Chapter 4

INFORMATION ABOUT ORGANIC MANURES, FERTILIZERS AND CROP PLANT

The more we pour the big machines, the fuel, the pesticides, the herbicides, the fertilizer and chemicals into farming, the more we knock out the mechanism that made it all work in the first place.

- David R Brower

The organic manures play an important role in soil by contributing carbonaceous matter, which when decomposes, provides mineral nutrients to the plants and act as a base exchange material and helps to improve the physical, chemical and biological properties of soil. Organic acid released during the decomposition of organic matter help to dissolve soil minerals slowly and make them available to growing plant. Organic matter also provides energy to soil microbes hence biological activity in soil increases. It has been realized that inorganic fertilizers give the best returns only when the organic matter present in the soil is sufficient. Soil richer in organic matter usually exhibits greater crop yield response to applied fertilizers. Due to constant destruction by oxidation under the prevailing hot and moist conditions as well as rapid utilization by the microbial population in the soil. The use of organic manures is important not only in the immediate contest of economy in fertilizer use but also in the larger interest of maintenance of soils at optimum level of fertility and productivity for a long period (Verma, 2004).

The Indian soils are proverbially poor in their organic status. In sufficiency of organic matter is serious problem in sugarcane soils of India. To improve the soil fertility organic manuring is one of the important solution. Manures are the organic material derive from animal, human and plant residues which contain plant nutrients in complex organic form (Reddy S.R., 1999) on the basis of concentration of nutrients, organic manures are mainly divided into Bulky organic manures and concentrated organic manures. Organic manures which are bulky in nature but supply the small quantities plant nutrients are termed as bulky organic manures. e.g. Farm yard Manure,
Compost, Vermicompost, Green manure, sheep manure, sewage waste, sludge etc. whereas concentrated organic manures are plant and animal originated. The plant originated manures are divided into edible oil cake and non edible oil cake. Lin seed cake, groundnut cake, safflower cake, sesamum cake, Niger cake are the common types of edible oil cake whereas Neem cake, Mahuwa cakes, castor cake, cotton seed cake, and karanj cakes are the common types of nonedible oil cake. The manures which are obtained through animal are called animal originated concentrated organic manures. Bone meal, fishmeal, blood meal, meat meal, house refuse, hoof meals and horns are the different types of animal originated manures.

Information about organic manures, fertilizers and sugarcane crop used under investigation is as follows.

4.1. Manures

4.1.1. Compost

Composting is a process by which organic wastes are converted into organic manures by means of biological activity under controlled conditions. In other word composting is defined as a method of solid waste management whereby the organic component of the solid waste stream is biologically decomposed under controlled conditions to a state in which it can be handled, stored and applied to the land without adversely affecting the environment.

It is an important technique for recycling organic agricultural, industrial wastes and for improving the quality and quantity of organic manure. The objectives in composting are to stabilize the putrescible organic matter in raw agricultural and industrial wastes produce a uniform, slow release organic fertilizer which stimulates soil life, improves soil structure; helps plants to tolerate/ resist pests and diseases reducing offensive odours, killing weed seeds and pathogenic organisms.

Principles of Composting

Composting is a self heating, thermophilic and aerobic biological process which occurs naturally in heaps of biodegradable organic matter such as manure, moist hay and straw. This biodegradation process is carried out by different kinds of heterophytic microorganisms, bacteria, fungi, actinomycetes and protozoa, which derive their energy and carbon requirements from the
Different organic manures and fertilizers

Compost
Vermicompost
Press mud
Cassia auriculata L.
Neem cake powder
Urea
The process of decomposing organic wastes is called composting and decomposed material is called compost. In another word we can say that a mass of rotted organic matter made from waste is called as compost. (Reddy and Reddi, 2002). Composting is a biological process in which micro organism decomposes the organic matter. The compost is prepared from stubbles of the crop, waste straw, vegetable refuse, sugarcane trash, paddy straw, weeds and other parts of plants and animal waste. Composting is largely a biological process in which micro organism of both the types, aerobic and anaerobic decompose the organic matter and lower down the C:N ratio of refuse. The final product of composting is well rotted manure called as compost. It contain relatively higher quantity of major nutrients than that of FYM. The average nutrient contents of farm compost is 0.5 percent nitrogen, 0.15 percent P$_2$O$_5$ and 0.5 percent K$_2$O (Reddy and Reddi, 2002). Farm compost is made by placing farm wastes’ in trenches of suitable size. The farm waste is placed in the trenches by layer by layer. Each layer is well moistened by sprinkling cowdung slurry and water. Then compost is ready for application within 5-6 months period.

Following methods are generally used for preparation of compost 1) Coimbatore compost 2) Indore method 3) Bangalore hot fermentation method 4) Rain water compost 5) Night soil compost 6) NADEP (Mendhe S.N. and et al, 2007). Generally farmers add organic matter in the form of compost so as to retain and improve fertility of soil, crop growth in most of the cases. A large proportion of organic materials like compost react with inorganic colloids to form the day organic complex and this reaction has profound influence on the physical chemical and biological properties of soil (Green land 1965). The compost present in the soil influences the growth of plants in number of ways. Organic acids liberated during the decomposition process, increase the solubility and availability of phosphate and metallic trace elements. The organic matter in general, encourage the growth of saprophytic micro organism in the soil and reduces the population of pathogens.
4.1.2 Vermicompost

Vermicompost is an organic manure produced by the activity of earthworms. It is mixture of worm casts which are rich in macro and micronutrients. The casts of earthworm have several enzymes and some growth regulating substances. The average nutrient content of Vermicompost is much higher than that of F.Y.M. Vermicompost contains 1.60 %N, 5.04 % P$_2$O$_5$, and 0.80 % K$_2$O with small quantities of micronutrients. The C:N ratio of vermi- compost is much lower (1:16) than that of F.Y.M. (1:30). The activity of earthwarms is recognized as beneficial for the improvement of soil physical condition and plant growth. (Mendhe, et. al.,2007).

Earth worms can consume all types of organic matter and convert them into nutrients. Vermicompost improves the physical and biological condition of soil, improves soil fertility, aeration and water holding capacity.

Vermicompost is an excellent base for the establishment of beneficial free living and symbiotic microbes. Application of vermicompost increase the total microbial population of nitrogen fixing bacteria and actinomycetes. Microbial activities are increased due to vermi compost which influence availability of soil phosphorus and nitrogen. Quick response can be obtained with vermicompost compared to ordinary compost or farmyard manures. The presence of earth worm in soil also help in aerating the soil. Numerous species of worms have been identified for vermi composting. Most commonly used are Eiseniafoetida, Eudrilusengenia, and Perionyxexcavatus, which work on the upper layer of soil and Pheritimaelougata, octochitoniacirataetc work in deeper layer of soil (Mendhe, et. al., 2007).

Preparation of vermicompost

Usually a tank of 2x1 x1 meter is constructed with brick and lime in properly shade place bottom of that tank is made up pieces of brick, stones, chips and sand. Wormy soil is spread over this to a thickness of 15 c.m. about 4 to 5 kg diluted dung has to be applied. About 1000 number of earth worms were placed over the soil bed. Then dried leaves are spread with 5 cm. thickness over vermi bed. Bed should be kept moist. About 10 c.m. layer of straw, leaves, kitchen waste etc are spared over this layer. After one month the contents are turned up and down and covered with gunny bags. Watering is
continued for another month. At maturation watering should be stopped. The nature of compost is a gray to brown coloured loose granular mass. After removal from the pit, it is sieved dried and packed (Mendhe, et. al., 2007).

4.1.3 Press mud cake (PMC)

The press mud cake is one of the major byproducts of sugar industry and constitutes about 3-7 percent of the total weight of cane crushed. The PMC is residue obtained by filtration which settles down in the process of clarification of cane juice during sugar manufacturing process. PMC is soft, spongy, lightweight material of dark brown or black colour. Normally it contain 50-70 % moisture. PMC is mixture of sugarcane fibers, sucrose and coagulated colloids including cane wax, albuminoids, inorganic salts and soil particles. The sulphitationpressmud and carbonation pressmud are the two different types of pressmud. The sulphitation process is carried out with the help of lime, SO$_2$ and CaSO$_3$ is obtained along with impurities from cane juice in the form of mud. In carbonation process lime and CO$_2$ are used and CaCO$_3$ along with impurities is obtained in mud. Most of the sugar factories in India adopt sulphitation process. PMC is used as organic manure and also as soil amendment. PMC is good source of organic matter and plant nutrients. It contains all the macro and micro nutrients though in small amount essentially required for growth of plant. Application of PMC showed positive crop yield responses. It is also helpful to soil improvement as well as physical, chemical and microbiological properties of soil. Sulphitation PMC can be used successfully for reclamation of alkali soils. (Verma, 2004)

4.1.4 Neem Cake

Classification

Botanical Name - *Azadirachta indica* L.

Family – Meliaceae

Vernacular Name – Neem/ Nim

Common Name - kadulimb

Origin of Neem

The Neem cake is mainly obtained from fresh fruits of Neem (*Azadirachta indica* L.). after extraction of oil as a residue. The Neem is native of India is now introduced to many other countries like Australia, Africa, Central and South America, Philippines, Mauritius and recently in Saudi
Arabia. In India about 14-20 million trees are existing producing more than 83,000 tones of Neem oil and about 3,30,000 tones Neem cake. Neem is a popular Indian tree, which has gained great importance in the past couple of decades in the field of agriculture as most effective organic biopesticide. The neem Kernel contains Azadirachtin which control wide range of agricultural pest.

**Morphology of Neem**

It is a large tree. The stem is erect, branched, cylindrical and woody, leaves are alternate, compound, bi pinnate, leaflets are 9-12 and they are sub opposite and oblique. Plant shows axillary panicle inflorescence. Flowers are white small. The fresh fruit are green in colour after ripening it becomes yellowish.

**Chemical constitute of Neem fruits**

Fresh fruit of Neem contain Azadirachtin. Neem seed kernels contain 0.1 to 2.02 %Azadirachtin. The azadirachtin is extract of neem kernel with concentration available from 10 % to 30 W/W and the rest other triterpenoids.

**Physiochemical Properties of Neem**

- Genetics Name - Azadirachtin.
- Empirical formula - AzaA C 35 H 44016, AzaB C33H_{4}2014
- Molecular Weight - Aza A720, Aza B 662.
- Chemical family - Tetranortriterpenoids.
- Colour - Pale cream / off white
- Composition - Azadirachtin15 % to 32 %

**Uses**

The Neem kernel contains several important constituents and Azadirachtin. It is very effective plant based, herbal pesticide. It has no side effects on human, animals, soil & environment. From ripened fruits Neem oil is obtained and remains portion all with kernels and epicarpis considered as Neem cake. This Neem cake is used as manure to various crops.

Neem cake is plant originated concentrated organic manure. Neem cakes contain not only nitrogen but also some phosphoric acid and besides a large quantity of potash. The organic nitrogen is converted into ammonia and finally nitrate nitrogen through bacterial action and then utilized by the crop. The Neem cake is commonly used for manuring sugarcane @ 1-2 t ha^{-1} in two
spilt doses one at the time of planting and another after 2 ½ months. The oilcake should be powdered before use for uniform application. It gets easily decomposed by micro organism when applied to the soil and release the nutrients. It also increase the humus content of soil and lowers the C/N ratio without affecting soil pH.

Neem cake is applied as broad cost, drilled or placed near root zone while earthing up. Neem cake is quick acting organic manure. Though it is insoluble in water its Nitrogen become quickly available to plants near about a week or within 10 days after application. Groundnut cake, Neem cake, Mahwah cake have been tried as manure for sugarcane which contain 4.13, 6.97, 5.25 percent nitrogen give rise 67.1, 601, 57.6 MT/ha cane yield respectively (singhkanwar, 1964). Now a days urea coated with Neem cake. Due to coating of Neem cake checked the nitrogen from urea to avoid ammonia volatization of urea. There is saving of nitrogen to the tune of 75 kg N/ha. Without affecting cane yield (Nasir Ahmed, et. al., 1987)

Benefits of Neem Cake Manure
1. Natural and free from mud and stones etc.
2. As compared to bulky organic manures less quantity is required.
3. Increase the nitrogen content in the soil thus increasing the crop yield.
4. Dose does not have any negative effects on another microbial organisms.
5. Make the soil more fertile.

4.1.5 Greenleaf Manuring with *Cassia auriculata*

Green manuring is practice of ploughing or turning green plant tissue in to the soil for the purpose of improving soil structure as well as fertility. Fresh undecomposed plant material used as manure is called as green manure. On the basis of crops, green manuring is divided into two types.

a) Leguminous crops- The leguminous plants provides nitrogen and organic substances to the soil e.g. Dhaincha (*Sesbania aculata*), Cowpea (*Vigna catjan*) Sannhemp (*Crotalaria juncea*) etc.
b) Non leghuminous crops- The non leguminous provide only organic matter and not the nitrogen. eg. *Parthenium, Achyranthes, Ipomoea, Calotropis, Lantana, Trianthema*, etc.
Green manuring is obtained by two methods 1) Green manuringsitu 2) Green leaf manuring

1) **Green manuringsitu** - Green manure crops are grown in the field itself either as pure crop or as an intercrop with the main crop and during flowering stage they are buried under the soil. Most common green manuring crops are Sunhemp, Dhaincha, Guarbeans, Senji etc.

2) **Green leaf manuring** - It refers to the turning of tender green twigs and leaves collected from waste lands, bunds, and forest. For green leaf manuring Gliricidia, Sasbania, Karanj, Neem, Gulmohor, Peltophorum, etc. are used. In addition to that certain weeds like *Parthenium*, *Trianthema*, *Ipomoea*, *Calatropis*, *Cassia* (*Cassia fistula* and *Cassia auriculata*) are also used for green manuring.

In olden days the biomass for manuring is generated as 'off farm' and 'on farm'. (Organic farming and Biodynamic Agriculture Training) off-farm green manure – as the foliages of the shrub cane and weeds that are grown along the roadsides, river bank and lake bunds. The common weeds are, *Pongamiapinnata*, *Cassia auriculata*, *Calotropis giganta*, *Ipomoea sps*, *Vitexnegundo*, *Eichornia*, etc.

On- farm green manure-

A) Tree green manure- Biomass from the farm can be generated from legume or non legume trees that are grown along the boundaries of the farm and along the main bunds of the fields. For e.g.- *Azadiractaindica*, *Pongamiapinnata*, *Gliricidiasps.*, *Cassia siamea*, etc.

B) Life fence and hedgerows- some shrub species can be grown along the fence as life fence along the pathways and waste patches e.g. – *Vitexnegundo*, *Neriumthevittfolia*, *Adathodavasica*, *Daturastramonium*, *Crotolaria*, etc. for the selection of green manure crops- a) fast growing b) produces abundant and succulent shoots and foliage c) well adapted to the climatic condition d) have a high rate of nitrogen fixation

**Advantages of green manuring**

a) Improves the soil fertility by increasing the humus content of the soil.
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b) Adds nutrients and organic matters

c) Improves the soil structure

d) Improve soil aeration

e) Increase the water holding capacity

f) Conserves and recycles plant nutrient

For the present investigation to study the effect of green leaf manuring *Cassia auriculata* plant species was selected and details about that is as follows

**Botanical classification of Cassia**

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<thead>
<tr>
<th>Kingdom</th>
<th>Plantae</th>
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<tr>
<td>Division</td>
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<td>Class</td>
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<td>Order</td>
<td>Fabales</td>
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<td>Leguminosae</td>
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<td>Cassia</td>
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**Habitat**

It is generally found in warm and moist climate. In India it is found in the western region of Maharashtra, and in other states as Gujarat, Rajasthan and Madhya Pradesh. As considered to the other parts of the globe is found in southern parts of Pakistan and certain parts of Africa. Its habitat revolves around the tropical region.

**Morphology**

It is a bushy small plant which attains a height of about 3 to 10 feet. Leaves are about 3 to 4 inch long. It has leaflets that are $\frac{3}{4}$ to 1 inch in length with apex curved and arranged in 8 to 12 pairs. Flowers are large in size and are attractive having shiny appearance. It is of yellow colour. Legumes are
10.16 to 12.70 centimeter long and 1.27 to 1.59 centimeter in breadth. It bears seeds that are 6 to 10 in number. Flowers blossom in man soon and it bears fruit in spring season. Bark is of dark colour and is used for dying purpose.

**Chemical Constituents**

Cassia plant contains 18 % of tannin in its bark. Its leaves also possess Di-(2-ethyl) hexyl phthalate. Besides these it contains alkaloids and resins. Presence of vitamins and minerals like calcium and phosphorus also has been reported.

**Pharmacology**

According to Ayurveda it decreases the aggravated pitta and kapha. It helps in coagulation of blood thus preventing hemorrhages. It also helps in increasing the sperm count in the body and is helpful in reducing the secretions from the uterus.

**Uses**

Powder made from seeds is used in preventing diarrhea and dysentery. Juice made out of fruit is very effective in treating the indigestion. It also gives relief in skin ailments. Leaves are used as leaf manuring. (http://www.ayushveda/herbs/cassia-auriculata.htm)

**4.2. Fertilizers**

Sugarcane crop produces a large amount of dry matter per unit area and hence requires huge quantities of nutrient elements. In order to achieve higher yield of sugarcane. It is necessary that the soils are replenished with proper quantities of such nutrients by judicious application of manures and fertilizers. Plant requires 16 different types of elements. These elements are obtained through soil, water and atmosphere or they can be supplied externally by adding into the soil in the form of manures and fertilizers. Fertilizers are industrially manufactured chemicals containing plant nutrient. Nutrient content is higher in fertilizers than in organic manures and nutrients are released almost immediately.

**Classification of fertilizers**

Fertilizers are classified into straight, complex and mixed fertilizers. Straight fertilizers are those which supply only one primary plant nutrient, mainly nitrogen, phosphorus, potassium. These are Urea, ammonium sulphate, potassium sulphate, super phosphate etc. are some of the straight fertilizers.
Complex fertilizer contain two or three primary plant nutrients in chemical combination. These are Diamonium Phosphate. Nitro phosphate, ammonium phosphate are complex fertilizers. Mixed fertilizers are physical mixtures of straight fertilizers. They contain two or three primary plant nutrient. Mixed fertilizers are made by thoroughly mixing the ingredients either mechanically or manually. Fertilizers are grouped based on the nutrient present in the fertilizers namely 1) Nitrogenous fertilizer, 2) Phosphate fertilizer 3) Potassic fertilizer.

4.2.1 Nitrogenous fertilizer

The fertilizer material containing nitrogen is called as nitrogenous fertilizer. The nitrogenous fertilizers are classified into four groups based on the chemical form of nitrogen in the fertilizers. Fertilizers containing nitrogen in the form of nitrate (NO$_3$) are called nitrate fertilizers. Examples of nitrate fertilizers are sodium nitrate (NaNO$_3$) and Calcium nitrate Ca(NO$_3$)$_2$.

Fertilizers containing nitrogen in the form of ammonium are called ammonical fertilizers. Some ammoniacal fertilizers are ammonium sulphate (NH$_4$)$_2$SO$_4$. (20 % N), ammonium chloride NH$_4$Cl (24 to 26 % N) anhydrous ammonia NH$_3$( 82 % N)

Fertilizers contain nitrogen in the form of amide are called as amide fertilizers. The two amide fertilizers are Urea CO(NH)$_2$ (46 % N) and Calcium Cyanide CaCN$_2$ (21 % N). (Reddy and Reddi, 2002)

Urea

Urea is the most widely used fertilizer and is produced by reacting ammonia with carbon dioxide under pressure and high temperature. Urea contains highest percentage of nitrogen (46 %) among the solid fertilizer when applied to the soil. It hydrolyses to ammonium carbonate.

$$CO(NH)_2 + 2 H_2O \xrightarrow{Urease} (NH_4)_2CO_3$$

The reaction takes place at a faster rate in the presence of enzyme Urease, Ammonium carbonate is an unstable compound and decomposes to ammonia and Carbon dioxide. Ammonia thus released is absorbed by plants on clay complex. When urea application is flowed by irrigation, urea is dissolved in water and enters the soil along with water and no volatile losses occur.

Urea is made into granules which approximately weigh one gram and are known as urea super granules. Modified forms of urea to reduce
denitrification losses, ordinary prilled urea is coated with Neem cake powder or blended with Neem cake powder.

**Urea based fertilizers** - Urea combined with other fertilizer materials so as to supply other nutrients like phosphorus, sulphur and calcium along with nitrogen. Common urea based fertilizers are Urea Sulphur, Urea Phosphate, Urea gypsum etc.

**4.2.2. Phosphatic Fertilizers** - Phosphorus containing fertilizers are called as phosphatic fertilizers. Phosphatic fertilizers are classified into three groups.

i. Phosphatic fertilizers containing water soluble Phosphoric acid. These fertilizers are available in the form of mono calcium phosphate or ammonium phosphate. They are single super phosphate and double super phosphate.

ii. Single super phosphate contains 16-22 percent \( P_2O_5 \) of which 90 percent is water soluble. It is a mixture of monocalcium phosphate and calcium phosphate. It also contain 8-11 percent sulphur and 18-21 percent calcium. Single super phosphate is manufactured in both powdered and granular form. When fertilizer is applied to the soil it is immediately converted into insoluble dicalcium phosphate in alkline soil and as iron and aluminium phosphates in acidic soil. The conversion of monocalcium phosphate into dicalcium phosphate is quite rapid when even in natural or slightly acidic soils. The double super phosphate contain 32 percent \( P_2O_5 \).

iii. Phosphatic fertilizer containing citric acid soluble phosphoric acid. These fertilizers contain citrate soluble phosphoric acid. These fertilizers are used for long duration crop like Sugarcane, Tea and Coffee. Phosphatic fertilizer belonging to this group are basic slag (14-18 % \( P_2O_5 \)), dicalcium phosphate (37-39 % \( P_2O_5 \)).

iv. Phosphatic fertilizer containing phosphoric acid not soluble in water or citric acid common examples are rock phosphate (20-40 % \( P_2O_5 \)), raw bone meal (20-25 % \( P_2O_5 \)).

**4.2.3. Potassic Fertilizer** - The fertilizers contain potassium are called as potassic fertilizers. Potassic fertilizers are grouped into chloride form and non-chloride form. The common examples of chloride form is potassium chloride.
Whereas potassium sulphate, potassium magnesium sulphate, potassium nitrate are non chloride form of potassic fertilizers.

Potassium chloride or muriate of Potash. It is the most common and cheap potassic fertilizer in white to slight red in colour. It contains potash and chloride. It is suitable for all the crops. Accumulation of sugar is affected in sugarcane crops due to chloride ions present in fertilizers. (Redddy and Reddi, 2002)

**Integrated Nutrient Management**

Impact of green revolution had come through mainly by the use of improved high yielding varieties, greater input of fertilizers and plant protection chemicals. But now it has been realized that increase in production was at the cost of soil health. Sustainable production is only possible by proper use of inputs for maintaining the soil fertility. The gravity of environmental degradation caused by faulty and intensive agricultural practices has become evident and there is increasing pressure to develop ecologically sound, viable and sustainable soil fertility management practices specifically through integrated nutrient management (INM).

The integrated nutrient management (INM) or integrated nutrient supply system (INSS) involves the use of chemical fertilizers in inputs through biological processes. A system approach of nutrient management by tapping all possible sources of organics, inorganics and biofertilizers in a judicious and synchronous way to harness the interactive advantages and to maintain soil fertility and productivity is the essence of INM.

The result of a large number of experiments with manures and fertilizers on sugarcane neither the chemical fertilizers alone nor the organic sources exclusively can achieve the production sustainability of soil as well as crops under intensive cropping system. The integrated nutrient supply system (INSS) helps to restore and sustain fertility and productivity soil. INSS has proved superior to the use of each components seperately. Further it bring economy and efficiency in fertilizer use and favorably affects physical, chemical and biological environment of the soil (Verma, 2004).

The basic concept of INM is the continuous maintenance of soil productivity on long term basis through appropriate use of fertilizers, biofertilizers and organic manures including green manures and their scientific
management for optimum growth, yield and quality of crops and cropping systems in specific agro-ecological situation. INM helps to restore and sustain soil fertility and crop productivity. It may help to check the emerging deficiency of nutrient. Further it brings economy and efficiency in fertilizer use and improvement in physical, chemical and biological environment of soils. Therefore integrated approach involving inorganic fertilizers, biological sources and organic manures are of great significance in the improvement of soil fertility. For which it is desirable to supplement inorganic sources through reliable, native, renewable and self replicating sources.

INM strategies emphasized on reduction of nutrient losses from applied inorganic fertilizers, retention of soil nutrients, alternate or supplementary source of nutrients. The application of fertilizers based on demand of crops as per soil test crop response programme at proper timing and placement of fertilizers with controlled release of nutrients and proper choice of crops are the important feature. The supplementary sources of nutrients includes organic manures and bio fertilizers play a important role. In Maharashtra farmers are using urban and rural organic wastes wherever available. Biofertilizers like blue green algae, Azolla, Azosprillum, Azatobactor, Phosphorus solubalizing bacteria and fungi, Rhizobium and VAM as alternative sources for N and P showed greater promises. The organic manure viz., FYM, compost, vermi-compost, poultry manure, oil cake (Castor, Karanj, Neem cake etc.) are well known to improve physicochemical and biological properties of soil, ultimately crop yield. But generally these are applied one month prior to sowing. Crop residue management, green manuring, legumes as intercrop etc. are the key components of INM. The important steps involved in INM studies are assessment of on-farm and of farm resource availability, soil test based nutrient requirement, integration of nutrient sources and establishment of time, method and mode of application by adopting appropriate soil and water conservation techniques.

Practicing Integrated Nutrient Management (INM) is a holistic nutrient management approach that is ecologically, socially and economically viable and at the same time sustaining productivity and ensuring high level of production.
The scientific integration of mineral fertilizers with organic sources of plant nutrients is important to sustain yields and soil health. INM is a step forward in the direction of balanced fertilization through soil test crop response approach. Organic manure and bio fertilizer are the only future viable option for sustaining soil productivity under the varied agro-ecological situations and especially in the rain fed region where maintaining soil fertility with less costly options is an imperative.

In Maharashtra on sugarcane crop various INM field experiments are conducted by considering different views. During present investigation field experiment was conducted on planted and ratoon sugarcane crop to study the effect of INM technique. During this field trial Nitrogen dose was supplied in combination of organic manures & chemical fertilizers. The organic manures such as compost, vermicompost, pressmud, Neem cake, Cassia leaves were applied along with fertilizers in two levels i.e. 50 % and 75 % and they are comprised with recommended dose and control treatment

**Role of Nitrogen, Phosphorous and Potassium in sugarcane Crop**

**Role of nitrogen**

Nitrogen is the most important elements of plant nutrient, as 40-60 percent of the total dry weight of the protoplasm contains nitrogenous compound. It enters into the compositions of aminoacids, proteins, nucleoprotein, chlorophyll and coenzymes. It needed for aminoacid and protein synthesis and chlorophyll formation. It therefore, needed by sugarcane crop in relative large amounts. The marked variation exists in the nitrogen contents of different parts of sugarcane plants such as green leaves, leaf sheath, stem and dry leaves. Proper dose of N application is essential as lack of adequate supply of results in reduced number and growth of stalks. The internodes reduce in size and leaves remain smaller on the other hand an excess dose of N delays maturity and also depresses juice quality by increasing the reducing sugar and decresing sucrose contents in juice.

**Role of Phosphorous**

Phosphorus is considered to be one of the key elements in sugarcane production and which is useful for several vital functions in plant life. It is a constituent of protoplasm and take part in energy storage and transfer, photosynthesis and respiration. A number of enzymes participating in the dark
reaction of photosynthesis are activated by phosphorus. It acts as a promoter of root development and tillering and tends to hasten ripening with improved juice quality. Further this nutrients has an important role to play in juice clarification in sugar and jaggery manufacture. Inadequate supply of P to sugarcane plants, reduced tillering root developments is restricted and shoot/root ratio increases undesirably. Stalk shows extremely short internodes and leaves are very narrow and somewhat reduced in length. The colour of the leaves may become somewhat darker or greenish blue.

**Role of Potassium**

Sugarcane is one of the heavy feeders of potassium. Although potassium does not enter into the composition of any plant constituents and it remains free as K\(^+\) ion in the cell but performs many physiological functions in the plant body. Acts as catalyst for the activation of number of enzymes responsible for change of sugar to starch and amino acids to protein. Potassium helps translocation of carbohydrate regulate the opening of stomata, maintains cellular organization and cell permeability. It also provides strength to the plant, tolerance to drought. Potassium application has been found to help inbalancing the uptake of N and other nutrients by crop. Inadequate supply of free ammonia acids in the plant or less synthesis of protein leading to production of less dry matter. The translocation of sugar is slowed down and leaves may accumulate sugars. Under drought conditions, K increase stomata resistance reducing transpirations loss of water and thus prevents moisture stress. Potassium application in sugarcane in addition to increasing cane yield also regulates maturity and improves cane quality by increasing sucrose and purity of cane juice (Verma, 2004).

### 4.3. Sugarcane

**Classification of Sugarcane**

- **Kingdom**: Plantae
- **Class**: Monocotyledons
- **Order**: Glumaceae
- **Family**: Gramineae
- **Sub family**: Panicoidae
- **Tribe**: Andripogoneae
- **Sub-tribe**: Saccharininea
Genus - **Saccharum**
Species - *officinarum*
English Name – Sugarcane
Hindi Name - Ganna
Tamil - karumbu
Malayalam - Karimbu
Marathi Name - Us
Sanskrit - Ikshudanda

**Botanical Description**
Sugarcane is a tall perennial tropical grass, which tillers at the base to produce unbranched stems from 2-8 m tall and to around 5cm in diameter; it is called as giant grass. It is cultivated for these thick stems i.e. canes, from which the sugar is extracted. The botany of cane consists of root, stem, leaves and inflorescences.

- **Root**
  
  The root system is adventitious and in two types namely ‘sett roots’ and ‘shoot roots’.
  
  - When the sugarcane sett is planted in the soil, the root primordial situated at the base of every cane joint is activated and produces roots. These roots are ‘sett roots’ and are mostly temporary.
  
  - The shoot roots arise from the root rings of the lower nodes of tillers. These roots are thick, fleshy, white and less branched.
  
  - These are permanent roots which are continually produced from tillers.

- **Stem**
  
  - Sugarcane is propagated vegetatively from stem cutting.
  
  - The stem of sugarcane is roughly cylindrical and consists of nodes and internodes, the former being the area around the bud from the leaf scar to the growth ring and the later being the part between two nodes.
  
  - The node consists of a lateral bud, root primordia and growth ring.
• Bud situated in the axil of the leaf on alternate sides of the stalk.
• Root primordia at lower side of the leaf scar arranged in rows.
• Growth ring present immediately above the each node, coated with waxy layer.
• The top of the stem is poor in sucrose and is of little value to sugar factory.

Leaf

• The leaf consists of two parts, the blade and the sheath, separated by a leaf joint.
• The leaves are attached alternately to the nodes.
• The leaf sheath is tubular in shape and is inserted at the node.
• The leaf blade is linear or lanceolate reaching one to one and midrib is prominent with groove on upper surface.
• The ligule is a membranous ring found as an appendage of the sheath, separating the latter from the blade, and bears long hairs.
• The scarious extension of the leaf sheath is known as auricles.

Inflorescence

• The inflorescence or tassel of sugarcane, generally called as ‘Arrow’ is a loose terminal panicle.
• 25-50 cm long arrow with silky appearance owing to rings of long hairs below each spikelet.
• The arrangement of the spikelet is racemose.
• Each tassel consists of several thousand tiny flowers, each capable of producing one seed. Sugarcane usually flowers at the age of 10-12 months but some varieties do not flower at all.
Climate

Sugarcane is a tropical plant. It grows more successfully in those regions where the climate is more or less tropical but it can grow in sub tropics too as in north India. Sugarcane is grown in the world from altitude 35° N and 35° S, from sea level to 1000m of altitude or little more.

Climatic factor

Latitude and altitude

Sugarcane is grown in the world from altitude 36.7° N and 31.0° S, from sea level to 1000m of altitude or little more.

Rainfall

A total rainfall between 1100 and 1500 mm is adequate provided the distribution is right, abundant in the months of vegetative growth followed by a dry period for ripening. It also grown in area where rainfall is low upto 500 mm. Above 1500 mm rainfall cause lodging of cane.

Temperature

Growth is closely related to temperature. It has a wide temperature range from over 38°C. Optimum temperature for cane growth (germination) is 27° to 33°C (80 to 90°F). Temperature below 27°C definitely injurious to the cane, reduce tillers and above 38°C adversely affect the sprouting.

Ideal temperature

Carbonassimilation-30°C, Sugar synthesis-30°C, Sugar transport- 30-35°C,
Tillering-33.3-34.4°C, Root growth- 36°C, Shoot growth- 33°C.

Relative humidity

High humidity (80-85 %) favours rapid cane elongation during grand growth period. A moderate value of 45-65 % coupled with limited water supply is favourable during the ripening phase. Above 40 % humidity coupled with warm weather favours vegetative growth of cane.

Sunshine

- Sugarcane is a sun loving plant.
- Greater incident radiation favours higher sugar yields.
- About 7-9 hr of bright sunshine is highly useful for both active growth and ripening.
Wind

High velocity winds exceeding 60 km/hr are harmful to grown up canes leading to lodging and cane breakage. (http://www.agritech.tnau.ac.in)

Uses of Sugarcane Crop

1. Out of total sugar produced in the world 60 per cent is obtained only from sugarcane. This sugar is used in our daily diet.
2. Ethanol is generally available as a byproduct of sugar production. It can be used as a biofuel alternative to gasoline.
3. Sugarcane crop is able to efficiently fix solar energy. After harvest, the crop produces sugar juice, bagasse, and the fibrous dry matter. This dry matter is biomass with potential as fuel for energy production. Bagasse is usually burned to produce steam, which in turn creates electricity. Current technologies such as those in use in Mauritius, produce over 100 KWh of electricity per tones of bagasse.
4. Technologies are being developed to use enzymes to transform bagasse into advanced biofuel and biogas.
5. A study by Smith Baez Consulting found that separating the sludge from the sugar cane into process water and thicker sludge creates biofertilizer. Biofertilizer is an organic fertilizer that can be used in gardens. It is alive with microorganisms and nutrients to help and keep plants healthy.
6. Sugar cane filter cake mud can also be used in animal feeds. It gives the nutrients they otherwise might not be getting, including a carbohydrate (sugar) and B-complex vitamins.
7. By using appropriate solvents, filter cake can be boiled down into cane wax. Waxes are used in different furniture polishes, car polishes and shoe polishes.
8. Like biofertilizers, filter cake mud (Press mud) soil amendments are used to improve soil’s natural biological properties. Filter cake mud can be used alone as a soil amendment or can be combined with other materials and wastes of sugar cane factories, like molasses and fly ash gives positive effect on growth and production of crop.
9. There are several foods and popular dishes derived directly from it, such as:

- Raw sugarcane is chewed to extract the juice.
- Sayurnganten is an Indonesian soup made with the stem of trubuk (*Saccharumedule*), a type of sugarcane.
- Sugarcane fresh juice extracted by hand or small mills, with a touch of lemon and ice to make a popular drink, known variously as usacharass, guarab, guarapa, guarapo, papelon, aseerasab, gannasharbat, mosto, caldo de can.
- Syrup is a traditional sweetener used in soft drinks, now largely supplanted in the US by high fructose corn syrup, which is less expensive because of corn subsidies and sugar tariffs.
- Jaggery is a solidified molasses, known as gur or gud or gul in India, is traditionally produced by evaporating juice to make a thick sludge, and then cooling and molding it in buckets.
- Falernum is a sweet, and lightly alcoholic drink made from sugarcane juice.
- Cachaca is the most popular distilled alcoholic beverage in Brazil.
- Rum is a liquor made from sugarcane products, typically molasses but sometimes also cane juice.
- Basi is a fermented alcoholic beverage made from sugarcane juice produced in the Philippines and Guyana.
- Panela is a solid pieces of sucrose and obtained from the boiling and evaporation of sugarcane juice.
- Rapadura is a sweet flour that is one of the simplest refinings of sugarcane juice.
- Rock candy is a crystallized cane juice Gateau de Sirop([http://en.wikipedia.org/](http://en.wikipedia.org/))