Chapter 9

The effect of IDM (Integrated Disease Management) on the crop in terms of productivity.

9.1: Introduction

Tea {Camellia sinensis (L.) O. Kuntze} belonging to the family Theaceae is a plantation crop and the plant lends itself well for the manipulative treatments (Manivel, 1999). It is a C₃ plant following Rubisco metabolism (Roberts and Keys, 1978). Tea plant has adapted well to the different terrain and climatic conditions. Similarly the plant has responded in a variety of ways to the inputs as incentives for the innovative attempts of the researchers (Barua and Wight, 1959; Dutta, 1964; Dutta and Grice, 1966; Magambo and Cannell, 1981). Productivity of tea plantations has improved by leaps and bounds all over the World during the past three decades. Factors affecting shoot production and architecture of the bush under plucking have been reviewed by Jain and Tamang (1988). Worlds total tea production in 2007 was 3.527 million tones and the total area under cultivation is around 5 million hectares (Saravanakumar et al., 2007). Tea agriculture and production is mostly performed in the underdeveloped and developing countries of the World. Production is realized on an average by 25 countries with more than 1500 tea varieties (Guleubuk et al., 2003). India is the largest producer (0.95 million tons) as well as the consumer (0.79 million tons) of tea in the World. In India increase in the tea cultivation area is recorded in due course but it showed a downward trend in its production and export (Annonymous, 2009). The Tea plantation industry has passed through difficult times since 1999 when average price realization in the auction centers fell sharply leading to losses across industry and closure of several tea estates in North and South India. Fortunately the situation has improved from 2008. Tea production in 2010 have seen a sharp decline to around 960 million kgs due to adverse weather conditions and virulent pest and disease attacks. However, the tea production has shown increasing trends during the year 2011-2012 financial year (Annonymous, 2012). Over the years, productivity of the plant has been decreasing and one of the reasons for this has been attributed to the continuous use of huge quantities of chemicals in tea plantations.
(Chakraborty et al., 2012). Hence, there is a pressing need in tea industry for utilizing either biological products or reducing the use of chemicals by supplementing with biological products in integrated management practices. The purpose of the present study was to evaluate the potential of different fungicides, plant extracts and fungal biocontrol agents isolated from the phyllosphere and environment (aeromycoflora) of tea plantation on tea growth (productivity) in the experimental field of the tea plantation area.

9.2: Materials and methods

Field experiments were carried out in Mechipur division (section 9) of Rosekandy Tea Estate to evaluate the effect of fungicides, biocontrol agents and plant extracts on the growth and productivity of tea {Camellia sinensis (L.) O. Kuntze}. The experimental plots were made in randomized block design (RBD). A total of 510 bushes were selected for the study. To these sixteen different treatments (i.e. chemicals, plant extracts and microorganism broths) were applied. A control plot was also maintained where only water was sprayed. The experiment was maintained in triplicate. Growth of the tea bushes was evaluated following the method described by Chakraborty et al., 2006. The growth promotion was studied in terms of productivity, chlorophyll content of the leaves, no of shoots and size of the foliage, length of the plucked shoots etc. of the bushes exposed to different treatments.

9.2.1: Evaluation of plant growth

Plant growth was evaluated in terms of length of the plucked shoots, size of the foliage and no of shoots recovered after every spray at an interval of 10 days. The length of the shoots and size (length and breadth) was measured with the help of a caliper. Emergence of new shoots was counted after plucking from the experimental plots and it was converted to the number of bushes per hectare.
9.2.2: Estimation of chlorophyll content

The extraction and estimation of chlorophyll content (mg/ml) of leaf was done according to Mahadevan and Sridhar (1986). Leaf sample of 0.02 g was put into test tubes having 5 ml Dimethyl sulfoxide (DMSO). Then the tubes were kept in boiling water bath at 65°C for half an hour. Absorbance was taken at 645 and 663 nm wavelength. Following calculation was used to determine the chlorophyll content with different treatments.

\[
\text{Chl a} = (12.7 \times \text{OD 663}) - (2.69 \times \text{OD 645}) \times \frac{V}{a} \times 1000 \times W
\]

\[
\text{Chl b} = (22.9 \times \text{OD 645}) - (4.68 \times \text{OD 663}) \times \frac{V}{a} \times 1000 \times W
\]

\[
\text{Total Chl} = (20.2 \times \text{OD 645}) + (8.02 \times \text{OD 663}) \times \frac{V}{a} \times 1000 \times W
\]

\[a = \text{absorbance path} = 1 \text{ cm}
\]

\[V = \text{solution amount}
\]

\[W = \text{weight of the leaf}
\]

9.2.3: Evaluation of productivity

Productivity of the bushes sprayed with different treatments was evaluated by weighing the pluckable shoots, after every treatment. Productivity per plot was calculated and the weight of the plucked shoots was converted to weight in hectares of that experimental plots.

9.3: Results

Aqueous solution of nine pesticides (in different concentrations), aqueous plant extracts of two allelopathic plants and the broth suspension of five antagonistic fungi were sprayed in 30 healthy bushes per plot separately.

Amongst the plant extracts, the tea bushes sprayed with the aqueous extract of *Chromolaena odorata* stimulated the development of new flush. After the 4\(^{th}\) round of spray, the number of shoots was recorded to be 68 per bush i.e. 33011.6 in 1 hectare (ha), while the bushes sprayed with *Ipomea carnea* exhibited only 37 shoots i.e.
18076.6, which was comparatively lower than the control in which only water was sprayed (table 9.1).

Productivity was recorded before and after the treatment of the bushes with the plant extracts. Before treatment the production of pluckable shoots was 88609.5 kg/ha which increased up to 112776.1 kg/ha during the treatment. After the last round of spray i.e. 4th spray in duration of 28 days the yield was observed to have increased every week. The data was recorded every week up to 6th week from the date of the last spray. The yield recorded was maximum, which went up to 217500 kg/ha. Comparatively, *Ipomea carnea* also gave a positive result in which the productivity had risen up to 201385.6 kg/ha, while in the bushes where only water was sprayed (control) the yield was recorded to be the lowest i.e. 177219 kg (table 9.2).

In terms of chlorophyll content, the leaves of the bushes where the aqueous extracts of *C. odorata* was sprayed, chl a (0.483) was recorded to be the highest so was chl b (0.918), whereas in the leaves of the bushes sprayed with *I. carnea* the chlorophyll content was recorded to be 0.318 and chl b was 0.415 respectively. In the plots where only water was sprayed the chl a content was 0.151 and chl b content was 0.154. The production of higher yield in the plots sprayed with *C. odorata* may be attributed to the higher chl a and b content in their leaves.

In terms of the size of the 3rd leaf of the plucked shoots, the length and breadth of the same was recorded to be the highest i.e. 4.16 cm and 2.15 cm respectively compared to those sprayed with *I. carnea* and control. It can also be observed that with more number of sprays the size of the foliage increased. This indicates a positive response of the treatments. Also the length of the plucked shoots reached to a length of 3.99 cm in *C. odorata* treated plots, while the length was recorded to be a minimum of 3.52 cm in *I. carnea* treated plots and it was moderate in the control i.e. 3.93 cm.

The number of shoots was recorded to be the highest in the bushes treated with the broth medium inoculated with $1 \times 10^8$ conidial suspension of *Trichoderma citrinoviride*, while the number of shoots harvested after 28th days of foliar spray with *T. atroviride* treated bushes was 33775.3 and that sprayed with *A. niger, Penicillium*
*Janthenellum* and *A. flavus* were 32335, 29773.3 and 23296.3, respectively. The control plots recorded 29483.3 no of shoots in 1 ha.

Maximum yield of 27776.1 kg/ha was recorded from the experimental plots sprayed with the broth of *T. atroviride*, *T. citrinoviride* which gave a yield of 209442.8 kg/ha, while *A. niger* recorded 209442.8 kg/ha. Minimum yield was recorded by *A. flavus* which was lower than the control i.e. 161109.5 kg/ha. Moderate yield of 241666.6 kg/ha was recorded in the plants treated with *Penicillium janthenellum*.

The shoots plucked from the plots treated with the broth culture of *A. niger* was reported to exhibit higher length value i.e. 3.93 cm followed by *T. atroviride* and *T. citrinoviride* (3.8 cm), while minimum length was exhibited by *Penicillium janthenellum* treated plants.

Amongst the plots sprayed with different broth culture of the antagonists, chl a, b and total chl content was found to be higher in the leaves sprayed with both the *Trichoderma* sp. followed by *A. niger* and *A. flavus*.

The length and breadth of the 3rd leaf of the pluckable shoots was found to be 4.27 cm and 1.82 cm respectively in *A. niger* treatment, while *T. atroviride* was observed to exhibit 4.26 and 2.44 cm length respectively. The least length and breadth was exhibited by the shoots plucked from the control plots.

Amongst the nine fungicides used, the plots sprayed with hexaconazole recorded 31030 number of shoots/ha which was comparatively higher considering all the other fungicidal treatments (table 9.11). However, the length of the plucked shoots recorded from the plots sprayed with the same fungicide gave the result of 3.87 cm, which was found to be lower compared to the other treatment with the chemicals. The highest length of the plucked shoots was recorded from those sprayed with copper oxychloride (Blitox). After every spray with a duration of 7 days, there was gradual increase in the length of the shoots (table 9.12). Moderate length of shoot result was observed in the plots sprayed with Captan, Tetraconazole, Tebuconazole and Mancozeb.
Tetraconazole gave higher yield in terms of productivity i.e. 241666.6 kg/ha followed by Mancozeb (209442.8 kg/ha), Tebuconazole (201385.6 kg/ha) and Saaaf (201385.6 kg/ha). Productivity was recorded before and after the treatment of the bushes with the plant extracts. Prior to the foliar spray the yield was 241666.66 kg/ha in the plots sprayed with Tetraconazole, amazingly it increased upto 241666.6 kg/ha. Control plots gave yields of 177219 kg/ha as compared with Captan and Hexaconazole sprayed plots.

However the size (length and breadth) of the foliage was recorded to be highest in the bushes sprayed with Mancozeb (4.28 cm and 2.44 cm) followed by the systemic fungicide Tebuconazole (4.28 cm long and 2.01 cm wide) and copper fungicide (4.28 cm and 2.01 cm).

The results of the chlorophyll content was found to be higher in the bushes sprayed with Hexaconazole i.e chl a content was 0.237 mg/ml, chl b was 0.151 mg/ml and total chl 0.388 mg/ml followed by Tebuconazole where the chl a content was found to be 0.164 mg/ml, chl b to be 0.149 mg/ml and total chlorophyll content to be 0.314 mg/ml. The control plots recorded the lowest chlorophyll content compared to all the other experimental plots sprayed with different fungicides.

9.4: Discussion

The plant diseases are required to be controlled to maintain the level of yield both quantitatively and qualitatively. Plant diseases need to be controlled to maintain the quality and abundance of food, feed, and fiber produced by the growers around the world. Different approaches are used to prevent, mitigate or control the plant diseases. From the work done in the present study, it can be said that, among the plant aqueous extract treatments, of *Chromolaena odorata* stimulated the development of new flush in the tea bushes. The yield recorded was higher in *Chromolaena odorata* sprayed bushes, recording 217500 kg/ha. Comparatively, *Ipomea carnea* also gave a positive result in which the productivity rises upto 201385.68 kg/ha, while in the bushes sprayed with water only (control), the yield was recorded to be the lowest i.e. 177219 kg/ha. In terms of chlorophyll content, the leaves of the bushes where the aqueous extracts of *C. odorata* was sprayed, chl a (0.483) was recorded to be the
highest so was chl b (0.918), whereas in the leaves of the bushes sprayed with *I. carnea* the chlorophyll content was 0.318 and chl b was 0.415 respectively. In terms of the size of the 3rd leaf of the plucked shoots, the length and breadth was recorded to be the highest i.e. 4.16 cm and 2.15 cm respectively in the bushes treated with *C. odorata* compared to those sprayed with *I. carnea* and control. It was also noticed that with more number of sprays the size of the foliage increased.

The number of shoots was recorded to be the highest in the tea bushes treated with $1 \times 10^8$ /ml conidial suspension of *Trichoderma citrinoviride* while the number of shoots recorded after 28th days of foliar spray with *T. atroviride* treated bushes was 33775.3 and that sprayed with *A. niger*, *Penicillium janthellum* and *A. flavus* were 32335, 29773.3 and 23296.6 respectively. Maximum yield of 25776 kg/ha was recorded from the experimental plot sprayed with the aqueous suspension of *T. atroviride*, while *T. citrinoviride* treatment gave a yield of 241666 kg/ha and *A. niger* recorded 209442 kg/ha. The shoots plucked from the plots where the aqueous suspension of broth culture of *A. niger* was reported to exhibit higher length value i.e. 3.93 cm followed by *T. atroviride* and *T. citrinoviride* (3.8 cm), while the minimum length was exhibited by *Penicillium janthellum* treated plants. Amongst the plots sprayed with different broth culture suspension of the antagonists, chl a, b and total chl content was found to be higher in the leaves sprayed with both the *Trichoderma* sp. followed by *A. niger* broth suspension and *A. flavus*. The length and breadth of the 3rd leaf of the pluckable shoots was found to be 4.27 cm and 1.82 cm respectively in *A. niger* while *T. atroviride* reported to exhibit 4.26 and 2.44 cm respectively. The least was recorded from the shoots plucked from the control plots.

Amongst the nine fungicides used, the plots sprayed with hexaconazole furnished 31030 number of shoots, which was comparatively higher than all the other fungicide treatments (table 9.11). However, the length of the plucked shoots recovered from the plots sprayed with the same fungicide produced shoot length of 3.87 cm, which was lesser compared to the other remaining chemical treatments. The highest length of the plucked shoots was recovered from those sprayed with copper oxychloride (Blitox). Tetraconazole gave higher yield in terms of productivity i.e. 241666 kg/ha followed by Mancozeb, Tebuconazole and Saaf. Productivity was recorded before and after the treatment of the bushes with plant extracts. Prior to the foliar spray the yield was 50
kg in the plots sprayed with Tetraconazole, amazingly it increased upto 241666 kg/ha. Control plots gave similar yields of 161109.5 kg/ha as compared to Captan and Hexaconazole sprayed plots. However the size (length and breadth) of the foliage was recorded to be the highest in the bushes sprayed with Mancozeb (4.28 cm and 2.44 cm) followed by the systemic fungicide Tebuconazole (4.28 cm long and 2.01 cm wide) and the contact fungicide, copper fungicide (4.28 cm and 2.01 cm). The results of the chlorophyll content was found to be higher in the bushes sprayed with Hexaconazole i.e chl a content was 0.237, chl b was 0.151 and total chl 0.388, followed by Tebuconazole showing the chl a content to be 0.164 mg/ml, chl b as 0.149 mg/ml and total chlorophyll content as 0.314 mg/ml. The control plots recorded lower chlorophyll content compared to all the experimental plots sprayed with different fungicide solutions.

A report on the moringa extract has shown increased growth and yield of tomato in both greenhouse and field. *Moringa* extract significantly increased the above ground dry matter yield (DM), root dry matter weight and plant height of the treated tomato plant (Mvumi et al., 2012). The leaf extracts of *Zizyphus jujuba* and *Ipomoea carnea* inhibited the mycelial growth of *Rhizoctonia solani in vitro*, and effectively reduced the incidence of sheath blight disease in rice (Sateesh et al., 2011). The biocontrol agent in crop protection and pest management will have the prospective to enhance crop yield quality and quantity (Oyekanmi et al., 2008). Ganesan et al., (2007) reported that the application of native micro-organisms *Rhizobium* and *Trichoderma harzianum* successfully decreased the stem rot incidence and also increased the growth and yield of the groundnut plants. Pre-infectional application of tebuconazole against *Fusarium* wilt of Wheat was found to be superior to application carried out during the post-infection period. Selective fungicide treatment saved yield, thousand grain weight and kernel numbers per head (Homdork et al., 2000). Treating faba bean plants with plant extracts (*Ipomoea carnea, Cuminum cyminum, Allium sativum* and *Hyoscyamus naticus*) and microbioagents (*Streptomyces exfoliates* and *Trichoderma harzianum*) improved most tested growth criteria as well as plant productivity and seed yield (Yehia et al., 2004).

Wilson et al., 2005 reported that programmes of four to six sprays, using two or three fungicides carbendazim+flusilazole, epoxiconazole, iprodione + thiophanate-methyl,
tebuconazole and vinclozolin with different modes of action, applied alternately, reduced smoulder by 35–69% and increased the bulb yield of *Gladiolus* sp by 7–59%. Subhedar *et al.*, (2006) reported that plants treated with *A. niger* achieved a height of more than 40 cm, while the control attained the height of 30 cm in the same period. Kundu and Gaur (1980a, b) have reported increase in yield of cotton and wheat owing to *Aspergillus* treatment. Nagaraju and Najundappa (1996) have also reported increase in yield of cowpea owing to *Aspergillus* treatment. Subhedar and Padwa (2003) studied the effects of *A. niger* on the soybean and found that the total number of pods present per plant in 20 ppm were 14, in 40 ppm were 28 and in 60 ppm were 10 in the stipulated period (i.e. 62 days) while control was in flowering stage only.

The inoculation with *Azospirillum brasilense* increased the number of harvested grains of wheat by 6.1% and grain yield by 260 kg ha$^{-1}$ (8.0%) (Martin and Maria, 2009). Arunakumara *et al.*, 2010 reported maximum yield of tomato in plots sprayed with 0.1 % propiconazole followed by 0.25 % mancozeb.

Some experimental results revealed the effectiveness of plant extracts (*Chromolaena*, Garlic, * Ocimum and Jatropha*) and benomyl against *Cercospora* leaf spot which drastically reduced the intensity of the disease by 7.1% to 8.64% and induced significantly better agronomic traits that increased yield of sesame by 40.7% and 38.22% over the untreated check (548.66 kg ha$^{-1}$ and 551.04 kg ha$^{-1}$) (Nahunnaro and Tunwari, 2012). Fungicide application reduced leaf disease severity and increased yield, kernel weight, test weight, and kernel plumpness, while decreasing dockage and thins of barley crop (Turkington *et al.*, 2012).

The highest percentage increase in plant height, number of leaves, number of branches and stem girth (130.6, 865.0, 220.4 and 114.0%, respectively) was observed in untreated *Corchorus + Celosia*, cypermethrin treated *Corchorus + Amaranthus*, cypermethrin treated *Corchorus* and *Azadirachta indica* extract treated (Cor + Ama) plants, respectively. The highest percentage increase in shoot weight (71.0%), marketable yield (53.9%) and total biomass (51.5%) was observed in *Azadirachta indica* treated *Corchorus olitorius* (Adeyela and Thomas, 2013).