORPTION, ION EXCHANGE, CONCENTRATION AND COMPOSITION OF IONS, CATION EXCHANGE CAPACITY

Substrates are perhaps the most important part of the overall production process when growing landscape plants in containers at the nursery or potted crops a greenhouse. Having the proper potting mix with optimum chemical and physical characteristics will promote plant growth and should decrease the amount of time needed until the plant is salable. Reducing production time while improving plant quality should increase profit from your crops. Substrates or potting media have many chemical characteristics that could be examined, including macronutrients and micronutrients.

Chemical properties

When evaluating chemical properties of growing media, the most important criteria are pH, cation exchange capacity (CEC) and the nutrient concentrations (Gruda et al., 2013, 2016). Unlike physical, chemical properties could be adjusted at a certain level by growers. The pH plays an important role in chemically active growing media as it determines the availability of various nutrients. For most plants the optimal nutrient availability occurs when the pH in the root environment is between 5.5 and 6.0. In general, a lower pH value and lower nutrient and salt concentrations are better for growing media preparation and production. Initial materials with these characteristics such as, e.g., peat moss, permit substrate manufacture where: (i) the pH value can be increased easily by lime addition; (ii) it is possible to regulate and balance the relatively high pH value of other component materials; and (iii) the demands or requirements of different plants can be accurately taken into account and controlled (Gruda et al., 2013).

pH of Potting Mixes

pH is the first and probably most important chemical property to discuss about potting mixes because pH of the substrate affects nutrient availability and can influence mineral deficiencies and toxicities. pH is measured as the inverse logarithm of the hydrogen ion concentration (abbreviated as [H+]. The pH can range from 0 ([H+] = 1 M) to 14 ([H+] = 1 x 10 M), and pH7 is considered neutral and has a [H+] = 1 x 10 -7

Plants can be grown in a pH range between pH 4 and 8, if micronutrients are maintained in available form. The pH range for plants grown in organic soils or soilless mixes is around 1.0 to 1.5 pH units lower than the pH range for plants grown in mineral soils due to differences innutrient availability. Nutrient availability is higher in soilless mixes around pH 5.0 to 5.5 compared to a mineral soil that has maximum nutrient availability around pH 6.0 to 6.8. Having the pH too low, however, can result in micronutrient toxicities. For instance, Mn, Al and sometimes Fe will become available at toxic levels if the pH of the medium drops below 4.0. Greenhouse crops such as geranium and celosia need to be grown in a medium with a pH around 6.0 to 6.8 to prevent Fe and Mn toxicity.

Electrical Conductivity (EC) of Potting Mixes

Electrical conductivity is the second important chemical property that you should know aboutyour potting mix. EC is an indirect measurement of the salts in a medium. EC readings can be multiplied by700 to determine the salt content in parts per million (ppm). This value, however, is only an approximation and be off by as much as 20% or more. Salts, mainly in the form of fertilizers or essential minerals, are needed for plant growth. High rates of fertilizers are used to achieve high rates of growth in container culture, but too many salts will damage plant roots and ultimately the plant. High salt concentrations cause problems by changing the osmotic potential of the substrate, causing water to leave plant roots and flow into the medium. Therefore, affected plants will grow poorly since they are in essence suffering from drought or water stress. Plant sensitivity to salinity depends on age, environment, cultural practices and species.

Table 1. Interpretation of EC Readings

Saturated Extraction Method ($dS \cdot m^{-1}$ or $mmhos \cdot cm^{-1}$)	Comments
<0.74	Very low
0.75-1.99	Suitable for seedlings and media with high organic matter
2.0-3.45	Satisfactory for most plants except sensitive ones
3.5-5.0	Slightly high for most plants
5.0-6.0	Reduced growth, stunting, wilting and marginal leaf burn

Savvas (2001) conducted the research about tomato cultivated in soilless culture and the results showed that the growth and yield responses of hydroponically grown plants to the total salt concentration in the nutrient solution may be described by the generalized model. According to this model, if the EC is lower than a particular value (a), an increase in the EC to values not exceeding (a) enhances the yield of the crop. If the EC ranges between (a) and (t), where (t) is the upper critical EC level, known as salinity threshold value (STV), the yield of the crop remains constant. However, any further increase in the EC above (t) results in yield decrease. If all nutrients are included at sufficient levels in the nutrient solution, the decreases in growth and yield follow a linear pattern as the EC increases to higher levels than (t). The rate of yield decrease per unit increase of EC is termed salinity yield decrease (SYD). The impact of the increased EC on plant growth in hydroponics depends also on the prevailing climatic conditions. As a rule, the detrimental salinity effects are more pronounced under high light intensity and low air humidity.

The optimal pH in the root zone of most crop species grown hydroponically ranges from 5.5 to 6.5, although values between 5.0–5.5 and 6.5–7.0 may not cause problems in most crops. However, in soilless culture, when maintaining marginal values of the optimum pH range, the risk of exceeding or dropping below them for some time increases due to the limited volume of nutrient solution per plant that is available in the root zone. Most plants, when exposed to external pH levels > 7 or < 5, show growth restrictions.

Different plant species have different preferences with regard to nutrient ratios in the nutrient solution. Thus, the determination of the most favorable nutrient ratio for each species is of major importance. Most experiments concerned with effects of nutrient ratios in nutrient solutions focused on the ratio between the metallic macronutrients (K:Ca:Mg or K:Ca), nutrient anion ratios, the N:K (or K:N) ratio and the ratio of NH_4^+ to total nitrogen. The ratio between the metallic macronutrients is important for the maintenance of the EC in the root zone, since excessively high Ca:K or Mg:K may result in accumulation of these ions.

Ion Sorption, Ion Exchange, Concentration and Composition of Ions, Cation Exchange Capacity

The surfaces of solids in horticultural substrates of volcanic or organic origin carry permanent and/or variable positive and negative electrical charges. Permanent negative charge results from isomorphous substitutions (Gast, 1977; McBride, 1989, 2000; Sumner and Miller, 1996; Sposito, 1989, 2000), that is substitution of structural cation by lower valencycation that has the same coordination number and size inlayer-silicates (common examples: Si4+by Al 3+ or Al 3+by Mg 2+). The extent of cation adsorption to the surfaces is referred to as the cation exchange capacity (CEC; cmol kg −1) and is used to characterize the cation exchange properties of the medium (Gast, 1977; Sposito, 1989).The CEC of several inorganic and organic horticultural substrates are presented in Table. These values represent CEC measurement of intact materials prior to use, and it is important to note that plant growth may affect the chemical properties of thesubstrate solids. CEC values of soil components are usually referred by weight (i.e., cmol kg −1). However, soilless production system involve a relative small fixed root zone volume and therefore it is more practical to relate substrates CEC to volume unit (cmol L −1). By using volume-based comparison it is possible to properly compareboth ‘heavy’ and ‘light’ media.

TABLE 6.1 Cation Exchange Capacity (CEC) of Several Horticultural Substrates

Substrate	CEC cmol kg^{-1}	CEC cmol L^{-1}	Reference
	Inorganic Substrates		
Perlite	25–35	2–4	Dogan and Alkan (2004)
Stone wool	34	5	Argo and Biernbaum (1997)
Tuff	10–60[a]	10–60	Silber et al. (1994)
Clinoptilolite (zeolite)	200–400	400–800	Mumpton (1999)
	Organic Substrates		
Coconut coir	39–60	2–4	Evans et al. (1996)
Peat	90–140	7–11	Puustjarvi and Robertson (1975)
Pine bark	98[b]	10	Daniels and Wright (1988)
Compost	160–180	15–20	Inbar (1989)

[a] CEC in pH 7, tuff has variable charge surfaces as shown in Fig. 6.2.
[b] CEC in pH 7, pine bark has variable charge surfaces as shown in Fig. 6.4B.

The variable charge (both negative and positive, depending on the solution pH) is generated mainly from the adsorption of H+ and OH- on solid surfaces such as metal oxides, hydroxides, microcrystalline silicates (allophane and imogolite), or on functional organic groups (Stevenson, 1994). The effects of solution pH on the magnitude of the surface charge may be determined experimentally by measuring the CEC and the anion exchange capacity (AEC) over a range of pH values. The pH at which the AEC is equal to the CEC is referred to as the point of zero net charge ZNC) (Parker et al., 1979; Sposito, 1981, 1984, 2000) and is frequently used to characterize the charge properties of the medium. Note that in all cases, pH is referred to the solutions. An alternative experimental method is to conduct a pH titration curve using an indifferent electrolyte (Gast, 1977; McBride, 1989, 2000; Sparks et al., 1996).

Adsorption of Nutritional Elements to Exchange Sites

The affinity of cations for negatively charged surfaces under equal concentration in the aqueous portion of the substrate is affected by ion characteristics such as valence, size and hydration status. The affinity of divalent cations are higher than that of monovalent cations because of their greater charge, and usually, the relative adsorption strength follows the order of hydration, that is, NH4 >Na and Ca > Mg. However, concentrations of each of the cations in a typical irrigation solution for greenhouses crops are not equivalent, with the K concentration commonly exceeding the concentration of Ca, NH_4^+ or Mg.

Lec. 10. Value added fertilizers- enriched with organics/chelates

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Value-added fertilizer is a synergistic fertilizer composition applied to agricultural crops to increase yields with reduced fertilizer use. Compared with traditional fertilizers, value-added fertilizers have additional nutrients such as humic acids, amino acids, alginic acid, proteoglycans and other natural substances.

Value-added fertilizer has no secondary processing, the process of manufacture is simple, low cost, do not corrode equipment, environmental safety and the effect is stable. According to FCO, customized fertilizers are multi-nutrient carriers designed to contain macro, secondary and/or micro-nutrient both from inorganic sources and/or organic sources, manufactured through a systematic process of granulation, satisfying the crop's nutritional needs, specific to its site, soil and stage validated by a scientific crop model, capability developed by an accredited fertilizer manufacturing /marketing company.

Advantages

- It supplies the plant available nutrients in adequate amount and in proper proportion, leads to the balanced application as it supplies not only primary nutrients but also secondary and micro nutrients and the particular texture ensures uniform distribution of nutrients.
- Enhanced nutrient use efficiency
- As the micronutrients are also added with the granulated NPK fertilizer the plants can absorb the micronutrient along with macronutrient which prevents nutrient deficiency in plant.
- Uniform distribution of nutrients.
- Increased crop yields
- Labour saving
- Improve soil fertility hence are environmental friendly and improve soil health.

Methods of developing value added fertilizers

The three modes of manufacturing value added fertilizers are through modified release method, employing stabillization act and synergistic law.

- **Modified-release method** represents addition of slow release polymers and other sparingly soluble synthetic forms to enhance the efficiency
- **Stabilization Act** refers to the addition of urease inhibitors and digestion inhibitors to stabilize the fertilizer and enhance the efficiency.
- **Synergist law** refers to addition of biologically active substances and nitrogen synergists such as alginic acid, humic acid etc.,

Fortified fertilizers

These are the fertilizers manufactured by the addition of secondary and micronutrients to the existing N / NP / NPK fertilizers as a means of value addition or fortification.

Examples

1. Boronated single super phosphate (16P – 15O – 20B)
2. Zincated urea (43N – 2Zn)
3. Zincated phosphate suspension (12.9 P – 19.4 Zn)
4. NPK fertilizer fortified with boron (10N - 26 P – 26K – 0.3 B)
5. NPK fertilizer fortified with boron (12N - 32 P – 16K – 0.3 B)
6. DAP fortified with B (18N - 46 P – 0.3 B)
7. Calcium nirate with boron (14.6N - 0.25 B)
8. NPK fertilizer fortified with zinc (12N - 26 P – 26K – 0.5Zn)
9. NPK fertilizer fortified with zinc (12N - 32 P – 16K – 0.5Zn)

Commercial value added fertilizers

- **Zincated Factamphos :** Addition of zinc to the complex fertilizer. A single fertilizer satisfies both macro and micronutrient requirement of plants. Produced by FACT
- **Zincated Gypsum :** Serves as a soil conditioner and fertilizer. Mainly preferred for alkaline soil.

- **10:26:26 :** Granular form of N – P – K. Manufactured by Mahadhan Smartek Company. Suitable for sugarcane, cotton, groundnut, soybean, grapes, pomegranate, banana, vegetables and pulses.
- **12:32:16 :** Granular form of N – P – K. Manufactured by Mahadhan Smartek Company. Ideal for soybean, potato and other commercial crops which require high phosphorus during the early stages of crop growth.
- **20:20:0 :13:** Granular form of N – P – K - S. Manufactured by Mahadhan Smartek Company. Suitable for sulphur loving crops.

Value added organic fertilizer

- **Poultry manure and biosolids**

The value added organic fertilizers maximize the sustainability and farmers income by reducing the cost of production. Value-added granulated organic fertilizers are produced from poultry litter and biosolids using agglomeration techniques. The granulated organic fertilizer includes biosolids, a nitrification inhibitor, such as dicyandiamide, and a binding agent, such as lignosulfonate, urea formaldehyde, or water. The nitrogen concentration of the granulated organic fertilizer is increased by fortifying with urea. The poultry litter and biosolids formulated into the granulated organic fertilizer aid in flowability, storage, and spreading, while value-added plant nutrient ingredients provide an environmentally safer fertilizer than fresh poultry litter, municipal biosolids etc., commonly used in urban and agricultural systems. The nitrification inhibitor reduces nitrogen losses via leaching and denitrification.

- **Phosphorus enriched FYM**

Farmyard manure enriched with Single Super Phosphate is a common value added organic fertilizer. Superphosphate required for one hectare of a crop is treated with 750 kg of FYM and incubated for 30 days. Enriched FYM helps in preventing the fixation losses of phosphorus.

- **Zinc enriched FYM**

Micronutrients help in preventing the fixation loss of nutrients thereby enhancing their use efficiency.

- **Vermicompost enriched with biofertilizers**

Azospirillum and Phosphobacteria @ 1 kg per tonne of the compost helps in enhancing the nutritional value of the compost.

Priority Areas of Research

- Development of crop specific customized fertilizers. In developing these fertilizers, special precautions are needed when boron, copper, manganese and molybdenum are incorporated in N / NP / NPK fertilizers, because there is a narrow margin between deficiency and toxicity limits of these nutrients.
- Development of low cost indigenous nitrification inhibitors and nano – VAFs.
- Coating of N / NP / NPK fertilizers with biodegradable polymers, nano clay, gypsum and other low cost indigenous materials
- Development of bio impregnated phosphate fertilizers

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Lec. 11. Methods and Guidelines for Preparing Designer Fertilizers - Filler Materials

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Need for Customized Fertilizers

India has diverse and numerous agro-ecological zones and production environment. Most of the farmers are in small and marginal category with variable investment capacity. Therefore developing customized fertilizers is essential to decrease the cost of production incurred on fertilizers.

Preparation of Customised fertilisers

Scientific principles are used as a guiding factor in deciding the grades of customized fertilisers. The following procedure is followed to develop crop-soil specific customized fertiliser grades (CFG).

- Geo-referencing of chosen area
- Selecting sampling points adopting appropriate statistical procedure
- Actual sampling of the sites
- Analysing soil, plant and water samples for nutrients and some soil characteristics
- Defining management zones
- Yield targeting in major management zones
- Computing crop removal of nutrients
- Calculating nutrient requirement (amount and ratio)
- Blending of nutrients based on the generated information

Solutions

- Identifying the major crops grown in the region
- Nutrient indexing in the study area based on soil analysis.
- Formulation of Customized Fertilizer solutions to provide a total nutrient package as basal application.

Eg.:

Grade 1-	N10	: P20	:K10	: S5	: Mg2	: Zn0.5	: B0.	: Fe0.2
Grade 2-	N20	: P10	:K10	: S5	: Mg2	: Zn0.5	: B0.3	: Fe0.2
Grade 3-	N10	: P20	:K20	: S3	: Mg2	: Zn0.5	: B0.3	: Fe0.2
Grade 4-	N15	: P15	:K15	: S5	: Mg2	: Zn0.5	: Fe0.2	

These customised fertiliser grades are subjected to change every three years as per the changing soil fertility and crop need

Development of Protocol

The protocol for development of customized fertilizer grades has three primary components:

(i) Defining fertility management zones

(ii) Using empirical models like QUEFTS/STCR

(iii)Use of secondary research data and experiential learning'

(i) Defining Fertility Management Zones

Soil fertility management zones are developed by a qualified team of crop specialists. Geo-referenced sampling is a rigorous process which is done in a two months' time available after *Rabi* and *Kharif* season [after *Rabi* season (June) and after *Kharif* season (October and November). Crop specialist use hand held GPS (Global Positioning System) and record latitude, longitude and altitude value of the field from where they take sample. Soil, crop and water samples are analysed for nutrients to build database for deciding the management zones.

(ii) Use of Empirical Models like QUEFTS/STCR

QUEFTS (Quantitative Evaluation of Fertility of Tropical Soils) needs to be calibrated for 'a' and'd' values for N, P and K; which basically refers to the nutrient uptake efficiency under adequate and limited growth conditions For this purpose, the database from secondary literature and from crop cutting trials are collected for the test crop to develop customized fertilizer grade. The soil supplying capacity is computed on the basis of soil test. The mechanistic model of QUEFTS is run for optimizing N, P and K requirement for a targeted crop yield by using the ‘a’ and ‘d’ values and soil test values for N, P and K. On the basis of the general availability of the micronutrient, common representative dose of these specific nutrients are decided. Soil Test Crop Response (STCR) approach is also applied in optimization of N, P and K for the same target yield of the crop.

(iii) Use of Secondary Research Data and Experiential Learning

Value of N, P and K requirement from both the approaches are compared and evaluated. The final decision making is however based on secondary research data and experiential learning.

Validation of Formulation Grade

Multi-location trials are conducted on the farmers’ fields and KVK farms using prevalent recommendations for the test crop. In all these tests, RBD design is used with four replications.

Eligibility Criteria for Manufacture and Sale of Customized Fertilizers

- Permission for manufacture and sale of customized fertilizers shall be granted to only such manufacturing companies whose annual turnover is Rs.500 crores and above.
- Manufacturing companies should have soil testing facility with an annual analysing capacity of 10,000 samples per annum for NPK, secondary and micro nutrients. Such laboratory must possess the requisite instrument viz., Atomic Absorption Spectrophotometer, Flame Photometer, pH meter Conductivity Bridge, Kjeldhal Distillation etc. The grades of customized fertilizers, which company will manufacture, must be based on scientific data obtained from area-specific, soil-specific, crop specific and soil testing results.
- Prospective manufacturers or marketers are expected to use the software tools like Decision Support System like DSSAT, crop models, etc. to determine the optimal grades of customized fertilizers.
- The manufacturing companies, in association with Agricultural universities / KVKs concerned, should also conduct agronomy tests of the proposed grade to establish its agronomic efficacy.

- Such manufacturing companies should generate multi-location trials (not On-Farm Demonstrations) on different crops for minimum one season. Such manufacturing companies must draw these soil samples from within its operational areas and should also ensure that minimum one sample necessarily drawn from University/State government may also be used to prepare soil fertility map and for determination of crop specific grades for potential marketing areas.

Grant of Permission

- Subject to fulfilment of eligibility criteria referred above, the permission for manufacture and sale of customized fertilizers is granted by Department of Agriculture & Cooperation, Ministry of Agriculture, GOI.
- Permission, for manufacture and sale of particular customized fertilizers grade is granted only for the specific area and for a period not exceeding three years.
- For grant of permission to produce and sell such customized fertilizers, the concerned manufacturing companies should necessarily apply for permission, to the Ministry of Agriculture under intimation to the State Government, in the prescribed proforma.
- The competent authority shall expedite the requisite permission/authorization or otherwise within 45 days of the receipt of such applications.
- Such manufacturing companies are required to start their manufacturing and sales process within a period of six months from the date of grant of such permission.

Renewal and Revision of Customized Fertilizer Grades

- On completion of three years or earlier, manufacturing company of customized fertilizers shall submit a renewal/revision application for varied customized fertilizers manufactured by it.
- In case, no change in the already approved composition of customized fertilizers is required, the same shall also be declared by the manufacturer.
- The competent authority, shall, accord its approval within a period of 45 days from the date of receipt of such applications.

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Lec. 12 Industries and Approved formulations and mixtures – Advantages and Disadvantages - Key Challenges

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Customized formulations available in India

There are about 36 formulations approved by Fertilizer Control Order of India. The important companies in the market producing customized fertilizers are Tata Chemicals Ltd., Deepak Fertilizers, Nagarjuna Fertilizers, Coromandel Industries Ltd. Etc. Integrated with soil information, the customized fertiliser is formulated on sound plant nutrition principles, thus becoming soil and crop-specific fertilizer.

Tata Chemicals Ltd (TCL), launched the ‘ParasFarmoola', the country's first ever customized fertilizer product specifically targeted at farmers in Western-Central Uttar Pradesh (UP). For manufacturing customized fertilizers, TCL has set up a Rs 60-crore 130,000 tonnes per annum facility at its existing area unit at Babrala in UP, with technology sourced from A.J. Sackett of the US.

Farmers’ Preference for customized fertilisers

Presently about 80 formulations having N, NP, NPK, NPKS are available in the country depending upon crops and regions. Development of customized fertilizers like zincated urea and boronated super phosphate in early period did not catch up popularity among the farmers-due to predominance of single micronutrient deficiencies, high cost and fear of toxicities due to their indiscriminate use. Even now farmers prefer to use straight sulphate salts of micronutrients like zinc, iron, and manganese compared to Zn or B fortified fertilizers. Blending of iron and manganese fertilizers with N/NP/NPK may not prove beneficial. High cost is another issue for developing customized fertilizers.

Application of customized or speciality fertilizers in horticultural and vegetable crops is widely practiced either for soil, foliar application or in fertigation. Development of soil and crop specific customized fertilizer may prove beneficial in achieving balanced nutrition of crops.

Customized fertilizer grades

The grades of customized fertilizer which the manufacturing company propose to manufacture and sell shall be based on area and crop specific soil testing results. The manufacturer may be in association with Agricultural Universities/KVKs concerned, shall also conduct agronomy tests of the proposed grade to establish its agronomic efficacy. The minimum nutrient content in a specific grade of customized fertilizer, proposed to be manufactured, shall contain not less than 30 units of all nutrients, combined.

Quality of customized fertilizers

Customized fertilizers to be used for basal application shall be granular in size with minimum 90% between 1-4 mm IS sieve and that below 1 mm should not exceed 5%. The moisture content should not exceed 1.5%. For foliar application, the grades should be 100% water soluble. The specifications of the customized fertilizers provided by the company to manufacture of customized fertilizer, duly approved by the Ministry, shall be strictly adhered to.

Quality check

(i) Procedure for drawal of sample of fertilizers

a. The method of drawing samples shall be provided in the FCO.

b.Weight of one sample should be 400g. as specified under Clause 4 A

(ii) Methods of analysis of fertilizer

a. The methods of analysis of fertilizers shall be as per the procedure prescribed in FCO.

b. For preparation of sample for analysis in the laboratory, the whole sample size of 400g should be powdered.

(iii)Tolerance limit

The tolerance limits prescribed under the FCO, 1985, for NPK mixture and NPK with micronutrients, shall be applicable to the customized fertilizers. However such tolerance limit shall not exceed 3% for all nutrients particularly when secondary and micronutrients are also present with NPK.

Labeling

1. The word Customized Fertilizer shall be superscribed on the bags.
2. The name of the crop and geographical area for which the customized fertilizer recommended shall also be indicated on the bags.
3. The grades of customized Fertilizer and the nutrient content shall be mentioned on the bags.
4. The manufacture should preferably have tampered proof bagging so as to check on adulteration

Pricing of customized fertilizer

The Company shall fix reasonable MRP for its approved grade of customized fertilizers taking all factors into consideration.

Customized fertilizer for higher crop productivity

Custom mixed fertilizer is a mixed fertilizer formulated according to individual specifications furnished by the consumer before mixing. Some land needs much higher quantities of balanced fertilizer mixtures in granulated form, for soil application; water soluble form for drip irrigation, mini sprinkler and foliar spray systems. Customized fertilizer may also be defined as multi-nutrient carrier which contains macro and/or micronutrient, whose sources are from inorganic or organic, which are manufactured through systematic process of granulation and satisfies crop's nutritional demand, specific to area, soil and growth stage of plant. Customized fertilizers are enriched with both macro and micro nutrients and are manufactured with stringent quality checks.

Application

The objective behind customized fertilizer is to provide site specific nutrient management for achieving maximum fertilizer use efficiency for the applied nutrient in a cost effective manner. A fertilizer formulated for a consumer prior to mixing, is usually based on the results of soil tests. Customized fertilizers depends on soil, crop, water and specific nutrients. Manufacture of Customised fertiliser basically involves mixing and crushing of urea, DAP, MOP, ZnS, bentonite sulphur and boron granules for obtaining the desired proportion of N, P, K, S and micronutrients. The mixture is subjected to steam injection, drying, sieving and cooling, so as to get a uniform product with every grain having the same nutrient composition.

Benefits

- Customized fertilizers generally maximize crop yields while minimizing unwanted impacts on the environment & human health.
- Fertilizer Best Management Practices make it for farmers, extension agents, crop advisers & researchers to exchange their experiences and also to restrict the unwanted nutrient impact on the ecosystem.
- Application of customized fertilizer is compatible with existing farmers' system and hence it will be comfortably accepted by the farmers.
- Production of customized fertilizers ensure improved Fertilizer Use

- Customized fertilizer satisfies crop's nutritional demand, specific to area, soil and growth stage of the plant.
- As the micronutrients are also added with the granulated NPK fertilizer the plants can absorb the micronutrient along with macronutrient which prevents nutrient deficiency in plant.
- Mixed fertilizers with micronutrients provide recommended micronutrient rates for the agricultural fields at the usual fertilizer application.
- The farmer need not buy micronutrient separately at extra cost, thus reducing the total cost.
- Incorporation of micronutrient with granular fertilizer at the time of manufacturing results in uniform distribution of micronutrients throughout granular NPK fertilizer.

Customized fertilizers for Site Specific Nutrient Management (SSNM)

Nutrient management is a major component of a soil and crop management systems. Site specific nutrient management involves nutrient management within a field that are known to require different management options. Site-specific nutrient management does not require special equipment and does not require a large farming operation. It is basically a systematic approach to apply sound agronomic management to small areas of a field that needs special treatment.

Priority areas for customized fertilizers

The introduction of SSNM strategies start with the priority areas facing one or more of the following problems:

- Areas having inadequate or unbalanced use of fertilizer nutrients with low yield levels.
- Areas with crops showing nutrient deficiency symptoms at large scale.

- Areas with occurrence of pest problems linked to nutrient imbalance or overuse of fertilizer N.
- Areas with inefficient fertilizer N use at higher rates
- Areas having evidence of multi-nutrient deficiencies including secondary and micronutrients in soils and crops.

Approach

The promotion of customized fertilizers aims at increasing farmers' profit by achieving the goal of maximum economic yield (MEY) of crops. The main features of customized fertilizers are:

- Application of nitrogen, phosphorus, and potassium fertilizer is adjusted to the location- and season-specific needs to the crop.
- Site-specific application of secondary and micronutrients based on soil tests.
- Promotion of customized fertilizers provide guidelines for selection of the most economic combinations of nutrients.
- Promotion of customized fertilizers should also ensure recommendations for wise and optimal use of existing indigenous nutrient sources such as crop residues and manures.
- Customized fertilizers to be effective should ensure adoption of all the components of integrated crop management (ICM) *viz.* the use of quality seeds. Optimum plant density, Integrated pest management, and good water management.

Achieving the goal of yield maximization through customized fertilizers

To achieve potential yields in crops, collaborative on-farm trials /demonstrations should be conducted by the scientists and fertilizer industry personnel to evaluate the effect of customized fertilizers for higher yields.

The scientists and the industry personnel should ensure providing the technology for continued higher yields.

Key Challenges

- Production of customized fertilizers requires technical expertise and huge investment
- Not applicable for all soil types and conditions
- Costly compared to straight fertilizers
- May sometime result in precipitation reactions affecting the crop

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Lec. 13. Quality of Designer Fertilizers - Compatibility of Fertilizer Materials - Issues In Storability- Hygroscopicity- Clogging- Toxicity

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Quality of Designer Fertilizers

- Designer fertilizers to be used for basal application shall be granular in size with minimum 90% between 1-4 mm IS sieve
- The moisture content should not exceed 1.5%.
- For foliar application the grades should be 100% water soluble.
- The specifications of the customized fertilizers provided by the company should be duly approved by the Ministry.

Quality control of customised fertilizers

Fertilizer Control Order has laid down fertilizer-wise detailed specifications and fertilizers not meeting the specification, cannot be sold in the country for agricultural purposes. It also lays down detailed procedure for sampling and analysis of each fertilizer. The Central Fertilizer Quality Control and Training Institute (CFQC&TI), Faridabad and its three Regional Fertilizer Control Laboratories (RFCL) (Chennai, Navi Mumbai and Kalyani) under the Department of Agriculture & Co-operation (DAC) take samples of imported fertilizers at the discharge port for analysis. The States also have their own State Notified Quality Control laboratories that analyse samples taken from field (Warehouses/Dealers/ Retailers) as well as from the manufacturing plants. Based on the analysis, the labs declare samples as **standard** or **non-standard** in terms of specifications laid down in the FCO. The sub-standard quantities are arrived at as per the procedure laid down in the FCO and the copies of analysis report are sent to DAC, DOF, the concerned manufacturer/importer etc. No subsidy is payable on quantities declared as sub-standard.

Quality check

(i) Procedure for drawal of sample of fertilizers

a. The method of drawing samples shall be provided in the FCO.
b. Clause 4A (iii) Weight of one sample should be 400g as specified under Clause 4 A (iii) for Part A in Schedule 1 of the FCO, 1985.

(ii) Methods of analysis of fertilizer

a. The methods of analysis of fertilizers shall be as per the procedure prescribed in FCO.
b. For preparation of sample for analysis in the laboratory (Clause 1-1) under part B in schedule II of FCO, 1985 the whole sample size of 400g should be powdered.

(iii)Tolerance limit

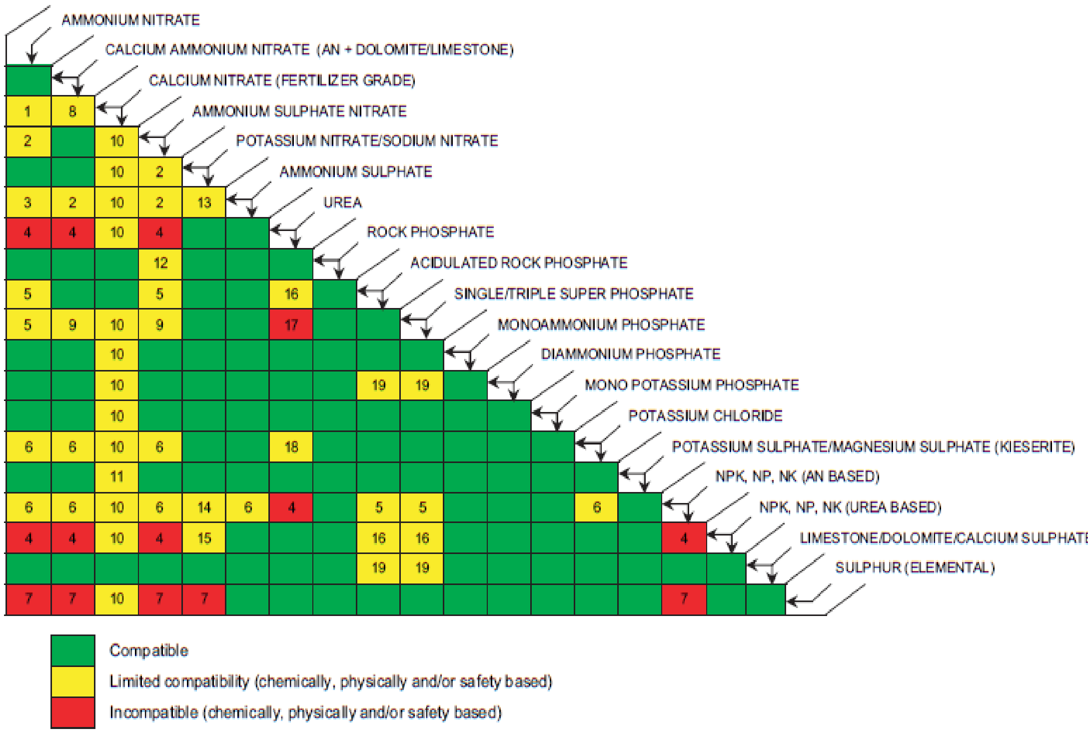
The tolerance limits prescribed under the FCO, 1985 for NPK mixture and NPK with micronutrients, shall be applicable to the customized fertilizers. However such tolerance limit shall not exceed 3% for all nutrients particularly when secondary and micronutrients are also present with NPK **(Table 1).**

Compatibility of fertilizer materials

Some raw materials are not compatible with others and blends containing such mixtures will be of very poor quality. The compatibility data are presented in three categories (Figure 1).

Compatibility (chemical and physical)

Compatibility primarily relates to blending of different fertilizers, cross contamination and other problems in safety and/or quality; e.g. caking, weakening, dust formation, and loss of resistance to thermal cycling in the case of ammonium nitrate.



Notes for the numbers in the boxes in the compatibility table

- Due to the hygroscopic behaviour of both the products, the type of stabilisation of the ammonium nitrate grade with calcium nitrate could influence the storage properties.
- Safety and legislative implications are concerned regarding Ammonium nitrate /Ammonium Sulphate mixtures. (Ammonium sulphate nitrate, Calcium Ammonium Nitrate with Ammonium Nitrate, Ammonium sulphate nitrate with Potassium Nitrate / Sodium nitrate)
- If free acid is present it could cause a very slow decomposition of Ammonium nitrate, affecting the packaging .(Ammonium Nitrate with Partially acidulated rock phosphate, Single/Triple super phosphate)
- Sulphur is combustible and can react with nitrates e.g. Ammonium nitrate, KNO_3 and $NaNO_3$.
- Due to the hygroscopic behaviour of both products, the type of stabilisation of ammonium nitrate based fertilizer could influence the storage properties.(Ammonium Nitrate, Calcium Ammonium Nitrate, Ammonium sulphate nitrate with Potassium chloride and NPK, NP, NK (AN based))

- Consider the moisture content of the SSP/TSP.
- Consider the relative humidity during blending Rock Phosphate with Ammonium sulphate nitrate
- Consider impurities in Ammonium sulphate and the drop in the critical relative humidity of the blend.
- Consider the possibility of ammonium phosphate/potassium nitrate reaction with urea and the relative humidity during blending, to avoid caking.
- If free acid is present, there is a possibility of hydrolysis of urea giving ammonia and carbon dioxide.
- Formation of very sticky urea phosphate on mixing urea with rock phosphate.
- If free acid is present, there is risk of a reaction e.g. neutralisation with ammonia and acid attack with carbonates (Limestone/ Dolomite/Sulphate/Calcium carbonate with single/Triple super phosphate)

Table 2: Common blending raw materials

Name	**Abbr**	**Formula**	**N**	**P_2O_5**	**K_2O**	**SO_3**	**MgO**	**CaO**
Ammonium Nitrate	AN	NH_4NO_3	33-34.5					
Calcium Ammonium Nitrate	CAN	$CaCO_3$/ NH_4NO_3	26-28					11
Ammonium Sulphate Nitrate	ASN	$(NH_4)_2SO_4$/NH_4NO_3	26			35		
Ammonium Sulphate	AS	$(NH_4)_2SO_4$	21			60		
Urea		$CO(NH_2)_2$	46					
Superphosphates:								
Single Superphosphate	SSP	$Ca(H_2PO_4)_2$*		18-20		30		
Triple Superphosphate	TSP	$Ca(H_2PO_4)_2$*		45-48		3		
Potassium Chloride	MOP	KCl			60-62			
Potassium Sulphate	SOP	K_2SO_4			50	45		
Potassium Magnesium Sulphate		K_2SO_4 + $MgSO_4$			30	42	10	
Ammonium Phosphates :								

Di-ammonium Phosphate	DAP	$(NH_4)_2HPO_4$	18	46-48				
Mono-ammonium Phosphate	MAP	$NH_4H_2PO_4$	12	52-53				
Calcium Carbonate		$CaCO_3$						52
Compacted Dolomite		$CaCO_3$ - $MgCO_3$					20	30
Magnesium Carbonate		$MgCO_3$					10	40
Kieserite		$MgSO_4$				50	25-28	

Mixing Fertilizers - Fertilizer Compatibility

Some fertilizers should not be mixed together in one stock tank because an insoluble salt might form very quickly. Some fertilizer materials interact to form insoluble compounds and precipitates. The precipitates tie up the nutrients and make them unavailable to the plant and cause clogging in the irrigation equipment. An example for such incompatibility is mixing fertilizers that contain calcium with those that contain phosphate or sulphate.

The Principle of Fertilizers Mix

Fertilizers that are not mutually compatible should be avoided from being mixed in one tank. The rule is that neither phosphoric nor sulphate fertilizers should be mixed with calcium or magnesium fertilizers in the same tank. This separation prevents precipitation of calcium phosphate or calcium sulphate compounds in the tank or in the pipeline.

Corrosivity of Water Soluble Fertilizers

Corrosivity is a characteristic that expresses the degree to which fertilizer solution attacks various metals.

- **Very Corrosive Solutions:** (with a pH below 3.5) corrode all metals, including stainless steel.
- **Weakly Corrosive Solutions:** (with a pH in the range from 3.5 to 6.0) corrode iron and steel but do not attack stainless steel.
- **Non-Corrosive Solutions:** (with a pH above 6.0) do not corrode metals such as: iron, steel, stainless-steel, aluminium, bronze, etc. The composition of a fertilizer solution determines its corrosivity. As a general rule, a strongly acid solution with a pH below 3.5

is considered to be very corrosive. Solutions with a pH above 3.5 are generally weakly corrosive or non- corrosive. Most fertilizer solutions containing phosphorous are corrosive. Acid fertilizer solutions containing chloride (Cl) are considered to be very corrosive; these solutions are prepared with Potassium Chloride (KCl)

Storage

Raw material storage must be arranged to avoid segregation within the materials, cross contamination and deterioration of the physical quality

Fertilizer Storage

- Store fertilizers separately from other chemicals in dry conditions.
- Extra care needs to be given to concentrate stock solutions. Secondary containment should be used.
- Provide pallets to keep large drums or bags off the floor. Shelves for smaller containers should have a lip to keep the containers from sliding off easily. Steel shelves are easier to clean than wood if a spill occurs.
- If storage is planned in large bulk tanks, a containment area large enough to confine 125 percent of the contents of the largest bulk container is to be provided.
- Keep the storage area locked and clearly labeled as a fertilizer storage area. Preventing unauthorized use of fertilizers reduces the chance of accidental spills or theft. Labels on the windows and doors of the building give firefighters, information about fertilizers and other products present during an emergency response to a fire or a spill.
- Provide adequate road access for deliveries and use, and in making the storage area secure, also make it accessible, to allow getting fertilizers and other chemicals out in a hurry.
- Never store fertilizers inside a wellhouse or a facility containing an abandoned well.
- Untimely application of fertilizer leads to excessive release from the production system to surface and/or ground water. Potential problems can be minimized through adequate environmental awareness, employee training, and emergency preparedness.

Storage Location

- Greenhouse fertilizer storage areas contain relatively large quantities of concentrated chemicals. Risks in storage areas include release through broken, damaged, or leaking containers; loss of security leading to irresponsible use; accumulation of outdated materials leading to excessive quantity of fertilizer unnecessarily raising risk level; and combustion of oxidizing compounds in fertilizer (e.g., nitrates) caused by fire or another disaster event.
- A building or area dedicated to fertilizer storage can be maintained, separated from offices, surface water, neighboring dwellings and bodies of water; separate from pesticides and protected from extreme heat and flooding.
- The storage area should have an impermeable floor with secondary containment, away from plant material and high traffic areas. Clean-up equipment should be readily available.
- Storage areas should not contain pesticides, or other greenhouse chemicals; There should be no food, drink, tobacco products, or livestock feed present.
- Sound containers are the first line of defense against a spill or leak. If a container is accidentally ripped open or knocked off a shelf, the spill should be confined to the immediate area and promptly cleaned up. The building should have a solid floor and, for liquid fertilizers, a curb. The containment volume should be large enough to hold the contents of the largest full container.

Containers

Fertilizer should be stored in their original containers unless damaged; labels should be visible and readable; food or beverage containers should never be used for storage. Labels should be in plain sight; no containers should come in contact with the floor; all containers should be stored up-right; aisles should be wide enough to comfortably accommodate workers; containers should not be crowded on shelves or pallets.

Partially-used Containers

Paper bags and boxes should be opened with a box cutter or scissors; Open containers should be resealed and returned to storage; all open paper bags should be sealed inside another, larger container, sealed and labeled.

Damaged Containers

Containers should be checked often for damage; when damaged containers are noticed, contents should be repackaged and labeled or placed in suitable secondary containment which can be sealed and labeled.

Containment

There should be no floor drain; the floor should provide containment in the event of a spill; there should be secondary containment routinely used for most open containers; damaged or leaking containers should be repaired and/or replaced as soon as possible; all spilled material should be cleaned up upon discovery; and cleanup materials should be discarded promptly and properly.

Fire Prevention and Suppression

Fire detection and alarm system should be present; oxidizers and flammable materials should be stored separately; fire extinguisher should be immediately available; the Fire Department should be notified at least annually of current inventory.

Inventory and Recordkeeping

Inventory should be actively maintained as chemicals are added or removed from storage; Containers should be dated when purchased; outdated materials should be removed on a regular basis; inventory should be controlled to prevent the accumulation of excess material that may become difficult to use

Lighting

Electrical lighting should allow view into all areas and cabinets within the storage area.

Monitoring

There should be monthly inspection of storage for 1) Signs of container corrosion or other damage - leaking or damaged containers should be repackaged as appropriate, 2) Faulty ventilation, electrical, and fire suppression systems – problems should be reported and corrected.

Security

The storage room should be locked and access restricted to trained personnel.

Signage

There should be signs posted; warning signs should be used as needed; emergency contact information should be posted.

Temperature Control

There should be active mechanical temperature control and no direct sources of heat (sunny windows, steam pipes, furnaces, etc.).

Ventilation

Mechanical ventilation should be working and used.

Storage and Record Keeping

Fertilizer stock tanks should be labeled with fertilizer formulation and concentration; Records should have information on fertilizer formulation, concentration, date, and location of application; records should be kept of media nutrient analyses.

Containment of Concentrated Stock

Concentrated stock should be stored near the injector in high density polyethylene or polypropylene containers with extra heavy duty walls; secondary containment should be provided.

Disposal

Sufficient planning should be made to eliminate the need for disposal; empty fertilizer containers should be discarded based on latest advice from environmental protection authorities.

Precipitate and Residue Disposal

Fertilizer systems should be cleaned. Solids and rinse solution should be composted.

Spill Prevention and Preparedness

Opening fertilizer product containers, measuring amounts, and transferring fertilizer to the delivery system involves some level of risk from spills. Secondary containment should be used for fertilizer stock tanks routinely; spill clean-up materials should be used for liquids (e.g., absorbent materials) and solids (e.g., shovel, dust pan, broom and empty and/or buckets) should be available within the general area.

Delivery System

The fertigation equipment should be checked monthly for accuracy. Recommendations of the manufacturer recommendations should be followed when calibrating or working on fertilizer injector equipment; stock solution tanks and the areas surrounding fertilizer injectors and concentrated solutions should be kept clean and free of debris.

Hygroscopicity

Some fertilizer raw materials are hygroscopic and stores holding these materials should be air conditioned or the material should be covered when not being used. The lower the critical relative humidity, the more moisture will be taken from the air. Generally the phosphates including the ammonium phosphates have a high critical relative humidity and thus almost never present hygroscopic problems. The opposite applies to nitrates such as calcium ammonium nitrate, ammonium nitrate and especially calcium nitrate **(Table 3).**

Table 3. Critical relative humidity of fertilizers

Component	Critical RH (%)
Triple Superphosphate	93.6 %
Mono-ammonium Phosphate	91.6 %
Di-ammonium Phosphate	82.5 %
Ammonium Sulphate	79.9 %
Potassium Chloride	77.0 %
Urea	74.6 %
Sodium Nitrate	72.4 %
Calcium Ammonium Nitrate	61.3 %
Ammonium Nitrate	59.4 %

Calcium Nitrate	46.7 %

Clogging of fertilizers

Since fertigation is a combination of irrigation and fertilization, clogging problems can be traced back to either the water supply or injected fertilizer. Water quality includes the physical, chemical, and biological qualities of irrigation water.

a. Water

- **Physical:** The irrigation water can have too many suspended solids, such as debris and tiny clay particles, which can plug irrigation lines and emitters. When suspended solids exceed 50 parts per million (ppm) in the irrigation water, clogging problems are likely. The clogging problem will be severe if suspended solids are in excess of 100 ppm.
- **Chemical :** Chemical problems include high pH and high concentrations of cations and/or anions in the irrigation water. In the presence of high pH and oxygen within the water, the ferrous iron species is vulnerable to oxidation and creates a ferric iron precipitate. This oxidization not only reduces the bioavailability of iron applied through fertigation but also creates clogging problems. Studies indicate that approximately 50% of the ferrous iron species can be oxidized to ferric iron at pH 6.3 in 20 minutes. Irrigation with "hard" water, which is high in minerals such as calcium and magnesium, can also cause clogging problems because the calcium and magnesium ions are susceptible to precipitation with carbonates and phosphates.
- **Biological :** Bacterial growth can cause clogging problems when the bacterial population is greater than 2,600 colony-forming units (CFU) per gallon. Water sources rich in nutrients have greater potential to support the growth of bacteria and clog irrigation systems. The bacteria oxidize iron and manganese and initiate the slime-like growth of biofilms, which can clog the system. The presence of algae in surface water supplies can also clog fertigation systems, as can root intrusion into buried drip emitters.

b. Fertilizer

Some fertilizers can also cause clogging problems if they are incompatible with fertigation. Chemical reactions may occur after the fertilizers are injected into the irrigation system. Additional problems can occur with regard to the temperature of the mixing water, the coagulation and secondary chemical reactions in the mixing tank, or failure to keep suspensions for a number of reasons.

- **Fertilizer incompatibility :** For example, calcium nitrate and diammonium phosphate are fertilizers commonly used for commercial crop production, but these two fertilizers are NOT compatible. If these fertilizers are mixed together, calcium from calcium nitrate and phosphate from diammonium phosphate can form calcium phosphate, which is insoluble and precipitates out, clogging lines and emitters during fertigation.
- **Chemical reactions:** There may be additional chemical reactions after the selected fertilizers are injected into irrigation water. These reactions include hydrolysis, dissociation, oxidization, and precipitation. The first two types of reactions can accelerate the second two types of reactions. These chemical reactions can all cause clogging.
- **Fertilizer Toxicity :** Fertilizer toxicity is an issue that is important for all farmers who place their seed and fertilizer in one operation, and the interaction between the two during germination and emergence. Producers must gain a good understanding of the benefits and dangers of seed & fertilizer placement to avoid an environment that is toxic to the crop.

  All fertilizer salts are toxic to germinating seeds and to plant roots if applied in sufficient concentration near or in contact with the seed. Fertilizers vary in toxicity per unit of plant nutrient due to

  ~ differences in the amount of salts contained in the fertilizer,

  ~ differences in the solubility of the salts in the soil,

  ~ the presence of specific materials or elements that are particularly toxic (for example, ammonia and boron).

~ Many nitrogen fertilizers, although they have a relatively low salt index, release free ammonia into the soil

Lecture No. 14. Crop response to designer fertilizers - Agricultural and horticultural crops- yield and quality- Soil health and nutrient use efficiencies

Crop response to fertilizer

Crop response to fertilizer application depends not only on the level of available plant nutrients in the soil but is also related to crop physiology and morphology. For a well-balanced nutrition the rate of nutrient supply to the roots must correspond with the rate of nutrient required for growth. Species or cultivars with a high growth rate generally respond more favourably to fertilizer application than those with low growth rates. An analogous relationship holds for the biomass produced per unit soil surface. Thus modern rice and wheat cultivars tolerate a more dense spacing than older ones. Due to the dense stand the yield and particularly the grain yield of the modern varieties may be several times higher than those of older cultivars, and therefore also the nutrient requirement, especially the demand for N and P, is higher for the modern cultivars.

On-farm trials

Fertilizer use development requires teamwork through collective and coordinated effort of several agencies involved in research, extension and input supply. In the larger context even agencies providing irrigation, credit energy and produce markets are also important because fertilizer use is a means to increase crop productivity leads which in tum to a marketable surplus, which can be sold by the farmers to increase their incomes and standard of living. Fertilizer use thus has a direct effect on raising the living standard of the rural population.

Effects on crop production

Concept of customized fertilizers may be new in India but it is common in agriculturally advanced countries. This shows the need for realization of the importance of CF by our government for attaining the food and nutritional security. Even though the production of customized fertilizers is difficult, the end is very promising. This can be substantiated by studying its performance on farmer's field.

Performance of customized fertilizers at farmers' field

The study was conducted by Tata chemicals Ltd. in Noida to know the effect of customized fertilizers in farmer's field. Here they compared the yield from customized fertilizers and the yield from common farmer practice. They got 14%, 20%, 15% and 40% increase in yield of rice, wheat, potato, and sugarcane respectively over the common farmer practice. They are saying that it has been heartening to observe that farmer using lower dose of customized fertilizer also got superior performance over their conventional practice.

Effect of nutrient management practices on castor-sorghum cropping system

Experiment conducted at Directorate of oil seed research, Hyderabad by Ramesh *et al.* in 2013 to study the effect of nutrient management practices like recommended dose of fertilizers (RDF), integrated nutrient management(INM), organic nutrient management(ONM), fertilizers based on soil test crop response(STCR) and customized fertilizers(CF) on the productivity and economic return of castor-sorghum cropping system.

Effect of nutrient management practices on yield attributes and economic returns

Application of customized fertilizers recorded significantly higher yield attributing characters compared to other nutrient management practices both in case of castor and sorghum. But were comparable with the treatment receiving fertilizers based on STCR resulted in about 18 and 15% increase compared to RDF and so system income and B:C ratio was also maximum in CF followed by STCR. CF recorded the highest uptake of nutrients in cropping system compared to RDF. Higher seed yields of castor and sorghum with customized fertilizers or STCR was due to favourable crop growth and higher yield attributing character. In these treatments, nutrients are applied in proportion to the magnitude of deficiency of a particular nutrient and the correction of nutrient imbalances in soil helps in harness the synergistic effects of balanced fertilizer application (Ramesh *et al.,* 2013) [11].

Effect of customized fertilizers on yield parameter of rice

The pooled analysis of two locations indicated that application of 100% RDF in the form of CF II increased the productive tillers (21 nos.), panicle length (27.70 cm) and number of filled grains per panicle (203 nos.).The number of productive tillers recorded in the treatment that received 100 % RDF in the form of CF II was on par with 100 % RDF through CF I +25 kg Zn SO4 ha-1 and 100% RDF through straight fertilizers. The lowest number of productive tillers, panicle length and number of filled grains per panicle were recorded in the treatment that received 50 % RDF through CF I +25 kg Zn SO4ha-1.Successive increase in fertilizer levels from 50% RDF to 100% RDF had marked influence on the yield attributes of rice. Application of 100% RDF of straight fertilizers recorded a grain yield of 5628 kg ha-1. Application of 100% RDF in the form of CF II recorded the highest grain yield of 6878 kg ha-1followed by the application of 100 % RDF as CF I + 25 kg Zn SO4 ha-1 (6622 kg ha-1). The lowest yield of 5061 kg $ha^{-1}$was recorded with the application of 50 % RDF in the form of CF I+ 25 kg Zn SO_4 ha^{-1}.An increase in yield of 15.1 per cent over the application of 100 % RDF of straight fertilizers was obtained with the application of 75% RDF through CF II. Application of 100 % RDF through CF II registered an increase in yield of 22.2 per cent over the application of straight fertilizers. This could be attributed to the addition of Zn increased the number of tillers and reduced the spikelet sterility. The increase in grain yield over the application of straight fertilizers was 11.1 per cent in the treatment that received 75% RDF in the form of CF I + 25 kg Zn SO4 ha-1. Application of 100 % RDF as CF I + 25 kg Zn SO4 ha-1 registered an increase in yield of 17.7 per cent over the application of straight fertilizers. **Effect of customized fertilizer on nutrient uptake (NPKS & Zn) of wheat (*Triticumavistivum*) crop**

The maximum uptake of N (117.3 kg/), P (21.4 kg/ha), K (150.5 kg/ha), S (96.1 kg/ha) and Zn (229.9 g/ha) were observed under 150% dose of CF (T6) which is statistically significant due to different doses of customized fertilizer. The higher nutrient uptake was mainly due to higher biological (straw+ grain) yield. Application of customized fertilizer helps to provide essential nutrient to get the targeted yield.

The availability of soil NPK in the mulberry garden was increased due to application of 150% nutrients through CF which recorded maximum available NP_2O_5, K_2O of 282.84,78.09 and 281.04 kg/ha, over other treatments. The next best treatment was T5(274.93N,76.69 P and 261.27K kg/ha) respectively.

Influence of customized fertilizers on yield and economics of finger millet

Significant differences in the yield of both grain and straw of finger millet were observed due to use of different doses of customized fertilizer. Highest grain and straw yield of 3279 and 4510 kg/ha, respectively were recorded in 150% customized fertilizer dose and was on par with 125% customized fertilizer dose (3227 and 4438 kg/ha) and 100% customized fertilizer dose (3031 and 4249 kg/ha, respectively). RDF as per package of practice recorded on par grain and straw yield (2138 and 3102 kg/ha, respectively) with 50% customized fertilizer dose (2130 and 3007 kg/ha, respectively). This was due to the fact that the crop has not experienced nutrient stress at any growth stage because of balanced nutrition and improved vegetative growth and growth parameters such as total dry matter production and increased number of tillers resulted in good grain yield.

Effect of customized fertilizers on the performance of potato

Results of the study indicated that Initial and final plant stand were non-significant under various customized fertilizer. Yield attributes viz. total number, weight (grade wise), total weight of tubers hill-1, plot^{-1} and ha^{-1} were recorded significantly higher under customized fertilizer F4 which was statistically at par with F6 and superior over rest of the customized fertilizers. Quality parameters viz. specific gravity, dry matter and starch content did not influenced significantly due to effect of customized fertilizers. The suitable customized fertilizer for potato crop was found to be F4-8 : 18 : 26 : 1 : 0.1 : 6 (N:P:K:Zn:B:S kg ha-1 150 : 67.5 : 97.5 : 3.75 : 0.37 : 22.5).

Effect of customized fertilizers on yield and micronutrients contents of okra grown on TypicUstochrepts soils of Anand

Okra yield increased significantly due to foliar treatment, i.e. micronutrient mixture grade-IV (for Fe and Zn deficiency), soil application of mixture Grade-V and also due to soil application of $FeSO_4$ at 15 kg/ha and $ZnSO_4$ at 8 kg/ha as per soil test value. The soil application of multi-micronutrients mixture grade-V was found beneficial and economical in increasing okra yield.

Effect of different levels of customized fertilizer on soil nutrient availability, yield and economics of onion

A field experiment was conducted to study the effect of different levels of customized fertilizer (CF) on soil nutrient availability, yield and economics of onion. The results revealed that the significantly highest plant height (57.77cm), stem diameter (6.03cm) and bulb diameter (15.13cm) at the time of harvest, fertilizer use efficiency, bulb yield (22.34 t ha^{-1}) and B:C ratio (2.56) of onion were recorded in 100 % recommended dose of NPK through CF in three equal split doses. The significantly highest available nitrogen (213 kg ha^{-1}), phosphorus (14.42 kg ha^{-1}) were recorded in 125 % recommended dose of NPK through CF in two equal split doses and available K (804 kg ha^{-1}) in 100 % recommended dose of NPK through CF in three equal split doses over the rest of the other treatments. The application of 100% recommended dose of fertilizer (100:50:50; $N:P_2O_5:K_2O$ kg ha^{-1}) either two or three splits through CF to onion appears to be improving soil fertility, yield and yield contributing character of onion and getting higher net monetary returns.

Nutrient use efficiency

- **Crop characteristics**: including root structures and root activity, stress tolerance, nutrient uptake (into roots), and efficiencies in nutrient incorporation (into plant tissue) and utilization (movement of nutrients to growth areas)
- **Soil characteristics**: including microbial diversity and biomass, pH, soil structure, salinity, organic matter content and water-holding capacity, and whether the soil is tilled
- **Fertilizer characteristics**: including their composition and when and how they’re applied

Nutrient use efficiency (NUE) is a critically important concept in the evaluation of crop production systems. It can be greatly impacted by fertilizer management as well as by soil- and plant-water management. The objective of nutrient use is to increase the overall performance of cropping systems by providing economically optimum nourishment to the crop while minimizing nutrient losses from the field. NUE addresses some but not all aspects of that performance. Therefore, system optimization goals necessarily include overall productivity as well as NUE. The most appropriate expression of NUE is determined by the question being asked and often by the spatial or temporal scale of interest for which reliable data are available. In this chapter we suggest typical NUE levels for cereal crops when recommended practices are employed; however, such benchmarks are best set locally within the appropriate cropping system, soil, climate and management context. Global temporal trends in NUE vary by region. For N, P and K, partial nutrient balance (ratio of nutrients removed by crop harvest to fertilizer nutrients applied) and partial factor productivity (crop production per unit of nutrient applied) for Africa, North America, Europe, and the EU-15 are trending upwards, while in Latin America, India, and China they are trending downwards. Though these global regions can be divided into two groups based on temporal trends, great variability exists in factors behind the trends within each group. Numerous management and environmental factors, including plant water status, interact to influence NUE.

Soil health

- Soil health has been defined as: “the capacity of soil to function as a living system. Healthy soils maintain a diverse community of soil organisms that help to control plant disease, insect and weed pests, form beneficial symbiotic associations with plant roots, recycle essential plant nutrients, improve soil structure with positive repercussions for soil water and nutrient holding capacity, and ultimately improve crop production. To that definition, an ecosystem perspective can be added: A healthy soil does not pollute the environment; rather, it contributes to mitigating climate change by maintaining or increasing its carbon content.
- Soil contains one of the Earth’s most diverse assemblages of living organisms, intimately linked via a complex food web. It can be either sick or healthy, depending on how it is managed. Two crucial characteristics of a healthy soil are the rich diversity of its biota and the high content of non-living soil organic matter. If the organic matter is increased or maintained at a satisfactory level for productive crop growth, it can be reasonably assumed that a soil is healthy. Healthy soil is resilient to outbreaks of soil-borne pests.

- The diversity of soil biota is greater in the tropics than in temperate zones. Because the rate of agricultural intensification in the future will generally be greater in the tropics, agro-ecosystems there are under particular threat of soil degradation. Any losses of biodiversity and, ultimately, ecosystem functioning, will affect subsistence farmers in the tropics more than in other regions, because they rely to a larger extent on these processes and their services.

Lecture No. 15 Feasibility of using designer fertilizers for drip fertigation - Poly houses - roof gardening

Water Soluble Fertilizers

Water-soluble fertilizers are 100% water soluble with very low salt index to minimize the potential for burning of plant tissue. The water soluble fertilizers are characterized by high purity and high benefit – cost ratio. The use of water-soluble fertilizers is largely concentrated in horticultural growing areas of different parts of the country besides it is ground in floriculture and vegetable crops also. The market size of water soluble fertilizers is constantly increasing in India. The annual usage of water soluble fertilizers estimated about 50,000 tonnes at present.

Water-soluble fertilizers dissolve easily in water and are applied to the crop in the irrigation water. One benefit of this type of fertilization is that growers can easily adjust the nutrient concentrations according to a crop’s changing needs over a growing season. Growers often choose a fertilizer concentration and apply this concentration at every watering. This is called continuous liquid feeding (CLF), or fertigation. By contrast there are fertilization programs in which growers apply higher rates of fertilizer less frequently, and irrigate with clear water between feedings.

Specialty Water Soluble Fertilizers Approved in India under FCO

At present there are 12 Water-soluble fertilizers listed in FCO. By recognizing the importance of water soluble fertilizers, Govt. of India created a separate category for 100% WS fertilizers in FCO 2003.In the Union budget 2012-13, Govt. of India reduced basic customs duty on water soluble fertilizers from 7.5% to 5%.

Water Soluble Fertilizers	Nutrients Composition %					
	N	P	K	S	Ca	Mg
Mono Potassium Phosphate	12	61	0	-	-	-
Mono Ammonium Phosphate	0	52	34	-	-	-
Potassium Nitrate	13	0	45	-	-	-
Calcium Nitrate	15.5	-	-	-	18.8	-
NPK	13	40	13	-	-	-
NPK	18	18	18	-	-	-
NPK	13	5	26	-	-	-
NPK	6	12	36	-	-	-
NPK	20	20	20	-	-	-
NPK	19	19	19	-	-	-
Potassium Magnesium Sulphate	-	-	22	20	-	18
Urea Phosphate	17	44	-	-	-	-

Source: FCO, Fertilizer Association of India, New Delhi (2011)

The Solubility of Some Water Soluble Fertilizers are Given Below

Fertilizer	Solubility (gL^{-1} at 20°C)
Potassium Nitrate (13:0:46)	310
Ammonium Nitrate	1950
Ammonium Sulphate (20:0:0)	770
Urea Phosphate (17:44:0)	495
Urea(46:0:0)	1060
Potassium sulphate (0:0:50)	100
Calcium Nitrate (15.5:0:0)	1200

Source: Fertilizer Statistics, the FAI (2010-2011)

Fertigation

Fertigation is the application of water soluble solid or liquid fertilisers through drip irrigation system. The factors that governs the fertigation are soil type, crop, method of irrigation used, water quality, types of fertilisers available, economic feasibility etc. Fertigation has become a striking method of fertilisation in modern intensive agriculture systems. Water and nutrient are the main factors of production in irrigated agriculture and are the major inputs in contributing higher activity. In intensive agriculture, both fertiliser and irrigation management have contributed immensely in increasing the yield and quality of crops. The method of fertiliser and irrigation application of these inputs in arid and semi-arid regions arid conditions of the world. Of late, it is also becoming popular in the arid and semi-arid region of India parti where canal irrigation systems are not developed (Hagin and Lowengart, 1999). With the advent of this new method of irrigation system, traditional method of fertilisation which is still practised by the farmers is being slowly replaced by fertigation. In drip irrigation, the wetted soil volume and thus the active root zone is reduced under drippers and this small volume does not allow the addition of all plant nutrients needed by the plants (Krishna needed is to be applied frequently and periodically in small amount with irrigation to ensure adequate supply of water and nutrient in the root zone (Biswas and Kumar, 2010). Therefore, as a result of the shift from surface irrigation to drip method of irrigation, fertigation becomes the most efficient fertilisation in the irrigated agriculture.

Major advantages of fertigation

1) In drip fertigation, fertiliser can be applied directly to the effective root zone of plant growth. Fertiliser application is synchronized and optimised with plant need and the amount and form of nutrient supply is regulated as per the need of the critical growth stages of plant.

2) Nutrients can be applied any time during the growing season based on crop need, thus saving in amount of fertiliser applied, due to better fertiliser use efficiency and reduction in leaching due to unseasonal weather.

3) Reduction in labour and energy cost by making use of water distribution systems for nutrient application.

4) Well-designed injection systems are available and are simple to use and suit automation, ensures better yield and quality of products obtained.

5) Timely application of small but precise amounts of fertilisers directly to the roots zone, which improves fertiliser use efficiency and reduces nutrient leaching below the root zone.

6) Ensures a uniform flow of water and nutrients causing minimal crop damage.

7) Smaller amounts of fertiliser can be applied quickly to address any deficiency issues and highly mobile nutrients such as nitrogen can be carefully managed to ensure rapid crop uptake.

8) Safer application method, as it eliminates the danger affecting roots due to higher dose.

9) Soil erosion is prevented.

The vertical garden or green wall is comprised of plants grown in supported vertical systems that are generally attached to an internal or external wall, although in some cases can be freestanding. Like many green roofs, Vertical gardens incorporate vegetation, growing medium, irrigation and drainage into a single system. Vertical gardens differ from green facades in that they incorporate multiple ‘containerized’ plantings to create the vegetation cover rather than being reliant on fewer numbers of plants that climb and spread to provide cover. They are also known as ‘green walls’, ‘living walls’, ‘bio-walls’. Green roofs are constructed for multiple reasons - as spaces for people to use, as architectural features, to add value to property or to achieve particular environmental benefits (for example, storm-water capture and retention, improved species diversity, insulation of a building against heat gain or loss). Vegetation on green roofs is planted in a growing substrate (a specially designed soil substitution medium) that may range in depth from 50 mm to more than a metre, depending on the weight capacity of the building’s roof and the aims of the design. For growing different types of plants- either perennially or annually there is a need to supply constant, reliable and sustainable systems of irrigation and drainage; and preferably with a fertigation scheduling along with the sprinklers or overhead irrigation system.

Lecture No 16. Quality Standards-Specifications for Designer Fertilizers

The main objective of customized fertilizer is to promote site specific nutrient management so as to achieve the maximum fertilizer use efficiency of applied nutrient in a cost effective manner. The Customized Fertilizer may include the combination of nutrients based on soil testing and requirement of crop and the formulation may be of primary, secondary and micro-nutrients. It may include 100% water soluble fertilizers grades required in various stages of crop growth based on research findings.

Eligibility criteria to manufacture and sale of customized fertilizer

(ii) Such manufacturing companies should have soil testing facility with an annual analyzing capacity of 10,000 samples per annum and should have analyzing capacity for NPK. Micronutrient and Secondary Nutrient.

(iii) The grade of customized fertilizer, which the company will manufacturer, must be based on scientific data obtained from area specific, soil specific and crop specific, soil testing results. These manufacturing companies, in association with concerned agricultural universities/KVKs concerned, should also conduct agronomy tests pf the proposed grade to establish its agronomic efficacy.

(iv)Such manufacturing companies should generate multi locational trials (not on farm demonstration) on different crops for minimum one season.

Soil sampling and analysis

Such,manufacturing companies must draw these soil samples from within its operational areas and should also ensure that minimum one sample is necessarily, drawn from each village. Scientific data on soil testing, results available with agricultural university /state Governments may also be used to prepare soil fertility map and for determination of required soil, area and crop specific grades for existing and potential marketing areas.

Grant of permission to manufacture

Subject to the fulfillment of eligibility criteria referred to in the preceding paragraphs, the permission for the manufacture and sale of Customized Fertilizer will be granted by Joint Secretary(INM). Department of Agriculture and Cooperation, MOA,GOI. Such permission, for manufacture and sale of particular customized fertilizer grade shall be granted only for the specific area and for a period not exceeding three years. Such manufacturing companies must start their manufacturing and sales process with in aperiod of six months from the date of grant of such permission. For grant of permission to produce and to sell such customized fertilizers, the concerned manufacturing companies should necessarily apply for permission, to the office of the Joint Secretary(INM), Ministry of Agriculture under intimation to the State Government in the prescribed Performa as provided in annexure II. The competent authority shall expedite the requisite permission authorization of otherwise within 45 days of the receipt of such applications.

Renewal/ revision of customized fertilizer grade

On completion of three years or earlier, manufacturing company of customized fertilizer shall submit a renewal/revision application for varied customized fertilizer manufactured by it. In case no change in the already approved composition of customized fertilizer is required, the same shall also be declared by the manufacturer. The competent authority, shall thereon, accord its approval; within .a period of 45 days from the date of receipt of such application, failing which the application duly acknowledged copy of such application shall be treated as official approval.

Customized fertilizer grades

The grades of customized fertilizer which the manufacturing company propose to manufacture and sell, shall be based on area specific and crop specific soil testing results. The manufacturer may be in association with Agricultural Universities/KVKs concerned, shall also conduct agronomy tests of the proposed grade to establish its agronomic efficacy. The manufacturing company, preferably in association with concerned agriculture universities/KVKs may continue to conduct agronomy tests of the proposed grades on the farm, for at least one season. The minimum nutrient contents in a specific grade of customized fertilize, proposed to be manufactured, shallcontain not less than 30 units of all nutrients, combined. For manufacture of area-specific subsequent grades of customized fertilizers, duly approved by the Joint Secretary (INM) MOA from time to time, the company shall intimate the competent authority within at least 45 days prior to its introduction of the said grades in the market. Since these grades will be based on the scientific data, no formal approval will be necessary.

Raw Material

(i) Use of subsidized fertilizers by Manufacturer of customized fertilizer

As per the existing policy, all subsidized fertilizers can be used for manufacturing of customized fertilizers. As such, domestic manufactures of all such subsidized fertilizers will have the choice to sell the requisite quantity to the manufacturing companies of customized fertilizers and the manufacturing company ofsuch subsidized fertilizers shall be eligible to claim subsidy from DOF under relevant rules.

(ii) Captive use of subsidized fertilizers by the manufacturer of customizedfertilizer.

Domestic manufacturer of subsidized fertilizers will have the option to supply therequired quantity of such fertilizers, as raw material, to its own manufacturing unit forproduction of customized fertilizers. All such supplies shall be eligible for subsidy as perthe policy of DOF.

(ii) Import of subsidized fertilizers by the manufacturer of customizedfertilizers.

All manufacturers of customized fertilizers will have option to import subsidizedfertilizers under the existing Policy guidelines of GOI for the manufacture of customizedfertilizers not exceeding its realistic requirements. On the imported quality of suchfertilizer to be used for manufacture of customized fertilizer, such manufacturers shallbe eligible for subsidy from DOF, under relevant rules.

(iv)Allocation of subsidized fertilizer as raw material for manufacture of customizedfertilizers.Specific allocations of subsidized fertilizers, to ensure adequate availability, inrespect of States, may be made for use as raw material for manufacture of CustomizedFertilizers, However, if required, permission for import of specific fertilizers as rawmaterial (not included in schedule 1 of FCO, 1985) may also be granted to themanufacturers.

Quality of customized fertilizers

The Customized Fertilizers to be used for based application shall be granular in sizewith minimum 90% between 1-4 mm IS sieve andBelow 1mm should not exceed 5%. The moisture content should not exceed 1.5%. Forfoliar applications, however, the grades should be 100% water soluble. Thespecifications of the customized fertilizers provided by the company to manufacture ofCustomized Fertilizer, duly approved by the Ministry, shall be strictly adhered to.

Quality Cheek

(i) Procedure for drawl of sample of fertilizers

(a) The method of drawing samples shall be provided in the FCO.

(b) Clause 4A(iii)- Weight of one sample should be 400g as specifiedunder Clause 4 A (iii) for Part A in Schedule 1 of the FCO,1985.

(ii)**Methods of analysis of fertilizer**

(a)The methods of analysis of fertilizers shall be as per the procedureprescribed in FCO.

(b) For preparation of sample for analysis in the laboratory (Clause 1-1) underpart B in schedule II of FCO,1985 the whole sample size of 400g should bepowdered. The whole sample size of 400 gms shall be powdered.

(iii)Tolerance limit

The tolerance limits prescribed under the FCO,1985 for NPK mixture and NPKwith micronutrients, shall be applicable to the customized fertilizers. However suchtolerance limit shall not exceed 3% for all nutrients particularly when secondary andmicronutrients are also present with NPK.

Labeling

(i)The word CustomizedFertilizer shall be super scribed on the bags.

(ii) The name of the crop and geographical area for which the CustomizedFertilizerrecommended shall also be indicated on the bags.

(iii)The grades of CustomizedFertilizer and the nutrient contents shall be mentioned onthe bags.

(iv)The manufacture should preferably have tampered proof bagging so as to check onadulteration.

Pricing of customized fertilizer

The Company shall fix reasonable MRP for its approved grade of customizedfertilizers taking all factors into consideration.

General

The permission for manufacture of customized fertilizer shall be restricted to such manufacturing companies of fertilizers who have the certificate of manufacture and authorization letter for selling fertilizers in a particular State. All the provisions of Fertilizer(Control) Order, 1985 and Essential Commodities Act 1955, shall be applicable for manufacture and sale of Customized Fertilizer.

Application for grant of permission for manufacture of Customized fertilizer

- Name of the Company and address
- Location of the unit where the Customized grade of fertilizer proposed to be manufactured.
- Annual Turnjover of the company
- Location/Particular of the Area where the Customized Fertilizer is to be introduced
- Soil Fertility Status of the Area.
- Introduction Season
- Cropping Pattern of the Area
- Soil PH
- Irrigated or unirrigated land
- Location of soil testing lab
- Annual Analyzing Capacity of soil samples
- Area Climate
- Grades and other details relating to composition of CustomizedFertilizer
- Raw Material(indicate whether the subsidized material to be used).
- Quantity to be produced in each season
- MRP

- Whether the company possess any permission for manufacturing the grades of customized fertilizer in any area

(i) Whether the company possess the soil testing facility as prescribed in Annex II of guidelines.

(ii) Whether the proposed grades are based on the soil testing results and crop requirement.

(iii) Whether the multi locational trials have conducted or not

(iv) Whether the agronomic test of the product in consultation with Agriculture Universities/KVK have been conducted or not.

Lecture No. 17 Guidelines for Patenting- Licensing and Registration of Newer Products

Guidelines for patenting

patent is an exclusive monopoly right granted by the Government for a new invention to an inventor for his/her disclosed invention for a limited period of time. This exclusive monopoly right is valid only within the territorial limits of a country of grant. Exclusivity of right implies that no one else can make, use, manufacture or market the invention without the consent of the patent holder. This right is available only for a limited period of time

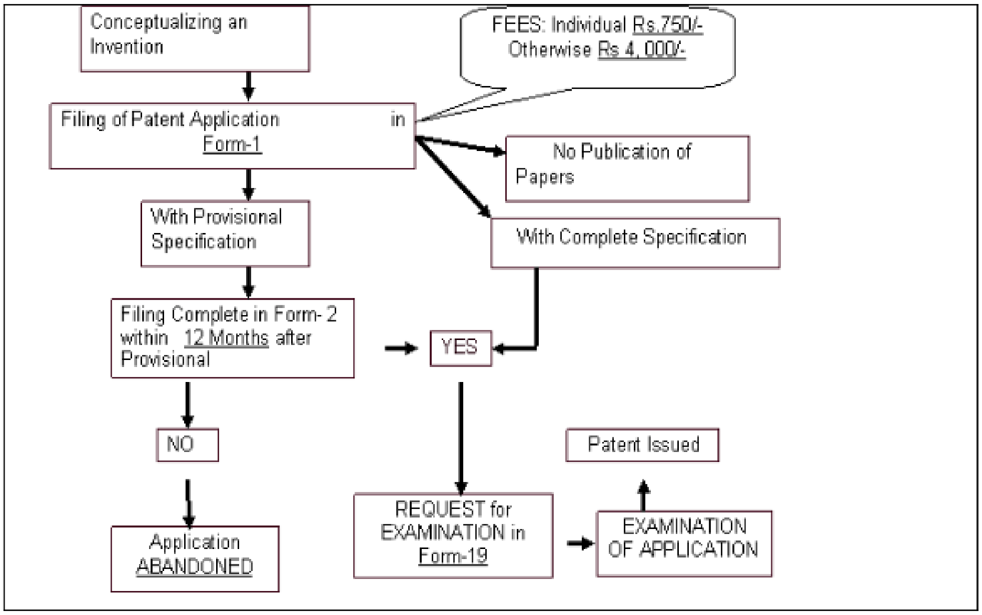
Requirements of Patenting

- Novelty
- Non obviousness
- Marketability and Utility

It is important to remember

- A patent has a time limit (20 years)
- A patent has a geographical limit
- A patent is restricted to the claims made in the application

Procedure for patent application



How to arrive at customized fertilizers?

Scientific principles were used as an ultimate guiding factor in deciding the grades of customized fertilizers. Following procedures were used to arrive at crop-soil specific customized fertilizer grades.

- Geo-referencing of chosen area
- Selecting sampling points on appropriate statistical procedure
- Actual sampling of the sites
- Analysing sampling of the sites
- Analysing soil, plant and water samples for nutrients and some soil characteristics
- Defining management zones
- Yield targeting in major management zones
- Computing crop removal of nutrients
- Calculating nutrient requirement (amount and ratio)
- Blending of nutrients based on the generated information

Development of protocol

The research on customized fertilizers aims at developing and perfecting the scientific protocol to arrive at a crop and region specific grade. Conventional approach adopted by soil scientist/ agronomist might not be appropriate in handling multi-nutrient deficiency and inter-nutrients interaction. Crop and soil-process modeller also has limitation of integrating these phenomena in the mechanistic growth models. Most of the dynamic models in the globe deal with one nutrient at a time. The basic framework of logistic evolution of customized fertilizer grades, as a currently under development have three primary components:

- Defining fertility management zones
- Using empirical models like QUEFTS/STCR
- Use secondary research data and experiential learning's

Eligibility criteria for manufacture and sale of customized fertilizers

Permission for manufacture and sale of customized fertilizers shall be granted to only such manufacturing companies whose annual turnover is Rs.500 crores and above. Manufacturing companies should have soil testing facility with an annual analysing capacity of 10,000 samples per annum for NPK, secondary and micro nutrients. Such laboratory must possess the requisite instrument viz., Atomic Absorption Spectrophotometer, Flame Photometer, pH meter, Conductivity Bridge, Kjeldhal Distillation etc. The grades of customized fertilizers, which company will manufacture, must be based on scientific data obtained from area-specific, soil-specific and crop specific and soil testing results.

The manufacturing companies, in association with agricultural universities/KVKs concerned, should also conduct agronomy tests of the proposed grade to establish its agronomic efficacy. Such manufacturing companies should generate multi-location trials (not on farm demonstrations) on different crops for minimum one season. Such manufacturing companies must draw these soil samples from within its operational areas and should also ensure that minimum one sample is necessarily, drawn from University/ State government may also be used to prepare soil fertility map and for determination of required soil, area, and crop specific grades for existing and potential marketing areas.

Grant of permission to manufacture

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Application for grant of permission for manufacture of customized fertilizer

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- Annual Turnover of the company
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- Cropping Pattern of the Area
- Soil PH
- Irrigated or unirrigated land
- 10.Location of soil testing lab
- Annual Analyzing Capacity of soil samples
- Area Climate
- Grades and other details relating to composition of customized fertilizer
- Raw Material(indicate whether the subsidized material to be used)
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- Whether the company possess any permission for manufacturing the grades of customized fertilizer in any area

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On completion of three years or earlier, manufacturing company of customized fertilizers shall submit a renewal/revision application for varied customized fertilizers manufactured by it. In case, no change in the already approved composition of customized fertilizers is required, the same shall also be declared by the manufacturer. The competent authority, shall, thereon, accord its approval within a period of 45 days from the date of receipt of such applications, failing which the duly acknowledge copy of such application shall be treated as official approval.