CHAPTER 1

INTRODUCTION

Ginger (*Zingiber officinale* Rosc., family Zingiberaceae), is an important commercial crop in tropical and subtropical countries. It is a perennial herb, grown annually for its spicy underground rhizomes or stems. The plant has fibrous roots emerging from the branched rhizomes. The rhizome produces closely grouped, unbranched pseudostems which are aerial shoots. Being a vegetative plant, ginger is asexually propagated from portions of the rhizome. The flowers of ginger are usually sterile and found to hardly set seed. The inflorescence arises directly from the rhizome on separate shoots and bear pale yellow with purple flowers.

Ginger is used all over the world as a spice or fresh herb, home remedy, condiment, flavouring agent in candies, beverages, liqueurs, ice cream, baked goods. It is used in food, cosmetic and pharmaceutical industries. It is also used particularly in traditional medicines of India (Lawrence 1984; Selvan et al. 2002) to cure several ailments like nausea, motion sickness, migraine, dyspepsia, and even to reduce flatulence and colic (Mowrey and Clayson 1982; Grontved et al. 1988; Borrelli et al. 2005). In 100 gm of ginger, approximately 9 gm protein, 6 gm fiber, 116 gm calcium, 71 gm carbohydrate and 147 IU of Vitamin A is found (Farrell 1999). The ginger rhizome is reported to contain various biologically active compounds such as gingerol, shogaol, ginger protease, capsaicin and several sesquiterpenes like zingiberol, zingiberenol (Tang and Eisenbrand, 1992).
Cultivated ginger originated in India or Southeast Asia (Ravindran et al., 1994). Ginger has been grown in India and China since ancient times. It was introduced into Europe in the ninth century AD and was brought to the Mediterranean region from India by traders during the 13th century (Lawrence, 1984). The most well-known true gingers - *Zingiber officinale*, is native to Southeast Asia, China, the Indian Subcontinent, and New Guinea. The genus *Zingiber* Boehm., with about 141 species, is distributed throughout tropical Asia, Australia and South Pacific with its centre of diversity in Southeast Asia (Theilade, 1999; Sabu, 2006). In Thailand, 25 species have been reported (Larsen, 1996) and in the Flora of China, 26 species have been reported and around 42 species have been computed (Theilade, 1999; Wu and Larsen 2000). In India, the genus *Zingiber* is represented by 17 species with 7 endemics of which four species are endemic to peninsular India, two species to North East India and one species to Sikkim Himalaya (Sabu et al., 2009). Today ginger is found to be grown in most warm parts of the world. Globally, the main producers of ginger are India, China, Nepal, Nigeria and Thailand (FAOSTAT, 2014).

In India, Kerala State ranks first in terms of area planted and total production (Selvan et al., 2002). About 60% of the area under ginger cultivation is in Kerala, which accounts for 25% of the country’s production. The area under ginger in North East region is 33.2 thousand ha which gives total production of 191 thousand tonnes at an average yield of 5.8 t/ha against national productivity of 3.5 t/ha (Basic Statistics of NER, 2002). Assam ranks first in ginger acreage as well as in production but productivity was highest in Mizoram, followed by Arunachal Pradesh, Assam and Nagaland (Rahman et al., 2009).
Ginger is also one of the most promising spice crop grown in North Eastern India. There are several cultivated types of ginger available in the region, which are named after the localities where they are grown. Certain indigenous types namely Maran, Bhola and Jorhat Local of Assam have been reported to be equally good in rhizome yield as well as in size. Dry ginger recovery of these varieties has been found to be even better than exotic type Rio-de-Janeiro. The pungency in ginger is due to
gingerol, which is found highest in Meghalaya Local genotype (medium size) and suitable for export purposes. In Mizoram, local varieties namely Thingpui, Thingaria and Thinglaidum are grown at large scale. In Meghalaya, in addition to local types namely Meghalaya Local and Tura Local, considerable area has been brought under selected type Nadia. It is estimated that more than 50% of the national production ginger comes from the North Eastern States.

This commercially important crop species faces serious diseases caused by various organisms such as fungi species like *Fusarium* spp, *Rhizoctoniasolani* and *Pythium* sp., bacterial pathogens and parasitic nematodes. In India rhizome rot and yellows caused by *Fusarium oxysporum* f. sp. *Zingiberi* is a serious threat to this crop during storage and under field conditions (Stirling, 2004). *Fusarium oxysporum* f. sp. *Zingiberi* being the cause of rhizome rot disease has been reported (Haware and Joshi, 1973), (Trujillo, 1963) and (Sharma and Dohroo, 1990). More than 87% transmission rate of *Fusarium* through rhizomes in Himachal Pradesh is reported (Dohroo, 1989). Infected plants are stunted in growth, the leaves get yellowed, the shoots dry out gradually and the plant finally dies. Infection is associated with wounds or insect and nematode damaged tissue. Small, brownish, irregular, water-soaked patches specifies *Fusarium* rot over the rhizomes (NARI, 2004) while white mycelium is observed over the infected areas (Cherian, 2002). It is found to be the most aggressive pathogen and the disease is controlled by chemicals such as Carbendazim, Indofil M-45 and Copper oxychloride to some extent.
A temperature range of 15°C to 30°C accompanied by high humidity is responsible for the development of the disease caused by *Fusarium* (Sharma and Jain, 1978). Infection by *Fusarium* yellow is difficult to control as the fungus grows saprophytically in the absence of the host and is carried in infected rhizomes. The fungus also produces chlamydospores which are resting structure in the decomposing tissues of infected rhizomes. Therefore, tissues from infected crops remaining in the field infecting the soil. The fungus can stay in the soil for many years once infected by *Fusarium* yellow. Therefore, ginger harvested from fields contaminated with the *Fusarium* yellows fungus may be infected and the fungus continue to destroy the rhizome tissues.

Resistance breeding in ginger is restricted to germplasm screening as it is an obligatory asexual crop (Ravindran et al. 2005). Conventional breeding methods for selection of disease resistant varieties are lengthy and cumbersome. However, genetic improvement, the most desirable method of disease management, has been so far limited in ginger. As a result ginger cultivars available today are highly susceptible to *Fusarium* yellow. Again, since ginger is an obligatory asexual species (Hooker 1894), propagated exclusively through its rhizomes, gene introgression through sexual crossing is impossible. Consequently, no effort has been made to systematically evaluate the wild relatives of ginger for *Fusarium* wilt resistance.

Progress reported in somatic hybridization (Fock et al., 2000; Collonnier et al., 2001; Tek et al., 2004), functional genomics (Yamazaki and Saito 2002) and transgenic approaches (Punja, 2007; Song et al., 2003) suggests that there is a possibility of
broadening the genetic base of ginger through these non-traditional molecular approaches. A suitable donor for *Fusarium* yellow resistance is required. So, wild genetic resources of ginger needs to be accessed for the transgenic improvement of ginger. Resistance gene candidates (RGCs) seems to hold much promise to investigate features of resistance-related loci in ginger for its genetic improvement. Therefore, in this study the *Zingiber* spp. found in the Northeastern region of India is screened for RGCs, characterized and its expression analysed. The RGCs could be used for the transgenic improvement of the crop in future and also can be used for marker development so that potential crops could be screened for its resistance to disease caused by *Fusarium* spp.
Considering the above facts, the present programme was designed to carry out isolation, characterization and expression analysis of *Fusarium* RGCs from *Zingiber* spp. of North-East India under the following objectives.

**Objectives of Research**

1. To collect the various *Zingiber* species from North-Eastern India for screening of *Fusarium* resistance gene candidates
2. To isolate *Fusarium* resistance gene candidate (RGC) using degenerate primers from the collected *Zingiber* spp.
3. To sequence and perform sequence analysis of the derived sequences of gene for *Fusarium* resistance
4. To characterize the *Fusarium* resistance gene isolated
5. To perform expression analysis of the gene using bioinformatic tools and compiling of findings