PREFACE
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Coffee is one of the most important agricultural commodities in world trade. Coffee plants are now grown in about eighty countries in four continents and about fifty countries export coffee. Arabica and Robusta are the most important cultivated coffee varieties. Arabica Coffee (*Coffea arabica* L.) is indigenous to the high lands of Ethiopia and Boma plateau in Sudan. In both these areas coffee forests still occur naturally at 1370-1830m above MSL (Wrigley, 1988). Kaffa province of Ethiopia is considered to be the original habitat of arabica. The Arabs grew coffee under irrigation in the province of Yemen for many years. Central Africa is regarded as the place of origin of robusta coffee, *Coffea canephora* Pierre ex. Froehner. Chevalier (1929) has recorded that coffee was first cultivated in Arabia during the fourteenth century and nowhere else until the 17th century.

There are some legendary stories about its discovery and use. Most interesting among them is the tale of the Arabian goatherd, Kaldi. He found his animals dancing and cavorting after consuming fruits and branch tips of certain bushes. Kaldi tasted the fruits and was so refreshed and greatly stimulated as to dance along with his goats. The knowledge about this stimulating plant was imparted to a monk of the nearby monastery in Mecca. From there it spread to other parts of the world (Welman, 1961).
COFFEE IN INDIA

According to legend, a Muslim pilgrim, Baba Budan, introduced arabica coffee into India during 1600 AD. He is reported to have brought seven seeds from Yemen, presumably Mocha coffee and raised seedlings on his hermitage, Dattatreya Peeta, on the hills near Chikmagalur (Anonymous, 1956). Coffee seedlings gradually came to be planted in the backyards and gardens of most of the neighboring villages especially in Atigundi. It is from these gardens that seedlings were introduced to Nalaknad in Kodagu, which subsequently gave rise to the luxuriant Kodagu plantations of today.

Coffee occupies a place of pride among plantation crops grown in India. Cultivation of this stimulating beverage crop is mainly confined to the southern states of Karnataka, Kerala and Tamil Nadu. It is also grown to a small extent in Andhra Pradesh, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Sikkim and Tripura forming the non-traditional belt.

Arabica and robusta are the two types of coffee cultivated on a commercial scale. The area under coffee is around 3,48,995 ha of which arabica and robusta account for 48% and 52% respectively (Anonymous, 2003). The annual average production is around 2,80,000 M.T., a share of 4.54% of the world production. Seventy-five per cent of the produce is exported annually.
The total coffee area is distributed among 1,56,811 holdings of which 60% come under the small grower sector (< 10 ha). Coffee industry provides livelihood to about 5.5 lakhs people in India (Anonymous, 2003). Coffee cultivation is instrumental in preserving the precious forest ecosystem in traditional areas while in the non-traditional areas coffee was introduced to check the 'podu' or 'shift' cultivation and thus to control denudation of forest and also soil erosion.

Coffee cultivation is confined mostly to the hilly tracts of Western and Eastern Ghats, receiving a well-distributed annual rainfall, which is preferable for coffee. Major coffee growing areas, which experience Southwest monsoon, are in Karnataka and Kerala. It is also grown in areas, which receive the Northeast monsoon as in Tamil Nadu, Andhra Pradesh and Orissa.

THE COFFEE PLANT

Coffee belongs to the genus Coffea of the family Rubiaceae. There are more than 70 species under the genus Coffea, most of which are native to Africa including two species viz., Coffea arabica L. and Coffea canephora Pierre ex. Froehner, which are commercially cultivated. Coffea liberica is also cultivated to a small extent. The other related species like C. bengalensis Heyne ex Roem &
Shult, *C. wightiana, C. travencorensis* White and Arn., etc., are native to India but are of not much economic importance.

**Coffea arabica** L.

It is a small tree and it looks like a shrub or even a bush under training. The leaves are dark green. Flowers are white, pentamerous, situated in the axils of leaves. Generally cultivated at higher elevations, under the canopy of permanent and temporary shade trees.

**Coffea canephora** Pierre ex. Froehner

It is a bigger tree than arabica with broader and larger pale green leaves. Flowers are white, fragrant and generally pentamerous. Cultivated at lower elevations, with less shade. Adequate blossom showers are required for good yields.

**Research support**

The ravages of the leaf rust disease and stem borer led to the demand for conducting systematic research on coffee in India. The Mysore Coffee Experimental Station was established in the year 1925, which later came to be known as the Central Coffee Research Institute under the Coffee Board, a statutory body under the administrative control of the Ministry of Commerce and
Industry, Government of India. Successful development of integrated management practices against the dreaded disease, *Hemileia vastatrix* B. & Br. and the stem borer and better agronomic practices helped in improving the production from 18,893 tonnes in the 50s to about 3,00,000 tonnes in the new millennium.

**PESTS OF COFFEE**

Coffee is a perennial plant, subject to attack by passing as well as sedentary pests. Though over a hundred species of insects, a few other invertebrates and mammals have been recorded as pests on coffee in India, only a few of them are of economic importance. Among coffee pests, insects form the major group. Almost all portions of coffee plants are susceptible to attack by one pest or the other.

The white stem-borer *Xylotrechus quadripes* Chevrolat, coffee berry borer *Hypothenemus hampei* Ferrari, Shot-hole borer *Xylosandrus compactus* Eichhoff, Mealybugs *Planococcus citri* Risso and *P. lilacinus* Ckll., Green scale *Coccus viridis* Green and root-lesion nematode *Pratylenchus coffeae* Zimmermann are the major pests recorded on coffee in India.
The Brown scale *Saissetia coffeae* Walker, Tailed mealybug *Ferrisia virgata* Ckll., Coffee bean beetle *Araecerus fasciculatus* Degeer, Cockchafers or white grubs *Holotrichia* spp., Hairy caterpillars *Eupterote* spp., Red borer *Zeuzera coffeae* Nietner, Snail *Ariophanta solata* Benson, Thrips *Heliothrips haemorrhoidalis*, *Retithrips syriacus*, *Scirtothrips bispinosus*, *Thrips nilgiriensis* have been recorded on coffee but are of minor importance (Anonymous, 1998).

**Coffee white stem borer, Xylotrechus quadripes Chevrolat**

The white stem borer is the most serious pest of arabica coffee in the country. This pest was first recorded in India during 1838 from Mysore district of Karnataka (Stokes, 1838). The female beetles deposit eggs in the cracks and crevices and under the loose scaly bark of the main stem and thick primaries. The hatched out young grub feeds on the corky portion just under the bark for about two months and later enters in to the hard wood. Feeding of the grubs just below the bark causes a reaction on the plant in the form of ridges. The infested plants show external ridges around the stem. The grub feeds on the wood, tunneling in a zigzag manner, which hinders the conductance of food and water thereby causing debility. Such plants may also exhibit signs like yellowing and wilting of leaves, which will be distinct after the onset of the monsoon when the healthy plants start putting forth new growth. The young plants withstand the attack for a few
seasons yielding more of floats, about 15 to 24 % (Anonymous, 1994). When the borer tunneling is concentrated at the collar region it is easy to break of the plants at the ground region. The attack by this pest results in debility and death of the plants thereby causing significant crop loss apart from incurring capital expenditure on replanting. If the loss of plants, on an average, is placed at five plants per acre per annum a total number of 20,40,250 plants could be lost in the whole arabica area (area =1,70,000ha) in India. This amounts to a loss of about 1686 acres of arabica every year and about 6,74,400kg of coffee every year (Anonymous, 2003a). This shows the potential of this pest to cause heavy economic losses if it is not checked by adopting timely control measures.

The IPM measures recommended by the Research Department are well adopted by the planting community. In the changing world scenario there is a need to develop better strategies with lesser dependence on chemical pesticides for the management of this pest.

The study on the biology of any pest gives us a better understanding about the pest and its behaviour, which would assist in evolving new strategies against the pest. With this view, an attempt was made to study the biology of coffee stem borer. The first chapter of this thesis, deals with the studies carried out on the biology and discusses the results obtained.
Continuous use of insecticides may lead to development of resistance in the pest, pest resurgence and toxicity to non-target organisms due to residual effects. At present application of Lindane @ 1300 ml in 200 liters of water is recommended for the control of coffee white stem borer. It is an organochlorine compound having long residual toxicity and continuous use, particularly on a perennial crop like coffee may eventually lead to poisoning of the ecosystem. It is better to have alternate insecticides, which are less toxic and have no residual toxicity. Thus studies were undertaken to evaluate new insecticides against the stem borer and the results of the same are presented and discussed in the second chapter.

Even though evaluation studies were conducted by using new pesticides, biological control is the best method for the management of the pest. No serious attempt on biological control of the stem borer has been done in India. Though the control exerted by the indigenous natural enemies is negligible, their role in population regulation cannot be ignored. Due to its concealed nature the stem borer larva is not subject to attack by many natural enemies. However, a few parasitoids and pathogens have been recorded on stem borer from India (Anonymous, 1976, 1984, Prakasan et al., 1986, Shylesha et al., 1992, Veeresh, 1993, Venkatesha et al., 1997). During January 2001 a single female of a wasp,
*Apenesia* sp. (Hymenoptera: Bethylidae), which is a parasitoid of the stem borer, was collected (Anonymous 2001). For the first time, it was possible to successfully multiply this wasp in the laboratory and make field releases.

A detailed study on the biology of this parasitoid has been conducted and a method evolved to rear this parasitoid in the laboratory. The results of the studies on the biology, rearing technique, field release and parasitism are discussed in the III chapter.