Introduction

The ornamental plants are generally grown for the display of their aesthetic features like lovely flowers, beautiful leaves, fragrance, texture, color (Kaufman and Lohr, 2008), symbolic significances (Mendonea de Carvelho, 2011; Koehn, 1952; Ferguson, 1966) therapeutic (Matsuo et al., 2008) and emotional values. They play an important role in making the environment beautiful and refreshing thus in addition to aesthetic properties, ornamental plants contribute in establishing a harmonious relationship between people and the nature by associating the beauty and utility. They are an inseparable part of the modern lifestyle, be it interior decoration, outdoor decoration or a greeting bouquet for our near and dear ones. Flowers, shrubs and trees beautifully decorate our gardens, parks and avenues, while household plants add a pleasant living touch to our hectic lives. Their economic and emotional impact is significant as they are grown for the display of their flowers and flowers are one of the nature’s most beautiful gift to people as they are born with flowers, live with flowers and finally die with flowers.

The ornamental horticulture is a global industry today. Approximately 15,000 ha is used for the production of ornamental plants only as commercial horticulture covers approximately 1,66,000 ha. The position of the ornamentals industry is much less institutionalized than the rest of agricultural production but it is getting the boom day by day. The ornamentals are spread over the entire plant kingdom including herbaceous, annuals, biennials or perennials or woody trees, shrubs and climbers, succulents, desert and aquatic plants, epiphytes and terrestrials in habit that could have originated in a wide variety of habitats representing different ecosystems. Ornamentals encompass a wide array of plants and are grouped into several categories such as cut flowers, ornamental grasses, lawn or turf grasses, potted and indoor plants, bedding plants, trees and shrubs. Out of these, a large variety of ornamental plants are grown in the gardens of India. A few very important flowering plants useful for garden display are the cut flowers as rose, jasmine, aster, chrysanthemum, orchids, gladiolus, marigold etc.
In recent years the global demand of cut flowers is increasing day by day. In the economies of developing countries the industry is becoming increasingly important, bringing in dynamic foreign exchange for investment in economic development. Employment opportunities are provided by flower production on commercial farms and millions of workers improved their livelihoods. Growing demand for a wide variety of locally grown, fresh-cut flowers has kept this market growing in volume for years. With this respect floriculture crops introduction could be an imperative intervention where a farmer can earn much more by exploiting the accessible natural resources. These crops also give premium prices almost around the year and as in the case of other routine crops there is no need to wait for a long time with these crops. Comparison with other conventional crops net profit against the investment is much higher with these crops. In all over the world the products are in very high demand. Thus, for export purposes Indian floriculture industry is shifting from traditional flowers to cut flowers.

In the international cut flower trade the important floricultural crops are rose, carnation, chrysanthemum, gladiolus, gerberas, marigold, aster, gypsophila, tulip, orchids, and lilies. Floriculture crops like gerberas, carnation etc. are grown in greenhouses and chrysanthemum, roses, gaillardia, lily, marigold, aster, tuberose etc. are open field crops. In our country Maharashtra, Karnataka, Andhra Pradesh, Haryana, Tamil Nadu, Rajasthan and West Bengal have come out into view as major floriculture centers. According to the data available from the NHB (National Horticultural Board) in floriculture about 248.51 thousand hectares area was under cultivation in the year 2014-15 in India and 1,685 thousand tonnes of loose flowers and 472 thousand tonnes cut flowers production are estimated.

Marigold and aster are important open field crops which may give more returns to the farmers by exploiting the available natural resources.

In India marigold (*Tagetes* spp.) hold first position among all the loose flowers. It is being grown as an ornamental cut flower and landscape plant as well as for natural carotenoid pigment used in poultry feed to impart pigmentation of egg yolk and broiler skin colour and also as a natural dye in various industries. Today it is one of the most
sought commercial flower grown world over and in India as well, accounting for more than half of the nation's loose flower production. *Tagetes erecta* L. (African Marigold) is commonly grown for its exquisite blooms. In India, the present area is more than 17,600 hectares with a production of 2,00,000 metric tonnes under marigold (Anon., 2003). It is cultivated commercially in most parts of India. Karnataka alone occupies around 4,500 hectares under its cultivation. Although in the cultivation of marigold a recent upsurge is evident, large efforts towards increased yields lack realization.

On the other hand, aster is a very fashionable annual flower crop and is chiefly propagated for production of cut flowers, loose flowers, as pot plant and for bedding plant purposes in landscape. It is cultivated worldwide as an ornamental plant and commercially grown in all over the world and in India as well. Among annuals it ranks next to chrysanthemum and marigold and is mainly grown by marginal and small farmers. Because of its easy cultural practices, diversity of colours and their use as loose as well as cut flowers it is gaining fast popularity in India. The flowers have long vase life and are used for various purposes, as for the preparation of garlands, bouquet and in flower arrangement as filler, as a mean to appeal to the Gods or ward of evil, in some Chinese herbal remedies, making an ointment to heal the effects of a bite from a mad dog. It is widely grown in Maharashtra, Tamil Nadu and West Bengal. In Karnataka it is expensively grown around Bangalore, Chitradurga and Kolar districts. They are available in a wide range of shades including white, pink, purple, blue, red, violet and yellow.

However, the varieties presently available are very old and obsolete, low yielding and inferior in quality compared to the modern cultivars grown in Holland, Israel, USA, France and UK. The quality and the type of flower produced largely determine the success in export rate.

In order to achieve the foreign standards and compete in the international trade, the Indian floriculturists have started growing imported varieties. But those varieties require high doses of fertilizers and heavy irrigation, for example an imported variety of gladiolus requires twelve times more inorganic chemicals per hectare per year as compared to Indian variety. The water requirements are even higher (about 80,000 litres.
per hectare per day). The cultivation of such varieties is expensive as well as it possess a threat of loss of soil fertility, soil contamination and other associated problems. Development of any technology, which may curtail the cost of cultivation of such varieties, will go a long way to help the Indian floriculturists.

Apart from high yielding varieties, heavy input of fertilizers and heavy irrigation, availability of land in the country is also one of the major constraints in the production of these flowers. India, which constitutes only 2% of the world’s total land, provides shelter to the 16% of the world population. Because of this high man to land ratio, there is a considerable pressure on land on account of the competing land uses. Horticulture plants compete with the agricultural crops for the same area of land. Owing to the basic necessity, food crops are given more preference in land competition. Horticultural plants are never treated as substitute for agricultural crops, as the former are non-conventional crops and farmers grow them only on the lands where agricultural crops cannot be grown. It is therefore, natural as well as necessary that for flower production at commercial level, focus should be turned towards the less fertile and problem soils which are at present lying fallow.

One of the important categories of wasteland is salt affected wasteland which occupies extensive area in the world and in India as well, but it presents a serious impediment to crop production. In India around 7 mha land is salt affected out of which 2.5 mha occurs in Indo-Gangetic plains covering the states of Uttar Pradesh, Haryana, Punjab, Delhi and parts of Bihar. In Uttar Pradesh alone about 1.29 mha is salt affected and commonly known as ‘usar’ or ‘reh’ in local language. Extensive occurrence of alkaline soils has been reported from the Indo-Gangetic plains of northern India. The agricultural history of the region suggests that these high alkaline and sodic lands have been left unproductive in this area for a long time. High alkalinity and high exchangeable sodium percentage (ESP) of the soil render it inhospitable for normal crop production and there is minimal bioproductivity in such soil.
To utilize these soils for floriculture is a major challenge. There is a need to develop a technology suitable for production of export quality flowers at the reduced cost of cultivation and make floriculture remunerative.

**Application of AM fungi and fly ash along with certain beneficial microbes may be novel and cost effective approach for the growers.**

**I. Application of AM Fungi:**

In the past few decades, it has been well established that the AM fungi enhance the ability of plants to cope with environmental stresses generally prevalent in the degraded ecosystems. These fungi form a symbiotic association with the roots of higher plants. The fungal partner gets shelter and food from the host and in turn provides an array of the benefits ranging from better uptake of nutrients, especially phosphorus and other relatively immobile micronutrients zinc, copper, calcium, magnesium etc., maintenance of water balance, increased rate of photosynthesis, improved hormone production, resistance to soil-borne pathogens to overall increase in plant growth and development. Therefore, AM association can be defined as a specialized system for nutrient uptake and transfer, more efficient than roots alone.

Several workers have reported the presence of AM association in salt stress environments. Plants exhibit considerable dependence on mycorrhizal association for an adequate supply of nutrients and water enabling them to thrive under salt stress conditions. This association helps in alleviating stress conditions by providing a number of nutritional as well as non-nutritional benefits. Under stressed conditions, mycorrhizal association improves rooting and root hair production in host, increases the absorptive surface of roots manifold for the uptake of nutrients and water, thereby helps in the establishment and survival of the seedlings. AM fungi are also known to enhance the activity of several antioxidant enzymes such as superoxide dismutase, catalase, ascorbate peroxidase, glutathione reductase etc. Thus, mycorrhizal protection is an important mechanism against oxidative damage in stress conditions by which host plants increases the tolerance through AM symbiosis.
In this respect AM fungi have emerged as a potential biofertilizer and an effective bioinoculant in the recent past. This aspect especially gains significance for a developing country like India, where utilization of AM fungi may prove its benefit for getting maximum and long term gains on such soils. Although varying degree of success in the establishment, survival and growth of some plants under various stressed soils using AM technology has been achieved, but very little work has been done to evaluate the potential of AM fungi in improving the growth performance of horticultural/cut flower plants under stressed soils.

II. Utilization of Fly Ash: a source of essential plant nutrients

Apart from alkaline soil tracts, there are large dumps of fly ash which are lying unused and polluting the environment. At present, large quantity of fly ash is being dumped in slurry form in large areas close to the power plants without being put to gainful use. Only a very small percentage (<3.5%) of fly ash generated in India is being used for gainful applications whereas the corresponding figures of other countries may vary from 20 to 80%. Owing to its pozzolanic property, the main emphasis up to now in our country has been towards the utilization of fly ash for low and medium value applications like bricks, part replacement of cement and in mass concrete for dams, for paving roads and airport runways, embankments, sea-port fill etc.

However, recent attempts in India and abroad are being made for biological association of fly ash e.g. in soil improvement, in wasteland management and also as a source of essential plant nutrients for nutrient deficient soil in terrestrial eco-system. Fly ash has been found to have manifold advantages especially in modification of soil texture and bulk density, in optimization of soil pH, in improvement of water holding capacity of soil, in the improvement of yield as a micronutrient supplement to soil and in creation of conducive condition for better plant growth.

In recent years, scientists paid a great attention for the application of fly ash and its utilization in floriculture to improve the growth and performance of the plants. It has a great potential as it improves the soil fertility by providing the essential nutrients and promote the plant growth. Studies have evaluated the impact of fly ash alone or in
combination with organic matter like FYM, *Cynodon*, sewage sludge and microbial cultures which enhanced the growth, yield and nutrient uptake of the cereals, pulses, oilseeds, sugarcane, vegetables, cut flowers etc.

Due to the easy availability and low cost of inputs it acts as an alternative exploitable resource to reclaim the degraded soil because it possesses several similarities like soil and contains essential micronutrients like Fe, Mn, Zn, Cu, Co, B and Mo and macronutrients like P, K, Ca, Mg and S. It possesses many of the functional properties of lime and gypsum which can be used in the reclamation of wasteland (Shainberg *et al.*, 1989; Kumar and Singh, 2003). Chemical constituents of fly ash can improve agronomic properties of soil and may use as the substitute of lime or fertilizers as soil amendments (Schumann and Sumner, 1999). Its application to wasteland decreases the soil bulk density, alters soil texture, increase water holding capacity, reduces compaction and enhances soil fertility (Chang *et al.*, 1977; Wong and Wong, 1990).

In view of the above facts present study has been planned to curtail the cost of cultivation of marigold and aster flowers by utilizing the less fertile soils e.g. alkaline soils and waste resource material the fly ash along with AM fungi and other microbial inoculants.

In the present study efforts were made to develop a low external input technology for the establishment and growth of *Tagetes* and *Callistephus* (Aster) in the alkaline soils and the detailed work on the following aspects has been undertaken:

**WORK PLAN**

- To determine the mycorrhizal status of the ornamental plants growing under natural and cultivated conditions of Allahabad.
- To determine the mycorrhizal status in different zones of alkaline/sodic soils of Phulpur, Allahabad.
- Analysis of physico-chemical characteristics of the rhizospheric soils of the plants growing in different zones of alkaline/sodic soils of Phulpur, Allahabad.
- Isolation of AM fungal spores from the rhizospheric soils of ornamental plants and alkaline/sodic soils of Phulpur, Allahabad and their identification.
• Propagation of isolated AM fungal spores on two trap plants *Sorghum bicolor* and *Trifolium repens* under greenhouse condition.

• Isolation of phosphate solubilizing and N\textsubscript{2} fixing microbes from the alkaline/sodic soils of Phulpur, Allahabad, their identification and maintenance.

• Evaluation of phosphate solubilizing potentiality of different P solubilizing microbes under *in vitro* conditions.

• Collection of the fly ash samples from IFFCO (Indian Farmer Fertilizers Cooperative) Phulpur, Allahabad for its physico-chemical characteristics.

• To study the effect of AM fungi and fly ash on the performance of *Tagetes erecta* and *Callistephus chinensis* raised in agriculture and alkaline/sodic soil amended with different doses of fly ash (20 t/ha and 40 t/ha), gypsum, organic matter (*Cynodon*/FYM, 2% w/w) and inoculated with consortium of AM fungi, PSF (*Aspergillus niger*) and N\textsubscript{2} fixer (*Azotobacter chroococcum*) in combination under pot conditions.

• To evaluate the performance of the selected dose of fly ash on *Tagetes erecta* and *Callistephus chinensis* raised in agriculture and alkaline/sodic soil amended with selected dose of fly ash (40 t/ha), gypsum, organic matter (*Cynodon*/FYM, 2% w/w) and inoculated with consortium of AM fungi, PSF (*Aspergillus niger*) and N\textsubscript{2} fixer (*Azotobacter chroococcum*) in combination under microplot conditions.