SUMMARY AND CONCLUSION
In order to identify the hot spot for foot rot (Quick wilt) disease of black pepper in malnad regions of Karnataka, stratified random survey on the disease incidence was conducted during 2002-2003 in major coffee based pepper plantations, namely Chikmagalur, Hassan and Kodagu districts by selecting two major pepper growing taluks in each districts as identified by the district Department of Horticulture of Karnataka State. The surveyed data revealed that average disease incidence in the whole of malnad region on black pepper was found to be 13.72 per cent and the incidence ranged from a minimum of 7.6 per cent to a maximum of 18.62 per cent. In the present study, the maximum disease incidence was recorded at 30.67 per cent in Maggalamakki which was closely followed by 30.42 per cent in Beejuvalli areas of Mudigere taluk of Chikmaglur district. Similarly, disease incidence was recorded at 29.39 per cent in Bettageri and 27.16 per cent in Sharambani coffee based pepper plantations in Madikeri taluk of Kodagu district. Whereas, the least incidence of this disease was recorded at 3.93 per cent in Gendehalli area in Belur taluk of Hassan district which was followed by 4.10 per cent in Madapura and 4.15 per cent in Shanivarasanthe areas of Somvarpet taluk of Kodagu district. Hence, these areas were identified as hot spot for foot rot disease in black pepper.

In the present investigation an attempt was made to estimate actual yield loss due to foot rot disease in surveyed areas where maximum and minimum incidence was recorded at random in each taluks on a total of 300 pepper vines at the rate of 50 vines. Accordingly, the data indicated that on an average yield loss
of 1.42% (0.12 kg) per vine with 13.72 per cent disease incidence in the whole of malnad regions. But maximum loss of 7.34 % (0.65 kg) per vine in Maggalamakki and 5.04 % (0.52 kg) per vine in Beejuvalli area of Mudigere taluk of Chikmagalur taluk was estimated. But similar situation prevailed in Madikeri taluk of Kodagu district where the loss in yield was found to be maximum at 4.28 % (0.30 kg) per vine in Sharambani and 3.94 % (0.29 kg) per vine in Bettageri areas. But the least loss in yield of 0.04 % (0.003 kg) per vine was recorded in Madenerlu area of Chikmagalur taluk of Chikmagalur where the plantations were taken care regularly against the disease.

However yield loss per hectare was estimated to an account of 92 kg with an economic loss of Rs. 19,200, which is quite significant, and need proper and timely care of the pepper vines in the plantations to avoid loss.

The yield loss was estimated by taking the parameters like number of infected spikes per vine, number of infected berries per spike and weight of 100 dry berries in the surveyed plantations. Besides, studies were also conducted in the observational trial in farmers field at Gonibeedu area of Mudigere taluk during 2004 by imposing the best five treatments such as Ridomil MZ-72WP (1.25 g/1 - 5 l/vine), Aliette-80WP (2.5 g/1 - 5 l/vine), Akomin-40SL (4 ml/1 - 5 l/vine), *Trichoderma harzianum* (75 g/vine) and combined treatment of Ridomil MZ + Akomin + bio-control agent with untreated check. There treatments were imposed during pre and post monsoon period i.e., April - May and August to September. After the care taken through integrated approach, the avoidable loss was estimated to an extent of 7.88 per cent with 25 per cent spike infection. However, the maximum 75.7 per cent loss was recorded in 71-100 per cent spike infection.
infection, which indicates that the scope for proper and timely measures to avoid loss due to foot rot disease.

Study was conducted on the role of epidemiological parameters that are favouring the development and spread of foot rot disease in black pepper. The data correlated with disease incidence and it was observed that the temperature ranging from 18.6 to 22.5°C coupled with 95 per cent relative humidity and well distributed rainfall supported for maximum disease development. However, during two years of study, the incidence of disease was found to be maximum in the month of August, which was positively correlated with RH-I and RH-II, rainfall and number of rainy days. However, relation between the incidence of disease with maximum temperature was found to be significantly negative.

Study conducted during 2003-04 and 2004-05 indicated that the average maximum disease incidence was recorded to an extent of 28.6 per cent which was coupled with higher rainfall of 496.22 mm and RH-I and RH-II (95 and 75%) in 2003 - 04. Whereas with 24.5 per cent disease incidence at a maximum of 490.3 mm rainfall and with RH-I and RH-II (94 and 85 %) during 2004-05. This study proved that better and effective management practices could be evolved based on these epidemiological parameters and it certainly helps for forecasting the disease incidence at least by the season ahead in particular geographical area.

Integrated management for foot rot disease was conducted by imposing a total of 15 treatments either single or in combination and evaluated for 2 years. It revealed that combined treatment of soil application of bio-control agents *Trichoderma harzianum* (75 g/vine), spraying and drenching with Ridomil MZ-72WP (1.25 g/l) and Akimin-40SL (4 ml/l) was found best in reducing the
disease. However, the other treatments like spraying and drenching with Ridomil MZ or Aliette or soil application of bio-control agent with panchagavya (2-3 l/vine) was also found better in reducing the disease incidence.

In the present study use of indigenous technologies which are followed locally like panchagavya used either alone or in combination with commercial formulation of bio-control agent (*Trichoderma harzianum*) which have performed better in brining down the disease incidence by supporting the growth and development of pepper vines were tested as these materials provide resistance. In 2003-04 field studies application of panchagavya alone recorded 2.44 kg dry berries vine with 82.37 per cent increased in yield over control. During 2004-05 field studies per cent increase in yield was more than 50 in treated fields. Thus, application of panchagavya alone or in combination with bio-control agent twice during April to May and August to September were found to be the effective management practices, which could also be recommended. This simple technology is easy, economical and environmentally safe for adoption by the farmers. In 2003-04 field trail maximum yield was recorded in the treatment combination of *Trichoderma harzianum* + Ridomil MZ + Akomin to an extent of 91.2 per cent increase in yield over control, followed by Ridomil MZ alone with 91.07 per cent. The other combined effect of *Trichoderma harzianum* and panchagavya and Allitite alone was also performed better in the integrated management strategies. In 2004-05-field trail also maximum yield was recorded in the combined treatment as that of 2003-04 trial with 77.22 per yield increase over control which was followed by Ridomil treatment which has increased yield upto 76.74 per cent over control. Hence, the present investigation identified that treating the pepper diseased vines with *Trichoderma harzianum* + Ridomil +
Akomin or Ridomil or Allitte or Akomin alone or in combination with bio-control agent and panchagavya found to be an effective measures in the integrated disease management programmes.

Observational trial in farmers field by selecting 6 best treatments revealed that the combined treatment of soil application with *Trichoderma harzianum* + Ridomil MZ + Akomin was found as best treatment in reducing the disease incidence and this was followed by Ridomil MZ or Akomin or the combined treatment of bio-control agent and panchagavya.

In case of yield in the observational trial study indicated that highest yield of 6.67 kg/vine was recorded in the combined treatment with 77.82 per cent increase in yield over control. Whereas, the single treatment increased yield over control to an extent of 76.93 per cent.

Thus, based on the two years study in the integrated disease management trial and one year observational trial in the farmers field combined application of bio-control agents, spraying and drenching with Ridomil MZ and Akomin can be recommended as best management package for foot rot disease in black pepper in malnad regions of Karnataka.

5.2. Conclusions and Recommendations for further studies

Mudigere of Chikmagalur and Madikeri of Kodagu districts were identified as hot spots for foot rot disease in coffee based pepper plantations, where dense vines with heavy shade creating forest trees as standards provide microclimate conditions for the development and spread of pathogen - *Phytophthora capsici* as compared to other locations of malnad regions of Karnataka.
Karnataka. Hence, it is recommended that preliminary base line survey has to be conducted before treating the vines so that it helps in need based control measures.

The epidemiological parameters like high rainfall (490.32 to 496.2 mm), number of rainy days (22 to 27) and temperature ranging from (18.6 to 22.5°C) coupled with high relative humidity (85 to 95%) are the inducing factors for foot rot disease development and spread in coffee based pepper plantations.

Combined application of bio-agent (*Trichoderma harzianum*) 75g/vine + spraying and drenching with Ridomil MZ-72WP (1.25g/l - 5 l/vine) + Akomin-40SL (4 ml/l to 5 l/vine) were found best in reducing foot rot disease in black pepper and to increase 91.2 per cent yield over the control. Besides, spraying and drenching with Ridomil-MZ or Aliette (2.5 g/l to 5l/vine) alone or combined application of bio agent and panchagavya have also capable of reducing the disease incidence by giving host resistance to the pepper vine.

Even meager loss of berries results in more loss to the grower in terms of money value Rs. 19,200 per hectare. It is quite high and care must be taken to protect the vines from disease attack. So it is recommended to follow the following integrated management practices without treating the vines only with chemicals.

Destruction of dead vines along with root system and drenching the spot with any chemicals recommended eradicating the source of inoculum in pepper plantations after harvest of crop in February-March.
Shade regulation every year during April-May in order to allow more sunlight and to avoid high humidity. Pruning of runner shoots, as they are first victim to disease attack from the soil inoculum and spreads upto the vine vertically. Application of lime at the rate of 1 to 2 kg/vine once in two years as it alters the pH in acidic condition and also suppresses spore germination during wet condition.

Removal and destruction of infected and fallen plant debris like leaves, laterals, spikes as they serves as sources of inoculum for the next season. Mulching the base either with legume crops/green grass/dried leaf litters at the base to regulate temperature and moisture during summer and to avoid more moisture and also run off with inoculum to other places during monsoon period.

Providing proper drainage in the plantation to avoid water stagnation as the pathogen develops during wet condition. Application of antagonistic pathogens along with organics to take care of the pathogen multiplications in the root zone of the plants. Application of organics like Farm Yard Manure, compost and vermicompost around the plant every year to develop host resistant against the pathogen.

Avoiding injury to aerial root system, as they are liable to attack by the pathogen. Avoiding movement of stray cattle’s as they carry inoculum from place to place. Drenching the soil and vines with recommended fungicides during pre and post monsoon periods.

In order to achieve better success in plant disease control, profile of the pathogen has to be studied to detect and destroy the weak point at early stage. Successful management strategy lies in early detection of disease symptoms and
arranging to tackle the same before it reaches to the mischief or economic threshold level. Research studies have to be conducted in farmer fields to develop confidence in the minds of farming community than conducting research at the Institute level.

Farmer's education in all respect of crop production technologies is the first and foremost aspect in present days. Hence, farmers have to be educated before cropping season starts and at frequent intervals during the season to tackle any problem coming across, so that increase in yield per unit area is not at all a problem for growing population in country as a whole.

This may be last but not the least for any successful plant disease management strategies, in my strong opinion that principles behind plant disease management should not be missed or over looked. Hence, it is absolutely essential to follow the principles like exclusion, eradication, protection and immunization for an excellent success.