Introduction
1. Introduction

Any part of herbaceous plant that humans eat whole or in part is a vegetable, except culinary fruits and arguably grains, nuts, herbs and spices. Vegetables are eaten in a variety of ways, as part of main meals and as snacks. The nutritional content of vegetables varies considerably, though generally they contain varying proportions of vitamins such as Vitamin A, Vitamin K and Vitamin B6, provitamins, dietary minerals and carbohydrates. It is hard to argue with the health benefits of a diet rich in vegetables and fruits as they contain a great variety of other phytochemicals, some of which have been claimed to have antioxidant, antibacterial, antifungal, antiviral and anticarcinogenic properties (Steinmetz and Potte, 1996; Gauda, 2005). Some vegetables also contain fiber important for GI function, nutrients necessary for proper hair and skin as well. Diets containing recommended amounts of fruits and vegetables may help in lowering down the risk of heart diseases and type-2 diabetes. These diets may also protect against some cancers and decrease bone loss. The potassium provided by vegetables may help to prevent the formation of kidney stone.

India is the second largest producer of vegetables in the world followed by China with the production of 137 million tonnes in 2011 followed by 133.73 million tonnes in the previous year (http://www.financialexpress.com/news/fruit-vegetable-production-up-3.7-in-201011-govt/842602/). The most common vegetables grown in India are the cole crops (Cabbage, cauliflower, knol khol, brussels sprout etc.), tomato, cucurbits. chilly, eggplant, okra, onion etc.

Cole crops are as diverse as leafy kale, cabbage, kohlrabi, broccoli, cauliflower, and Brussels sprouts. According to an extension leaflet of Iowa State University, all cole crops are cultivated varieties of the species Brassica oleracea L. (Haynes et al., 2009). The extreme plasticity of the species has allowed differentiation, under human selection, of this large number of forms due to the specialization of different plant organs that have given rise to various crops and uses. These include, for example, the leaves in the case of cabbage and leafy kale, the stem in kohlrabi and marrow stem kale, the inflorescences in broccoli and cauliflower, and the axillary (lateral) buds in the brussels sprout. The
variation in forms and colors is marked within each of these crop types (Maggioni \textit{et al.}, 2010).

Insect pests are major obstacles in low production of cauliflower and cabbage starting from nursery stage to the harvesting stage. Lal (1975) reported that 37 species of insects attacked the cruciferous vegetable crops, out of which 27 insect species were the pest of cauliflower alone at various stages of crop growth. Some of the important insect pests were diamondback moth \textit{(Plutella xylostella} L.), mustard aphid \textit{(Lipaphis erysimi} Kalt.), cabbage aphid \textit{(Brevicoryne brassicae} L.) cabbage butterfly \textit{(Pieris brassicae} L.), leaf webber \textit{(Crocidolomia binotalis} Zell.), tobacco caterpillar \textit{(Spodoptera litura} Fab.), Greasy cutworm \textit{(Agrotis ipsilon} Huf.) etc. It has been estimated by Mohan and Gujar, (2003) that, collectively the pest is known to cause a loss of about US $16 million at 2.5 % damage in India.

The out breaks of diamondback moth (DBM) at Aligarh, India led the growers to plough down their standing crops inspite of multiple insecticide applications (Ansari \textit{et al.}, 2007). Since it has attained the status of major pest, farmers are more concern to control it. it has been estimated that, globally the cost of control is about of US$ 1 billion (Grzywacz \textit{et al.}, 2010), however in India, the cost of pest control particularly DBM \textit{(P. xylostella)}, cabbage worm \textit{(S. litura)} and aphids, was estimated around US $ 168 million (Sandure \textit{et al.}, 2004). The wide spread use of insecticides on cabbage and cauliflower has led to the elimination of natural enemies of DBM (Xu \textit{et al.}, 2004) thus paving the way to attain the status of most noxious pest of various cole crops in India (Singh \textit{et al.}, 2005).

The principles of pest management are very interesting and appealing but in real world, application is very difficult primarily because of inadequate information on pest complex (Pradhan, 1971). In modern high intensive agricultural practices, farmers frequent apply synthetic pesticides to combat pests of vegetable crops without considering how pesticide usage would affect the health and environment. Such situation may not sustain in future primarily due development of resistance among insects against many insecticides (Shelton \textit{et al.}, 2000; Sarfraz and Keddie, 2005). Presence of residues due to the indiscriminate use of pesticides on fresh produce and
vegetables entering into food chain are other major issues being dealt seriously across the scientific community. These problems have excessive interest in evolving alternative control methods and new technologies, such as transgenic crops using genetic engineering. Host plant resistance however should be the basis for pest management, but in many cases no suitable resistant germplasm is available (Kennedy, 2008). In this context Government of India aims to develop a sustainable strategy to increase the production through use of transgenic approaches. Bt transgenic cabbage and cauliflower have been developed in India yet to be applied on large scale at farmers field for the control of the lepidopteron pests resistant against all sorts of chemicals. Transgenic crops have the ability to overcome the problem of pesticide resistance. Considering the seriousness of insect pests and the problem of resistance as well as future prospects in the use of transgenic cole crops, the experiments were designed with following specific objectives.

1. Determination of current status of insect pests and their management practices in cauliflower (*Brassica oleracea* var. *botrytis*) and cabbage (*Brassica oleracea* var. *capitata*).

2. To determine seasonal incidence and distribution pattern of insect pests and their natural enemies in cauliflower ecosystem.

3. Evaluation of simulated Bt-transgenic cauliflower with current insect pest management practices in cauliflower ecosystem and their impact on natural enemies.

4. Evaluation of the performance of Cry 1 Ba 2 + Cry 1 Ca 4 dual gene cauliflower and cabbage against diamond back moth (*Plutella xylostella* L.) and tomato fruit borer (*Helicoverpa armigera* Hub.) under green house condition.

5. Screening of Bt-cauliflower and cabbage germplasms against major insect pests.

6. Determination of the performance of *B. thuringiensis* insecticidal proteins Cry 1B. Cry 1C and insecticides on target insect pests of cole crops.

7. Determination of persistence and dissipation of commonly used insecticides.