4.1 Introduction

A weed is a plant growing where it is not desired. Jethro Tull a Great Britain farmer was the first person to use this definition of weeds in his famous writing “The New Horse Hoeing Husbandry” published as a first book on agriculture in 1731, since then several definitions of weeds have been suggested around this basic information. Of these definitions, a comprehensive and widely accepted one is; a weed is a plant growing out of place and time. To elaborate this, weeds are plants growing in places and times where or when we wanted either some other plants to grow or no plant grow at all. This definition of weed as one would note does not identify a particular portion of plant kingdom as weedy. Rather, it tags the weedy nature of a plant to the situation in which it occurred and the attitude of an individual towards it. Several plant species growing on roadsides and wastelands may be of no concern to us at certain times when they are not to be considered as weeds. But when they hinder the efficient use of roads and highways immediately one considers these plants as weeds. Thus, it is the situation involving space and time and the individual interest in that situation, which class a plant as a weed. In this context it is well said that while all weeds are unwanted plants, all unwanted plants may not be weeds.

Despite the good intensions of the above accepted definitions of weeds for all intents and purposes about 30,000 plant species have been identified as definite weeds in the world infesting croplands, water bodies, woodlands, gardens, orchards, airfields, utility rights of way etc.

4.1.1 Weed Menace in Agriculture: Weeds reduce crop yield and production efficiency

Growing with crop plants weeds cause tremendous reduction in crop yields and elevate their production costs in varied ways. Several scientists have estimated such losses in crop yields in different parts of India. A very broad based average of
these estimates shows that weeds reduced productivity of wheat by 15-30%, rice by 30-35% and maize, sorghum, pulses and oil seeds by 18-85% each. There were also frequent cases of complete crop failure due to weeds particularly in upland rice and vegetable crops (Mukhopadhyay, 1991-92, Jain and Chaube 1969, Friesen and Korwar, 1983).

Besides, the direct reduction in crop yields inflicted due to the presence of weeds, there are many indirect ways by which the weeds may be troublesome in agriculture. For example in weedy fields farm operations like application of fertilizers, insecticides and irrigation become cumbersome. Even when a crop is made despite the presence of weeds it may be difficult to harvest it, particularly when prickly weeds like wild safflower (*Carthamus oxyacantha* Bieb.), Canada thistle (*Cirsium arvense* (L.) Scop.) and cocklebur (*Xanthium strumarium* L.) invade the fields Cowage (*Mucuna prurient* (L.) D.C.) annoy the harvest labour by causing itching. Bindweed (*Convolvulus arvensis* L.) and Morning glories (*Ipomoea species*) bind the crop plant together so well that their harvesting becomes troublesome. The weeds at harvest time also bring about excessive wear and tear of farm machines. Add to this the cost of separating weed seeds and fruits from the grain and other farm produce. There is yet another way the weeds limit our annual agricultural production. This is by permanently occupying thousands of hectares of otherwise productive land and taking these out of cultivation.

Recent estimates show that weeds cause an annual loss of Rs.1980 crores to Indian Agriculture, which is more than the combined losses caused by insect, pests and diseases.

4.1.2 Weed reduce crop quality

Weeds mar the of farm produce in many ways. Contamination of food grains with weed seeds particularly of poisonous nature fetches low price. The weedy grains produce flour with bad odour. In ware houses the weed seeds and weed fragments continue respiration and thus cause the grain to heat and rot. In tea, the presence of loranthus (*Dendrophthoe falcata* (L.f.) Ettingsh) leaves impair its quality. In cotton the dry weed fragments adhere to its lint and hinder the spinning process. In dry land agriculture weeds cause severe moisture stress and force the food grains to shrivel. The vegetables and fruits are discoloured and deshaped in the presence of weeds.
Cirsium arvense (L.) Scop, a common weed of mint plantations is often crushed with the mint leaves and thus lowers its oil quality.

### 4.1.3 Weed menace in Animal Husbandry Loss of animal produce

Growing with forage crops weeds often help to fill the carts and silos but it is in the milk and meat returns that their damage becomes apparent. The chemical analysis of weedy and weed free forages may sometime not show different nutritive values particularly when there are leguminous weeds in the mixture, but in feeding tests the animals exhibit clear preferences for the weed free forage. When some hungry animals are forced to feed upon weedy forage, their meat and milk are odd flavoured and tainted. Weeds like Cichorium intybus L., Allium vineale L., Argemone Mexicana L., Brassica kaber (D.C.) L. C. Wheeler., Anthemis cotula L., Thalapi sp. Ambrosia sp., Helium sp. and Oxalis acetosella L. are particularly notorious in this respect.

### 4.1.4 Loss of animal health

Certain weeds cause sickness in animals while others may prove fatal due to high level of specific alkaloids, tannins, oxalates, glycosides or nitrates. Halogeton (H. glomeratus (M. Bieb.) C.A.Mey. a weed of arid and semi arid region has brought death to herds of sheep with its high oxalate content. Johnson grass (Sorghum halepense (L.) Pers) at its tillering stage and Xanthium pungens Wallr. at its cotyledon stage are poisonous due to their high prussic acid content. Corncockle (Agrostemma githago L.) seeds have been found poisonous to horses, cattle and poultry. Their toxic principle is githagin (or Agrostemine). Puncture vine (Tribulus terrestris L.) a weed of drylands, induces in sheep extra sensitivity to light. Also, its thorny fruits cause sores in the hooves of animals. The spiny fruits of Xanthium strumarium L., Achyranthes aspera L., Cenchrus setigerus Vahl., Cirsium arvense (L.) Scop and Cenchrus incertus M.A.Curtis stick on to the mouth, tail and body of animals and annoy them badly.

The leaves of lantana (Lantana camara L.) induce acute photosensitivity and jaundice in animals due to their toxic principle ‘Lantra dene-A’. Carrot grass (Parthenium hysterophorus L.) causes dermatitis in livestock and it is reported to be poisonous to sheep. Ageratum sp. growing in abundance in Himalayas and Nilgiris are often hazardous to livestock. In Rajasthan there is growing concern about rapid spread
Chapter IV Information about weeds, crop plants and biofertilizers

of the weed golden crown beard (*Verbesina enceliodes* (Cav) Benth & Hook.f.ex A. Gray) since it is poisonous to sheep and goat. Locoweeds (*Astragalus and Oxytropis sp.*) inflict abortive and tetratogenic effects on sheep and cattle. Such weeds possess the toxic alkaloid swainsonine. *Lupinus sericeus* Pursh. induce crooked calf disease in cattle. *Rhododendron* sp. has been found responsible for causing diarrhea in milk animals in Kashmir. It also stains the milk of affected animals with blood. Leafy spurge (*Euphorbia esula* L.) causes scours and weakness in cattle and it is fatal to sheep. *Crotolaria* sp. is fatal to chick. Sweet clover (*Melilotus albus* Medik.) contains a dicumarin which acts as an anti-blood coagulant. *Heliotropium amplexicaule* Vahl, *Helenium* sp. and *Datura stramonium* L. are other sickening weeds for animals.

Under drought conditions weeds like *Chenopodium, Amaranthus, Cirsium,* and *polygonum* sp. develop nitrate levels as high as 100 ppm or more which causes asphyxia in animals. Spines of *Tribulus terrestris* L. can puncture animal skin, when ingested it can also injure the stomach. The hair of nettle (*Urtica urens* L.) causes severe itching and inflammation in animals.

### 4.1.5 Weed Menace to human Health.

Health, comfort and work efficiency of men are adversely affected by weeds. Numerous people are plagued year after year with hay fever and asthma aggravated by pollens of *Ambrosia artemesiifolia* L. and *Franseria* sp. The air-borne pollens and other biotic particles of several other weeds belonging to diverse families are known to cause rhinitis and conjunctivitis. Carrot grass (*Parthenium hysterophorus* L.), poison ivy (*Rhus sp.*), common ragweed (*Ambrosia artemesiifolia* L.) and sneezeweed (*helenium spp.*) are held responsible for different kinds of dermal allergies on humans.

Weeds provide food, protection and habitat for the reproduction of vectors of fatal human disease. Aquatic weeds like water lettuce (*Pistia sp.*), salvinia (*Salvinia auriculata* Aubl.) and alligator weed (*Alternanthera sp.*) shelter alternate hosts and vectors of malaria, yellow fever, encephalitis, dengue fever, filariasis. Tsetse fly which causes African sleeping sickness (*Trypanosomiasis*) flourishes under the cover of brush weeds. Eye gnats serving as vectors of mastitis and tropical ulcer also breed in certain weeds.

Then there are weeds which causes direct food poisoning. Wheat flour contaminated with seeds of corn cockle (*Agrostemma githago* L.) gives bread a bitter
taste and irritates the gastro-tract of the consumer. Mexican poppy (*Argemone mexicana* L.) seeds crushed with mustard seeds have brought death and blindness to thousands of people in India. Milk from animals feeding upon this weed can cause glaucoma in humans. The *Argemone* toxicity is due to alkaloid called sanguinarine and 11-Oxotriacontanoic acid. Some other poisonous weed seeds are from darnel (*Lolium temulentum* L.), wild mustard (*Brassica kaber* (D.C.) L. C. Wheeler) Saponaria (*Saponaria vaccaria* L.), ragwort and wild garlic (*Allium vineale* L) their seeds contaminate the food grain.

**4.1.6 Weed menace to aquatic ecosystem**

Not only on land, weeds are a nuisance in and around water bodies too. Aquatic weeds make the appearance of water bodies repulsive and decline their recreational values. In other water bodies they hinder navigation and fishing. Water flow in irrigation canals and channels is slowed. The potable and drinking waters are fouled by the presence of decomposing aquatic weeds.

**4.1.7 Weed menace to Industry and Public utilities**

Weeds growing on industrial sites and air fields are potential source of fire hazards besides being unseemly. They hide industrial pipelines and valves and contribute to deterioration of stores, equipment and material. Weeds force the fence lines to corrode and obstruct road signs and curves on highways. The working road widths are reduced by weeds. Some weeds penetrate through even asphalitic surfaces which get weakened. Weeds growing around electric poles prevent their ready access to the work crew. Weeds also weaken the rail tracts and air strips.

**4.1.8 Weed menace to woodland and forests**

In forest dry weeds offer potential source of fire hazards. A weed like lantana (*Lantana camera* L.) can catch fire even when green. Also, the presence of unwanted brush weeds reduces tree growth and prevents recreational and other uses of woodlands. In extreme cases the brush weeds take over land from the young forest trees.

**4.1.9 Weeds and Aesthetics**

In advanced countries lowering of aesthetic values is the primary objection to weed. Their presence around living and working places make the surroundings dull and insipid.
4.1.10 Misutilisation of weeds

Certain weeds have been used for purposeful adulteration of food in peace time and for toxicating mankind in war time. A recent example of adulteration of crop seeds with weed seed is of mustard seeds with Mexican poppy seeds. The resulting oil is very harmful to humans. Growing chicory plants with Lucerne and berseem likewise is an unhealthy adulteration of forage crops. The history reveals that during war time rootstocks of false hellebore (Veratrum sp.) were used to poison the drinking waters of enemy. Another weed henbane was used to extract ‘truth serum’ in Korean War. It forced the prisoners to reveal truth, unknowingly (Fulweiler, 1984).

4.1.11 Economic Uses of Weeds

Several well known weeds have been put to certain economic uses since ages. Of these their medicinal use in perhaps the most ancient one in India. Typha and saccharum sp. are used in cottage industry for making ropes and as thatch material. Cyperus sp. and Clinogyne dichotoma (Roxb.) Salisb. dry shoots are used on large scale to make mats. Cichorium intybus L. roots are used for adding flavour to coffee powder. Weeds like Chenopodium album L., Amaranthus viridis L., and portulaca sp., form good leafy vegetables. Certain weeds have been used to donate specific genes to our crop plants, for instance Saccharum spontaneum L. has been used widely in developing and present noble cane for North India. Fruits and rhizomes of certain weeds are used as vegetable and food material (Pirie, 1970). Attempts are underway to convert weedy vegetation into useful manure, animal feed, paper pulp, biogas, edible proteins etc. on the commercial basis to make physical control of weeds more attractive.

More recently certain weeds have exhibited nematicidal properties. Their incorporation into the soil has been found to result in greatly reduced root knot nematode population (Subramaniyam and Vadivelu, 1991). Some promising weeds in this respect are Crotolaria, Parthenium, Calotropis and Eichhornia sp.

Some entomologists have found that parasites and predators of certain crop pests also survive on insect pests of certain weeds, thus such weeds help in maintain the continuity of life cycle of certain useful parasites. Trichogramma chilonis Ishii. is one such parasite found feeding upon the eggs of Catopsilla sp. which infests the weed Cassia occidentalis L. as well as upon the eggs of castor semi-looper which damages the castor plants.
Enlightened with economic potential of certain weeds some authors tend to define weeds as plant for which economic uses are yet to be discovered. But this in no way lowers the undesirable nature of weeds in agriculture or reduces our concern towards them as harmful plants (Gupta O.P., 2005).

This research emphasized on conversion and utilization of harmful weeds in a beneficial manner by using them for preparation of compost and vermicompost for sustainable agriculture.

4.2 Dominant weeds used in these experiments are –

1) *Achyranthes aspera* L.

Marathi : Aghada, Aghara.
Hindi : Apand, Chirchira, Chinchda, Chichiri, Chirchita, Latjira,
English : Prickly Chaff flower
Latin : *Achyranthes aspera* Linn.
Family : Amaranthaceae

It is found almost everywhere throughout tropical Asia, Australia and America. It is an abundant weed in dry places and waste lands from the sea shore to 2,100 m high.

It is an annual or if near water perennial herb, it is 0.5-2.0 m high, stems erect, procumbent, base woody, angular or ribbed, simple or slightly branched often tinged with pink colour, nodes bulged. Leaves are opposite, petiolate, ovate-elliptical or obovate-rounded in various sizes, tomentose at the apex. Flowers are many greenish white in terminal spike or axillary spike, bracteate and bracteolate, Perianth lobes 4-6, glabrous, shining, ovate, oblong and pointed. Stamens-5 staminode truncate, fimbriate, ovary oblong, solitary, enclosed in the hardened perianth, Fruit easily disarticulate, oblong or ovoid and utricle. Seed sub cylindrical inverse with truncate apex seed testa coriaceous brown. Flowering and fruiting from October to January.

It is a common weed on waste land, road side and around the field. It has medicinal value in dropsy, piles, cough and colic skin eruptions, opthalmia, eye and liver complaints, rheumatism, scabies. It is astringent diuretic, alterative and purgative. The leaves and seeds are used in hydrophobia along with *Piper longum* L. and insect bite, renal dropsy, bronchial affections and in leprosy. It also used as
abortificient, contraceptive and anticoagulant in traditional medicine. Leaves useful in gonorrhea and roots in cancer, stomach trouble and bladder stones. The whole plant is used as medicine. Two aporphinoid alkaloids extracted from Achyranthes aspera L. by using ethyl alcohol. This alkaloid extract inhibited activity of Bacillus subtilis, Staphylococcus aureus, Pseudomonas aeruginosa and Shigella dysenteriae (Raman et al, 1996). Decoction (6 tablespoon) or paste (5 tablespoon) of Achyranthes aspera use up to 6-8 week or two month it cures menorrhagia. Branches and roots are used as tooth brushes.

2) **Tephrosia hamiltoni** Drumm.

| Marathi : Sharpunkha, Unhali. |
| Hindi : Sarfonka, Sarfoka. |
| English : Purple Tephrosia, Wild indigo. |
| Latin : Tephrosia hamiltoni Drumm. |
| Family : Fabaceae |

It is commonly grown in grassland and waste land along the roadside. It is an annual under shrub 30-60 cm tall, branches zigzag and stem angled, gray pubescent. Leaves are pinnate, 6-10 cm long. Leaflets 9-15 oblanceolate; flowers pink in extra axillary receme, pods linear 2.5-4 cm, apiculate, 4-6 seeded, seeds oblong and pale yellow, flowers and fruits July to December. Root leaves and seeds are used in medicine. Used as a fish poison; the leaves and seeds contain tephrosin, which paralyzes fish. Larger doses are lethal to fish but mammals and amphibians are unaffected. It is used traditionally as folk medicine. According to Ayurveda plant is digestible, anthelmintic, alexiteric and used in leprosy, ulcers, as antipyretic, alternative, cures diseases of liver, spleen, heart, blood, tumours, asthma etc. A decoction of the roots is given in dyspepsia, diarrhoea, rheumatism, asthma and urinary disorders. The root powder is salutary for brushing the teeth. It quickly relieves the dental pains and arrests bleeding (Arnold and Harry, 1968).

3) **Cassia auriculata** L.

| Marathi : Tarawad |
| English : Avaram senna. |
| Latin : Cassia auriculata L. |
| Family : Fabaceae |
| Sub Family: Caesalpinioideae |
It occurs in the dry region of India and Sri Lanka. It is common along the sea coast and dry zone in Sri Lanka. It is much branched shrub with smooth cinnamon brown bark and closely pubescent branchlets. The leaves are alternate, stipulate, paripinnate compound, very numerous closely placed, rachis 8.8-12.5 cm long, narrowly furrowed, slender pubescent, with an erect linear gland between the leaflets of each pair, leaflets 16-24, very shortly stocked 2-2.5 cm long, 1-1.3 cm broad, slightly overlapping, oval oblong, obtuse at both ends, mucronate, glabrous or minutely downy, dull green, paler beneath, stipules very large, reniform-rotund, produced at base on side of next petiole into a filiform point and persistent.

Its flowers are irregular, bisexual, bright yellow and large (nearly 5 cm across), the pedicels glabrous and 2.5 cm long. The racemes are few-flowered, short and erect and crowded in axils of upper leaves so as to form a large terminal inflorescence (leaves except stipules are suppressed at the upper nodes). The 5 sepals are distinct, imbricate, glabrous, concave, membranous and unequal with the two outer ones much larger than the inner ones. The petals number 5, free, imbricate and crisped along the margin bright yellow veined. The anthers number 10 and are separate with the three upper stamens barren; the ovary is superior, unilocular with marginal ovules. The fruit is a short legume, 7.5–11 cm long, 1.5 cm broad, oblong, obtuse, tipped with long style base, flat, thin, papery, undulately crimped, pilose, pale brown. 12-20 seeds per fruit are carried each in its separate cavity. *Cassia auriculata* L. is suitable for landscaping roadways and home gardens. It tolerates drought and dry conditions but not much cold. The flowers in racemes are also attractive (Martin, 1983; De Silva, 1998).

**Medicinal uses**

The root is used in decoctions against fevers, diabetes, diseases of urinary system and constipation. The leaves have laxative properties. The dried flowers and flower buds are used as a substitute for tea in case of diabetes patents. It is also believed to improve the complexion in women. The powdered seed is also applied to the eye in case of chronic purulent conjunctivitis. In Africa the bark and seeds are said to give relief in rheumatism, eye diseases, gonorrhea, diabetes and gout (Jayaweera, 1981a, b, c). The plant has been shown to have antibacterial activity in the laboratory (Maneemegalai et al, 2010)
4) *Azadirachta indica.* A. Juss.

Marathi : Kadunimba, Nimba  
Hindi : Neem  
English : Indian Lilac  
Latin : *Azadirachta indica.* A. Juss  
Family : Meliaceae

Neem (*Azadirachta indica* A. Juss) is a tree in the mahogany family Meliaceae. It is one of two species in the genus *Azadirachta* and is native to India, Myanmar, Bangladesh, Sri Lanka, Malaysia and Pakistan growing in tropical and semi-tropical regions. Other vernacular names include Neem (Hindi, and Indian Lilac (English). In East Africa it is also known as *Muarubaini* (Swahili) which means the tree of the 40, as it is said to treat 40 different diseases.

*Azadirachta* is a genus of two species of trees in the flowering plant family Meliaceae (Mahogany family). Numerous species have been described in the genus but only two are currently recognized, *A. excelsa* (Jack) Jacobs and the economically important Neem tree, *A. indica* A. Juss. (Pennington and Styles, 1975). Both species are native to the Indomalaysian region and *A. indica* is also widely cultivated and naturalized outside its native range. The resin from the trees has been attributed with medical benefits.

Neem is a fast-growing tree that can reach a height of 15–20 m (about 50–65 feet) rarely to 35–40 m (115–131 feet). It is evergreen, but in severe drought it may shed most or nearly all of its leaves. The branches are wide spread. The fairly dense crown is roundish or oval and may reach the diameter of 15–20 m in old, free-standing specimens.

**Leaves**

The opposite, pinnate leaves are 20–40 cm (8 to 16 in.) long, with 20 to 31 medium to dark green leaflets about 3–8 cm (1 to 3 in.) long. The petioles are short. Very young leaves are reddish to purplish in colour. The shape of mature leaflets is more or less asymmetric and their margins are dentate.

**Flowers**

The (white and fragrant) flowers are arranged axillary normally in more-or-less drooping panicles which are up to 25 cm (10 in.) long. The inflorescences which branch up to the third degree bear from 150 to 250 flowers. An individual flower is 5–
6 mm long and 8–11 mm wide. Protandrous, bisexual flowers and male flowers exist on the same individual. Flowers are used to make a curry called ugadi pachadi.

**Fruit**

The fruit is a smooth (glabrous) olive-like drupe which varies in shape from elongate oval to nearly roundish and when ripe is 1.4-2.8 x 1.0-1.5 cm. The fruit skin (exocarp) is thin and the bitter-sweet pulp (mesocarp) is yellowish-white and very fibrous. The mesocarp is 0.3-0.5 cm thick. The white, hard inner shell (endocarp) of the fruit encloses one rarely two or three, elongated seeds (kernels) having a green yellow seed coat and brown after senescence.

Neem Cake has an adequate quantity of NPK in organic form for plant growth. Being a totally botanical product it contains 100% natural NPK content and other essential micro nutrients as N (Nitrogen 2.0% to 5.0%), P (Phosphorus 0.5% to 1.0%), K (Potassium 1.0% to 2.0%), Ca (Calcium 0.5% to 3.0%), Mg (Magnesium 0.3% to 1.0%), S (Sulphur 0.2% to 3.0%), Zn (Zinc 15 ppm to 60 ppm), Cu (Copper 4 ppm to 20 ppm), Fe (Iron 500 ppm to 1200 ppm), Mn (Manganese 20 ppm to 60 ppm). It is rich in both Sulphur compounds and bitter limonoids.

According to research calculations, neem cake seems to make soil more fertile due to an ingredient that blocks soil bacteria from converting nitrogenous compounds into nitrogen gas. It is a nitrification inhibitor and prolongs the availability of nitrogen to both short duration and long duration crops.

**Use as a fertilizer**

Neem cake organic manure protects plant roots from nematodes, soil grubs and white ants probably due to its content of the residual limonoids. It also acts as a natural fertilizer with pesticidal properties. Neem cake is widely used in India to fertilize paddy, cotton and sugarcane. Usage of neem cake has shown an increase in the dry matter in *Tectona grandis* L.f. (Teak), *Acacia nilotica* (L.) Delile. (Gum Arabic), and other forest trees.

Neem seed cake also reduces alkalinity in soil as it produces organic acids on decomposition. Being totally natural, it is compatible with soil microbes, improves rhizosphere micro flora and hence ensures fertility of the soil. Neem Cake improves the organic matter content of the soil, helping improvement in soil texture, water holding capacity, soil aeration for better root development.
Pest control

Neem cake is effective in the management of insects and pests. The bitter principles of the soil and cake have been reported to have seven types of activities (a) antifeedant (b) attractant (c) repellent (d) insecticide (e) nematicide (f) growth disruptor and (g) antimicrobial.

The cake contains salannin, nimbin, azadirachtin and azadiradione as the major components. Of these, azadirachtin and meliantriol are used as locust antifeedants while salannin is used as an antifeedant for the housefly.

4) Phaseolus aureus Roxb. Syn Vigna radiata (L.) Wilczek

Marathi : Mung (मूंग)

Hindi : Moong (मूंग)

English : Green bean, Green gram

Latin : Phaseolus aureus Roxb.

Family : Leguminosae

The seed of Vigna radiata is native to Bangladesh, India, and Pakistan. The split bean is known as moong dal, which is green with the husk and yellow when dehusked. The beans are small, ovoid in shape and green in color. The English word "mung" derives from the Hindi moong. The whole or split grains of this crop are consumed whole after germinating them, parched, salted or boiled with condiments.

The mung bean is one of many species recently moved from the genus Phaseolus to Vigna and is still often seen cited as Phaseolus aureus or Phaseolus radiatus. These variations of nomenclature have been used regarding the same plant species.

Mung bean or mung is cultivated all over the country. The important states producing this pulse are Maharashtra, Madhya Pradesh, Uttar Pradesh, Andhra Pradesh, Rajasthan, Karnataka and Tamilnadu. The crop grows well on deep well drained loams in the north as well as on red and black soils of peninsular and southern India. The crop needs well distributed rainfall. This pulse is largely grown as rain fed kharif crop. In some parts of Maharashtra it is cultivated in summer season. The Rabi crop is generally grown unmixed, whereas the kharif crop may be sown alone or mixed with maize, pearl millet, cotton or sugarcane. The Kharif crop is sown in June or July and the Rabi in September or October. The seeds are either broadcasted on
field or sown in rows 20-30cm apart. Plants grow fast during favorable conditions. Flowering starts in about 60 days.

It is herbaceous annual plant erect in habit, 45-120 cm tall with a slight tendency to twining in its upper branches. The trifoliate leaves have large petioles which are entire, rarely trilobed and ovate in outline. The flowers are papilionaceous.

**Uses** Tender pods are eaten raw or used as vegetable. The ripe seeds used as dal. Green gram is esteemed as food as it does not produce heaviness and flatulence. It is employed as a light diet during fever and is considered to have cooling and astringent effect. The seeds are sprouted and seedlings of four day growth are eaten as vegetable. The flour of mung is used as an excellent substitute as a soap for cleaning the body.

**Medicinal Uses** The pulse is prescribed in Malaya for vertilago. In the Philippines, a decoction of the seeds is used as an effective diuretic in beriberi. The mung extract said to have protective and curative properties in *Polyneuritis gallinarum*. The herb is valued as feed for cattle and horses (http://en.wikipedia.org/wiki/mung_bean).

5) *Vigna unguiculata* (L.) Walp.

Marathi : Chavali

Hindi : Lobya, Lobiya, Chowali

English : Black eyed peas, Cowpea


Family : Leguminosae

Cowpeas are one of the most important food legume and fodder crop in the semi-arid tropics covering Asia, Africa, Southern Europe and Central and South America. A drought-tolerant and warm-weather crop, cowpeas are well-adapted to the drier regions of the tropics where other food legumes do not perform well. It also has the useful ability to fix atmospheric nitrogen through its root nodules and it grows well in poor soils with more than 85% sand and with less than 0.2% organic matter and low levels of phosphorus (Singh et al, 2003). In addition, it is shade tolerant and therefore, compatible as an intercrop with maize, millet, sorghum, sugarcane and cotton. This makes cowpea an important component of traditional intercropping systems.

It is twining, rarely sub erect herbs or under shrubs, stem scabrid, hairy at the nodes, leaves pinnately trifoliate, membranous ovate, rhomboidal, entire or slightly lobed, stipulate, stipules subulate, large, basifixed or rarely peltate. Inflorescences few
flowered, axillary racemes or fascicles, peduncle long, flowers often in alternate pairs, corolla papilionaceous, pods linear, slender often very long, rounded or compressed, seeds small but varied usually sub-reniform. Cowpea beans are a common food item in the Southern United States where they are often called field peas. A subcategory of field peas is Crowder peas, so called because they are crowded together in their pods, causing them to have squarish ends. According to the USDA food database, cowpeas have the highest percentage of calories from protein among vegetarian foods (Shaw Monica, 2007).

6) Raphanus sativus L.

Family : Brassicaceae
Marathi : Mula
English : Radish
Latin : Raphanus sativus L.
Family : Brassicaceae

It is herbaceous plant grown for their crisp and pepper tasting root. It is an edible root vegetable, a cold climate crop. It is annual or biennial plant of Chinese origin. Plant grown for thickened root which is eaten uncooked as a salad vegetable. The most commonly eaten portion is the napiform taproot, although the entire plant is edible and the tops can be used as a leaf vegetable. It can also be eaten as a sprout. The bulb of the radish is usually eaten raw, although tougher specimens can be steamed. The raw flesh has a crisp texture and a pungent, peppery flavor caused by glucosinolates and the enzyme myrosinase which combine when chewed to form allyl isothiocyanates also present in mustard and horseradish. Radishes may be used in salads as well as in many European dishes (http://en.wikipedia.org/wiki/Radish).

7) Pennisetum glaucum (L.) R.Br.

Syn : Pennisetum typhoides (Burm. f.) Stapf & C. E. Hubb.
Marathi : Bajri
Hindi : Bajara, Bajera, Bahara, Lahra.
English : Pearl millet
Latin : Pennisetum glaucum (L.) R.Br.

Pearl millet is the most widely grown type of millet. Grown in Africa and the Indian subcontinent since prehistoric times, the center of diversity and suggested area of domestication for the crop is in the Sahel zone of West Africa. Recent
archaeobotanical research has confirmed the presence of domesticated pearl millet on the Sahel zone of northern Mali between 2500 and 2000 BC (Manning, 2010). Cultivation subsequently spread and moved overseas to India. The earliest archaeological records in India date to 2000 BC (Fuller, 2003); domestication in Africa must have taken place earlier. Its origin has been traced to tropical Africa. Cultivation subsequently spread to east and southern Africa and southern Asia. Records exist for cultivation of pearl millet in the United States in the 1850s and the crop was introduced into Brazil in the 1960s.

Pearl millet is well adapted to production systems characterized by drought, low soil fertility and high temperature. It performs well in soils with high salinity or low pH. Because of its tolerance to difficult growing conditions, it can be grown in areas where other cereal crops such as maize or wheat would not survive. Today pearl millet is grown on over 260,000 km² worldwide. It accounts for approximately 50% of the total world production of millets.

India is the largest producer of pearl millet. It is known as Bajra and is primarily consumed in the states of Haryana, Rajasthan, Gujarat and Madhya Pradesh. It is annual, erect, tillering plant 1.5-1.8m tall, roots fibrous, stem is round to oval, green, usually solid, divided into nodes and internodes. Leaves are long, scabrous, medium broad, linear lanceolate, wavy margin, green or light green. Inflorescence is a spike (Panicle). The spike-lets are small, lanceolate in shape and sharply acute. Each spikelet consists of two florets, the lower usually male and upper hermaphrodite. Grains are gray, rarely yellow, a caryopsis fruit, 3-4mm long, and 3-10 mg in weight. It is grown both as summer crop and winter crop. It is eminently suited to light soils. Most of the cultivars in India are photo-insensitive. It is also cultivated as fodder crop, harvesting of fodder crop at the milk stage of ear heads and before stem become too dry (http://en.wikipedia.org/wiki/Pearlmillet).

8) *Trigonella foenum-graecum* L.

Marathi : Methi
Hindi : Methi
English : Fenugreek
Latin : *Trigonella foenum-graecum* L.
Family : Fabaceae
Fenugreek is used both as an herb (the leaves) and as a spice (the seed). It is cultivated worldwide as a semi-arid crop. It is frequently used in curry. Major fenugreek producing countries are India, Pakistan, Argentina, Egypt, France, Spain, Turkey, Morocco and China. India is the largest producer of fenugreek in the world where Rajasthan, Gujarat, Uttarakhand, Uttar Pradesh, Madhya Pradesh, Maharashtra, Haryana and Punjab are the major fenugreek producing states. Rajasthan produces the lion's share of India's production by accounting for over 80% of the nation's total fenugreek output (http://en.wikipedia.org/wiki/Fenugreek). Qasoori methi, more popular for its appetizing fragrance comes from Qasur, Pakistan and regions irrigated by the Sutlej River, in the Indian and Pakistani states of Punjab. It is also called "venthyam" in Tamil.

It is an annual herb reaching a height of about 0.9m, leaves light green, pinnately trifoliate, leaflets obovate, flowers papilionaceous, small white, fruit legume, long narrow, curved, tapering with a slender point and containing small, deeply furrowed seeds (Samba Murty, Subrahmanyam N. S. (1989)).

Fenugreek seeds are thought to be a galactagogue that is often used to increase milk supply in lactating women because the maple syrup-like flavor is strong and not always liked the seeds are ground to a powder and administered in capsules. Many lactating women who take fenugreek in the quantities required to increase their milk supply notice that their skin exudes a distinct "maple syrup" odour (Chantry et al, 2004).

Fenugreek seeds are a rich source of the polysaccharide galactomannan. They are also a source of saponins such as diosgenin, yamogenin, gitogenin, tigogenin and neotigogens. Other bioactive constituents of fenugreek include mucilage, volatile oils and alkaloids such as choline and trigonelline. Diosgenin steroidal substance is important to the pharmaceutical industry as a starting material in the partial synthesis of sex hormones and oral contraceptives. Seeds of Fenugreek are used in Traditional Chinese Medicine under the name Hu Lu Ba. In TCM it warms and tonifies kidneys, disperses cold and alleviates pain. Main indications are called hernia, pain in the groin. It's used raw or toasted. Fenugreek seed is widely used as a galactagogue (milk producing agent) by nursing mothers to increase inadequate breast milk supply it can be found in capsule form in many health food stores. Supplements of fenugreek seeds were shown to lower serum cholesterol, triglyceride and low-density lipoprotein in human patients and experimental models of hypercholesterolemia and
hypertriglyceridemia, although the benefits of lowering serum cholesterol in and of itself is controversial. Several human intervention trials demonstrated that the antidiabetic effects of fenugreek seeds ameliorate most metabolic symptoms associated with type-1 and type-2 diabetes in both humans and relevant animal models by reducing serum glucose and improving glucose tolerance. Fenugreek is currently available commercially in encapsulated forms and is being prescribed as dietary supplements for the control of hypercholesterolemia and diabetes by practitioners of complementary and alternative medicine. Fenugreek is employed today in Indian and Ethiopian medicine as a carminative and tonic for gastric troubles and mucilage produce during soaking of seed in water soothing mucilage said to aid in digestion (herbwisdom.com; Trigonella foenum-graecum information).

4.3 Biofertilizers

A biofertilizer is a substance which contains living microorganisms which when applied to seed, plant surfaces or soil it colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant (Vessey, J.k., 2003). Bio-fertilizers add nutrients through the natural processes of nitrogen fixation, solubilizing phosphorus and stimulating plant growth through the synthesis of growth-promoting substances. Bio-fertilizers can be expected to reduce the use of chemical fertilizers and pesticides. The microorganisms in bio-fertilizers restore the soil's natural nutrient cycle and build soil organic matter. Through the use of bio-fertilizers, healthy plants can be grown and enhancing the sustainability and the health of the soil. Since they play several roles, a preferred scientific term for such beneficial bacteria is "plant-growth promoting rhizobacteria" (PGPR). Therefore, they are extremely advantageous in enriching soil fertility and fulfilling plant nutrient requirements by supplying the organic nutrients through microorganism and their byproducts. Hence, bio-fertilizers do not contain any chemicals which are harmful to the living soil. (http://www.springerlink.com/content/q327j346t7233222/fulltext.pdf).

Bio-fertilizers provide eco-friendly organic agro-input and are more cost-effective than chemical fertilizers. Bio-fertilizers such as Rhizobium, Azotobacter, Azospirillum and blue green algae (BGA) have been in use a long time. Rhizobium inoculants are used for leguminous crops. Azotobacter can be used with crops like wheat, maize, mustard, cotton, potato and other vegetable crops. Azospirillum
inoculations are recommended mainly for sorghum, millets, maize, sugarcane and wheat. Other types of bacteria, so-called phosphate-solubilizing bacteria, such as *Pantoea agglomerans* (Ewing and Fife) Gavini. strain (P5) or *Pseudomonas putida* Trevisan. strain (P13) are able to solubilize the insoluble phosphate from organic and inorganic phosphate sources (*http://en.wikipedia.org/wiki/Biofertilizer*).

### 4.3.1 Advantages of biofertilizers

1. It is an important mechanism which influences plant growth, productivity, yield and its quality.
2. They enhance biomass production and grain yields by 10-20%.
3. Biofertilizers are the preparation containing active strains of nitrogen fixing micro-organisms. Mainly bacteria and algae which stimulate plant growth.
4. They are suitable in organic farming for sustainable agriculture and ecofriendly.
5. Living biofertilizers material composed of microbial activity which increased fertility of soil and make it more productive.
6. The biofertilizers are solubilized plant nutrients like phosphate and stimulate plant growth by increasing necessity of soil.
7. It has impact on morphology, physiology and even genetic makeup and gene expression in plants. Such influences have many implications on agricultural practices and crop yields.
8. Chemical fertilizers utilize petroleum are costly, short in supply and all the more they damage the environment. Biofertilizers on the other hand are low cost inputs, enrich the soil are compatible with long term sustainability and pose no damage to environment and so invite increasing demands.
9. They do not require non renewable source of energy for their production.
10. For vegetables Azotobacter and phosphate solubilizers are commonly used biofertilizers.

### 4.3.2 How do these fertilizers work?

- These microbial cultures fix atmospheric nitrogen, helps in phosphate solubilization or producing hormones, vitamins and other growth factors required for plant growth.
These are called biological instruments and play a very significant role in the augmenting the productivity.

4.3.3 Necessity of Biofertilizers

The use of biofertilizers in agriculture is the need of time
1. The manufacturing cost of chemical fertilizers is very high as compared to biofertilizers.
2. Chemical fertilizers are non-renewable whereas biofertilizers are renewable.
3. Chemical fertilizers are short in supply as compared with biofertilizers.
5. For biofertilizers waste material may be recycled.
6. Biofertilizers vigorous more growth and increased disease resistance hence yield also increased.

Biofertilizers are bacterial, algal, phosphate solubilizing, Azolla and manures type (http://www.springerlink.com/content/v2315pl5736061g7/fulltext.pdf).

4.3.4 Types of biofertilizers

1. Azotobacter:

   *Azotobacter* is a genus of usually motile, oval or spherical bacteria that form thick-walled cysts and may produce large quantities of capsular slime. Azotobacter is an aerobic, free-living soil microbe which fixes nitrogen from the atmosphere. Beyond Azotobacter’s use as a model organism it has biotechnological applications. Examples are its use for alginate production and for nitrogen production in batch fermentations (Schindelin et al, 1997; Chiu et al, 2001). Polyhydroxybutyrate is produced under certain conditions. Azotobacter is Gram-negative bacteria.

   *Azotobacter vinelandii* Lipman.
   *Azotobacter chroococcum* Beijerinck.
   *Azotobacter agilis* Beijerinck.

   *Azotobacter vinelandii* Lipman is a diazotroph that can fix nitrogen while grown aerobically. It is a genetically tractable system that is used to study nitrogen fixation. These bacteria are easily cultured and grown. It is a free-living N\textsubscript{2} fixer which is known to produce many phytohormones and vitamins in the soil.
The beneficial effect of Azobacter biofertilizer on cereals, millets, vegetables, cotton and sugarcane under both irrigated and rain fed field conditions have been substantiated and documented by many workers. Application of Azobacter has been found to increase the yield of wheat, rice, maize, pearl millet and sorghum by 0-30% over control. Apart from nitrogen, this organism is also capable of producing antibacterial and antifungal compounds, hormones and siderophores.

1. Azobacter is free living nitrogen fixing bacteria, fixing nitrogen equivalent to 25-30 kg N / hact
2. It is also produces hormones like Indole Acetic Acid (IAA) and gibberellins. Vitamins like biotin, folic acid and different B groups also produced.
3. The application of Azobacter supported by judicious use of organic matter ensures good seed germination, increasing productivity.

2. Phosphate solubilizing Biofertilizers

Phosphate solubilizing Bacteria (PSB) are a group of beneficial bacteria capable of hydrolyzing organic and inorganic phosphorus from insoluble compounds (Chen et al., 2006) P-solubilization ability of the microorganisms is considered to be one of the most important traits associated with plant phosphate nutrition. It is generally accepted that the mechanism of mineral phosphate solubilization by PSB strains is associated with the release of low molecular weight organic acids through which their hydroxyl and Carboxyl groups chelate the cations bound to Phosphate, thereby converting it into soluble forms. In addition, some PSB produce phosphatase like phytase that hydrolyse organic forms of phosphate compounds efficiently. One or both types of PSB have been introduced to Agricultural community as phosphate Biofertilizer. Phosphorus (P) is one of the major essential macronutrients for plants and is applied to soil in the form of phosphate fertilizers. However, a large portion of soluble inorganic phosphate which is applied to the soil as chemical fertilizer is immobilized rapidly and becomes unavailable to plants. Currently, the main purpose in managing soil phosphorus is to optimize crop production and minimize P loss from soils. PSB have attracted the attention of agriculturists as soil inoculums to improve the plant growth and yield. When PSB used with rock phosphate, it can save about 50% of the crop requirement of phosphatic fertilizer. The use of PSB as inoculants increases the P uptake by plants. Simple inoculation of seeds with PSB gives crop yield responses equivalent to 30 kg P2O5 /ha or 50 percent of the need for phosphatic
fertilizers. Currently, different strains of these bacteria has been identified for using in biofertilizer, of all three new strains *Pantoea agglomerans* (Ewing and Fife.) Gavini., strain (P5), *Microbacterium laevaniformans* (Dias and Bhat) Collins., strain (P7) and *Pseudomonas putida* Trevisan. strain (P13) has been recently identified as the highly efficient insoluble phosphate solubilizer

- These biofertilizers play a significant role in solubilizing insoluble phosphate.
- Around 95-99 % of the total soil phosphorus is insoluble which is directly not available to the plants.
- The phosphorus solubilizers containing bacteria or fungi may convert insoluble form of phosphate to soluble form by producing organic acids in general.
- About 15-25% of insoluble phosphate can be solubilised, saving chemical fertilizers significantly.

4.3.5 Important micro-organisms are

* Bacillus polymyxa* (Prazmowski) Mace
* Aspergillus awamori* (Nakaz)
* Penicillium digitatum* (Pers.) Sacc.

4.3.6 How to apply Biofertilizers

1. Seed treatment
2. Cut piece / set treatment
3. Seedling treatment
4. Soil application

4.3.7 Seed treatment

- About 200 gm of biofertilizer is required to treat 10-14 kg of seeds.
- Suspend one pocket of 200 gm in approximately 400ml water and mix it thoroughly.
- Pour this mixture on seeds and mix with hands to obtain uniform coating on each and every seed.
- Spread the seeds in shade for drying about 10-15 minutes then sow them immediately.

4.3.8 Cutting/set treatment

- Prepare a culture suspension by mixing 1 kg of culture in 50-60 liters water.
- The cut pieces of planting material required for 1 acre are kept immersed in the suspension.
• Bring out these cut pieces and allow to dry for some times before planting
• Cut pieces method is applicable for crops like potato.

4.3.9 Seedling treatment
• Seedling treatment is recommended for Tomato, Chili, and Onion etc.
• Prepare the suspension by mixing 1 kg of culture in 10-15 liters of water.
• Get seedlings required for 1 acre and make small bundles of seedlings.
• Dip the seedlings in the suspension for 10-20 minute
• Transplant treated seedlings immediately.
• Generally the ratio of inoculants and water should be 1:10 approximately i.e. 1kg pocket in 10 liters of water.

4.3.10 Soil application
• Prepare the mixture of 2-3 kg of biofertilizer in 40-60 kg of soil/compost.
• Broadcast the mixture in one acre of land either at sowing time or 24 hours before sowing. The application of phosphate solubilizers is very common for all crops and to be used along with Rhizobium/Azobacter a Azospirillum biofertilizer.

In the present investigation such holistic and sustainable approach in crop improvement through use of biofertilizer is undertaken by applying through soil.