INTRODUCTION

Chapter- I

The cultivated strawberry (*Fragaria* × *ananassa* Duch.) is originated from the hybridization of two American species *Fragaria chiloensis* and *Fragaria virginiana* which was first developed in France in the 17th century. All the cultivated varieties of strawberry are octaploid having chromosome number 2n =56 (**Anonymous, 1956**).

Strawberry (*Fragaria* × *ananassa* Duch.) is one of the most delicious fruits of the world, which is a rich source of vitamins and minerals and has fabulous flavour and tantalizing aroma (**Kher *et al.*, 2010).** Strawberry is one of the most important herbaceous perennial temperate fruit crop which belongs to the family Rosaceae which can also be grown in tropical and sub tropical region of the world. Its successful cultivation requires an optimum day temperature of 22 to 23 ^{0}C and night temperature of 7 to 13^{o}C. (**Shoemaker, 1954).** Strawberry cultivation was mainly in India confined to Jeolikote, Nainital (Uttarakhand), Solan, Kullu (H.P.), Srinagar (J & K) but now its cultivation has been extended to subtropical regions namely, Gurgaon (Haryana), Pune (Maharashtra), Bangalore (Karnataka), Ghaziabad, Meerut, Saharanpur and Muzaffarnagar (U.P.) **(Singh, 1992).** The fully mature ripe fruits of strawberry attain attractive red colour, sweet-sour taste and a pleasant aroma **(Mitra, 1991)**. Fruits are mostly eaten fresh and are consumed not for the food value but for the flavour. Besides dessert purposes, strawberries are processed into various value added products viz., canned strawberry, jam, jelly and ice-cream, (**Hughes *et al.*, 1969**). For good quality strawberry, its cultivation is affected by many factors i.e. soil, climate, irrigation, nutrition, mulching, growth regulators etc. Soil is an important factor for good quality fruits. Plants on sandy-loam, well-drained soil perform better and produce healthy and good quality fruits. (**Chindler *et al.*, 1995**).

In India, strawberry was first introduced by the NBPGR Regional Research Station, Shimla (H.P.) in the early sixties. But the early effort to popularize its cultivation in Himachal Pradesh and Uttar Pradesh had received a setback an account of the poor adaptability of the cultivars, low returns per unit area and lack of technical know-how (**Sharma, 2002).** Some cultivars are being tried to generally grown in tropical and sub-tropical northern India, are Sweet Charlie, Chandler, Belrubi, Pusa Early Dwarf, Fern, Selva, Pajaro, Winter Dawn, Camarosa, , Red Coat, Addie, Swiss, Gorella, Jucunda, , Sweet Heart, Mecharenj, Red

Ground, Florida-90, Elsanta , Brighton, Dilpans,Florida Go. However, some cultivars Sweet Charlie, Chandler and Selva have shown the promising result under Lucknow conditions.

As far as global scenario is concerned Europe produces about 1/3rd of the total strawberries of the world. Among different countries, Spain, Poland, Germany and France are the major strawberry producers of the world. USA, Mexico, Egypt, Japan, Italy, and Russian Federal also produce sizable amount of strawberries. However, due to pressing demand of farmers and consumers, adoption of modern and standardized agro-techniques, introduction of day-neutral varieties and use of protected cultivation, both the area and production in India have increased substantially during the past few years **(Sharma, 2002)**. Commercial strawberries are successfully grown in a broad range of climates including temperate, grassland, Mediterranean, taiga and sub tropical. However, most of the current production is limited to the temperate and Mediterranean climates, located between latitudes 28^0 and 60^0. When growing strawberries in hot environments, attention must be paid to temperature and photo period patterns across the whole season, not just the summer. The strawberry is composed of several different meristems that are regulated by the interaction between photoperiod and temperature **(Darrow, 1996; Larson, 1994)**. No floral induction under short days in plant of strawberry held at 26/22 and 30/26^{0}C day/ night temperature regimes. In warm climates, high air temperature probably plays an important role in restricting growth and fruit development by reducing photosynthetic activity and increasing respiration rate **(Larson, 1994)** observed.

Nutrition is one of the most important aspects of crop production. Strawberry requires a number of minerals nutrients for proper growth and development. Vermicompost can significantly influence the growth and productivity of plants **(Sinha *et al.*, 2009**). Vermicompost, which is a stabilised organic material produced by interactions between earth-worms and microorganisms, in a non-thermophilic processes, has been reported to enhance seed germination and growth and plant yields in a greenhouse (**Atiyeh *et al.*, 2000**) and to improve growth and plant yield under field conditions **(Arancon *et al.*, 2004)**. The availability of plant growth-influencing substances in vermicomposts, such as plant growth hormones and humic acids has also been suggested as a possible factor contributing to increase micro-biological processes, plant growth and yields (**Pramanik *et al.*, 2010**). Vermicompost represented hormone-like activity and increase in number of roots, thereby, enhancing nutrient uptake as well as plant growth and development **(Alvarez and Grigera, 2005)**. The application of vermicompost had favorable effects on the growth, development and physiology of the Lilium asiatic hybrid var. Navona (**Ladan Moghadam *et al.*, 2012)**. The physical and biological property may be modified in the vermicompost amend soils

(**Srivastava *et al.*, 2012**). Vermicompost enhanced plant growth may resulted from the modified physiochemical and microbiological characteristics of the soil, increased availability of macro and micro nutrient element **(Anwar *et al.*, 2005; Sahni *et al.*, 2008**). Vermicompost is an environmentally acceptable means for convert waste to nutritious compost **(Singh *et al.*, 2010**). Vermicompost increases nutrient content, enhances soil respiration and different enzymatic activities (Dehydrogenase, urease, β-glucosidase, phosphatase, arylsulfatase and activates microorganisms in soil (**Tejada *et al.*, 2010**). Vermicomposts restrain nutrients such as nitrates, transferable phosphorus, soluble potassium calcium, and magnesium in plant available forms **(Orozco *et al.*, 1996; Edwards, 1998**) and have large particular surface area that provides many microsites for microbial activity and for the strong retention of nutrients (**Shi-wei and Fu-zhen, 1991**). Apart from providing mineralogical nutrients, vermicomposts also contribute to the biological fertility by adding beneficial microbes to soil. Mucus, excreted through the earthworm`s digestive canal, stimulates antagonism and competition between diverse microbial populations resulting in the production of some antibiotics and hormone-like biochemicals, boosting plant growth **(Edwards and Bohlen 1996**). Adding up vermicompost to soil improves soil structure, fertility, plant growth and suppresses diseases caused by soil-borne plant pathogens, increasing crop yield (**Singh *et al.*, 2008**). Vermicompost has been found effective for improving soil aggregation, structure, and fertility, increasing soil microbial diversity, populations, and enzymes, improving moisture-holding capacity of soils, increasing cation-exchange capacity (CEC), and finally also crop yields (**Tejada *et al.*, 2008**). Various greenhouse and field studies have examined positive significant effects of vermicomposts on growth and yield of cereals legumes, vegetables, ornamental, flowering plants, and other field crops (***Arancon et al.*, 2008; *Sangwan et al.*, 2010).**

Azotobacter represents the main group of heterotrophic, non symbiotic, gram negative, free living nitrogen-fixing bacteria. They are capable of fixing an average 20 kg N/ha/year. The genus *Azotobacter* includes 6 species, with *A. chroococcum* most commonly inhabiting in various soils all over the world **(Mahato *et al.*, 2009).** Besides nitrogen fixation, *Azotobacter* also produces thiamin, riboflavin, indole acetic acid and gibberellins. When *Azotobacter* is applied to seeds, seed germination is improved to a considerable extent, so also it controls plant diseases due to above substances produced by *Azotobacter*. The exact mode of action by which *Azotobacter* enhances plant growth is not yet fully understood. Three possible mechanisms have been proposed: N_2 fixation; delivering combined nitrogen to the plant; the production of phytohormone-like substances that alter plant growth and morphology, and

bacterial nitrate reduction, which increases nitrogen accumulation in inoculated plants (**Mrkovacki and Milic, 2001**) . *Azotobacter* species are free living bacteria which grow well on a nitrogen free medium and are an important source of bio-fertilizers. These bacteria utilize atmospheric nitrogen gas for their cell protein synthesis. This cell protein is then mineralized in soil after the death of the *Azotobacter* cells thereby contributing towards the nitrogen availability of the crop plants thus resulting in a strong symbiotic relationship **(Haller and Stople, 1985**). They also exudates some compounds like auxins, cytokinin and antibiotics improving growth and productivity of the crops **(Forlain *et al.*, 1995).**

Urea as an inorganic fertilizer contains 46% nitrogen. Nitrogen is a chlorophyll component, which promotes vegetative growth and green colouration of foliage **(Jones, 1983).** Nitrogen is essential during early growth, bud differentiation and flowering in strawberry (**Albregts and Howard, 1980)**.

Among perennial crops, strawberries are an ideal model to study the nutrients transformations. This has been attributed to the production of berries within a few months of planting due to small plant size and establishment of more plots within uniform soils. Although, strawberry cultivation is becoming popular in India, but the farmers are continuing to grow them as a subsidiary crop. Due to lack of proper attention farmers usually harvest smaller fruits, use of chemical fertilizers has contributed significantly. However, and indiscriminate use of chemical fertilizers has caused serious damage to the soil ecosystem and Physico-chemical characteristics. Although, many organic options are available but high yield and better quality fruits cannot be expected from the sole application of organic manures or biological products. Therefore, a judicious combination of inorganic and organic fertilizers or bio-fertilizer is helpful in increasing the fruit production in strawberry. Moreover, such efforts shall be helpful to maintain sustainable productivity and soil health. Amongst various available organic options, bio-fertilizers are agriculturally important beneficial microorganisms which have ability to mobilize the nutritionally important elements. Moreover, they are cost effective and renewable. Bio-fertilizers are also known to increase the yield of strawberry (**Shiow and shin, 2002**).

Keeping in view the above facts in mind, it was thought imperative to formulate scientific studies to work out on **"Studies on the efficacy of vermicompost, urea and *Azotobacter* on growth, yield and quality attributes of strawberry (*Fragaria* × *ananassa* Duch.)"** Therefore, the present investigation has been planned with the following objectives.

1. To find out the effect of vermicompost on growth, yield and quality traits of strawberry.

2. To ascertain the effect of urea on growth, yield and quality attributes of strawberry.

3. To assess the effect of *Azotobacter* on growth, yield and quality characters of strawberry

4. To work out the combined effect of vermicompost, urea and *Azotobacter* on growth, yield and quality parameters of strawberry.