Introduction
1. INTRODUCTION

Chilli (Capsicum annuum L.) is an important vegetable cum spice crop grown in almost all parts of tropical and subtropical regions of the world. It belongs to the family Solanaceae and originated from South and Central America where it was domesticated around 7000 BC. The genus Capsicum includes 30 species, five of which are cultivated: Capsicum annuum L., C. Frutescens L., C. Chinense Jacq, C. pubescens R. & P. and C. Baccatum L. (Bosland and Votava, 2000; Wang and Bosland, 2006 and Ince et al., 2010).

Capsicum annuum is cultivated either for pungent fruited genotypes called chilli (synonyms: hot pepper, American pepper, chile, azi, cayenne, paprika etc.) or non-pungent fruited genotypes called sweet pepper (synonyms: Capsicum, paprika, bell pepper, Shimla mirch). Chilli has many culinary advantages. It comprises numerous chemicals including steam-volatile oils, fatty oils, capsaicinoids, carotenoids, vitamins, proteins, fibres and mineral elements (Bosland and Votava, 2000). Capsicum fruits may serve as a source of natural bactericidal agents to be used in food and medicinal systems.

Many chilli constituents are important for nutritional value, flavor, aroma, texture and colour. Chillies are low in sodium and cholesterol free, rich in vitamin A, vitamin C, vitamin E, a good source of potassium and folic acid. Fresh green chilli peppers contain more vitamin C than citrus fruits and fresh red chilli has more vitamin A than carrot. It with bright colour and less pungency are preferred in Europe and in the West. Chilli is commercially important for two qualities, i.e., its red colour is due to the pigment capsanthin and its biting pungency is due to capsaicin. Among these alkaloids, capsaicin and dihydrocapsaicin are the major alkaloids that contribute up to 80 per cent of the total capsaicinoids (Hornero-Méndez et al., 2002; Pérez-Gálvez et al., 2004; Manjula et al., 2011 and Sharanakumar et al., 2011).

In India chilli occupies an area of 7.50 lakh hectares with an annual production of 11.67 lakh tones (2009). Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu are major chilli growing states in India which together contributes about 75 per cent of the total cultivated area (Rajesh Kumar et al., 2011). Karnataka stands second in area (1.234 lakh hectares) and production (1.419 lakh tones), while in productivity it ranks eighth in position with an average yield of 1150 kgs of dry chilli per hectare.
The important chilli growing districts in Karnataka are Haveri, Dharwad, Gadag, Koppal, Belgaum, Bellary and Raichur of which Haveri and Dharwad districts themselves make up 72 and 60 per cent of total area and production, respectively (http://horticulture.kar.nic.in). In recent years, there has been a great demand for increasing the diversity in chilli for within both culinary and ornamental purposes.

Though India is the leading producer, the average yield of chilli is very low (1.11 t/ha dry chilli) as compared to developed countries like USA, China, South Korea, Taiwan etc, where the average yield ranges from 3 – 4 t/ha. Low productivity in chilli is mainly attributed to lack of high yielding, pest and disease resistant varieties or hybrids. Only about 2.60 percent chilli area is under hybrids in India, while in the countries like Korea and Taiwan more than 90 percent area is covered by hybrids.

Capsicum has been cultivated over centuries, producing both pungent and sweet fruits. Capsicum annuum L. is characterized by a wide variety of fruit size, shape and with different capscaicinoid content. Despite the importance of this plant as spice and its medicinal uses, research on its genetic variability and potential for breeding program is still incipient. There is also an urgent need to investigate the genetic control of some traits with the objective of introgressing these traits into cultivated varieties.

Diversity study helps to select desirable parents for production of hybrids and would provide a guideline for breeders to devise breeding experiments in such a way that they raise adequate populations in the segregating generations to isolate the desired recombinants. Yields can be boosted by eliminating the undesirable characters and by bringing together the desirable genes. Genetic manipulation is one of the methods through which this can be achieved and is possible only when the genetic architecture of the plant is thoroughly understood. Assessment of variability at molecular level is more meaningful, accurate and reliable than variability at phenotypic level as the former is less dependent and influenced by environmental factors. Random Amplified Polymorphic DNA (RAPD) is considered as an essential tool in cultivar identification (DNA typing), in assessment of genetic variability and relationship management of genetic resources and biodiversity, in studies of phylogenetic relationship and in genome mapping (Welsh and McClelland 1990, Williams et al., 1990 and Sandigwad and Patil 2011a, 2011b). Estimation of inter cultivar molecular diversity and their association, if any, with the trait of economic importance would help in identifying molecular markers associated with the trait of interest. RAPD markers could be used to
determine the sex of plants at seedling stage (Baratakke and Patil, 2009). This may pave the way for mass cultivation of dioecious tree species where the economic importance is tagged with specific sex.

The genus capsicum is often a cross pollinated crop and natural cross pollination may go up to 50 per cent depending upon the extent of style exertion, time of anthesis, wind direction and insect population (Murthy and Murthy, 1962 and Hosmani, 1993). This accounts for considerable variation in fruit and yield parameters. Because of chance hybridization with many non-quality chilli varieties/hybrids grown adjacent to these varieties, both desirable and undesirable genes might have been introgressed into these varieties over several decades in addition to accumulation of minor genetic mutations resulting in a lot of variations in these varieties grown in farmer's field. There is a vast reservoir of variability in respect of both yield and quality. Hence, there is a need to assess the variability, identify the best lines, purify and restore or improve the original quality of chilli and pepper cultivars.

The knowledge of the inheritance of various characters of qualitative nature is of paramount importance to achieve success in plant breeding, whose studies appear to have helped and contributed in a significant way to the plant breeding in general and chilli breeding in particular, in evolving early, high yielding and disease resistant varieties. The knowledge of interrelationships especially in terms of linkage, of distinct characters like pigmentation with economically important characters like number of fruits per plant, flowering, trichome density sterility will help in selecting the superior genotypes.

Genetic studies leading to linkage information are important from theoretical and applied point of view. Cross over values indicate the distance with economically important characters like number of fruits per plant, flowering, male sterility, branching etc., which would be of invariable help to the breeder at least indirectly in selecting superior genotypes for high yields. Moreover, the marker traits like pigmentation in particular plant part may assume greater importance for identification of the varieties or true hybrids when these marker traits are added to male parents. Further, assigning of all the genes governing different qualitative characters to their respective linkage groups has its fundamental importance. Drosophila, Maize and rice are the examples where this task has been carried out to a greater extent.
India, being the largest chilli producer, has vast potentiality to increase production and promote export besides meeting its domestic requirements. However, despite continuous efforts at various levels, the chilli productivity did not gain accepted momentum. This could be attributed to various biotic and abiotic constraints. Among biotic constraints, thrips and mites complex causes on an average yield loss to the tune of 34 per cent.

In India, nearly 70 percent of chemical insecticides produced are being used in pest control alone. The large scale use of chemical insecticides is a hazard to the environment and undoubtedly the use of insecticide has created the problem of killing natural enemies of the pests, thereby leading the development of secondary pests. Overdependence on insecticides may also lead to the resurgence of primary insect pests (Dempster, 1968). Hence, there is an urgent need to adopt biological control index for the protection of environment.

However, there are some limitations in biological control also as with the insecticidal control of pests (Johnson et al., 1986). Thus, exploitation of the built-in mechanisms of the plant itself alone or in combination of other methods, is one of the best alternatives for minimizing reduction in yield due to insect-pest damage in terms of reducing the cost of cultivation and protection of the environment. Presence of trichomes, thick cuticle on the epidermal surface of the leaf renders some resistance to many insects. In addition, secondary metabolites are known to confer resistance to a variety of insect pests in chilli.

The low productivity could be improved through hybridization since marked heterosis (3.8 to 71%) has been reported for yield and its yield components. The occurrence of male sterility in nature is very rare. Male sterility in chilli has not been observed in nature but has been induced artificially by chemicals (Goetz et al., 2001). Male sterility was considered as disadvantageous but now it has place of pride in the breeding of both cross and self-pollinated crops. The deliberate exclusion of pollen in this kind of situation has solved many problems like elimination of tedious emasculation, providing correct combinations of parents, providing more flexibility to breeding programme, facilitating quick incorporation of diverse genes for disease resistance in hybrids etc. This has of special advantage in the struggle against continuously changing pathogen, reducing cost of F1 hybrid seed production and saving of time upto 70 per cent.
To improve the productivity of chilli, use of hybrid seed is an important tool and for production of hybrid seeds the sterility could play a vital role. The male sterile lines permit hybrid seed production and commercial exploitation of heterosis in crops where emasculation on a large scale is a tedious job. The occurrence of commercially utilizable genetic male sterility or cytoplasmic male sterility is not reported in chilli. Accordingly, induction of male sterility using mutagens has been tried and a few male sterile lines have been obtained but such mutations are rare, recessive and associated with negative and agronomically inferior features. However, when male sterile trait exists in a genotype, its transfer into an agronomically useful variety is possible through back crossing.

In view of its immense practical value, there arises a necessity to understand more about the mechanism of male sterility and the possible cellular changes associated with it. So, one cannot over look the need for enhancing the knowledge of the structural features of the phenomenon of male sterility which include the histological events of microsporogenesis.

The present investigation therefore, was undertaken, with the following objectives:

- Assessment of genetic diversity among *Capsicum annuum* L. genotypes revealed by RAPD markers
- Genetic variability studies among *Capsicum annuum* L. genotypes for morphological and yield related traits
- To understand the nature of inheritance of pigmentation and other morphological characters in chilli genotypes.
- Comparative study of anatomical and histological basis of resistance of chilli genotypes to thrips and mites
- To study histological basis of male sterility in chilli VN2 lines.