CHAPTER V

CONCLUSIONS
• Based on the FAO methods of plant disease assessment, a new scale is developed to assess the brown spot disease severity on field crop. Brown spot severity is found to be higher in certain pockets of KLS region, covering Periyapatna, H.D. Kote, Arkalgud and Hunsur Taluks which receive high rainfall during monsoon and soils with relatively high organic matter or clay content. Sollepura farm of the CTRI Research Station, Hunsur, is identified as a 'hot-spot' area for brown spot disease.

• Early (May) planted FCV tobacco crop escapes brown spot severity due to the absence of favourable weather factors for sufficient number of days during its harvest period. Crop planted later in the season invariably gets exposed to brown spot epiphytotics due to the availability of more number of days with favourable weather factors for disease, coinciding with the harvest period during September and October.

• Crop age also plays an important role in brown spot disease development. Brown spot severity increased with increase in age of the crop. At around 74 DAT, the crop is more vulnerable for the attack by brown spot pathogen.

• For the three popular FCV tobacco varieties of KLS region, brown spot disease progress curves (DPCs) are developed, which clearly show that in early planted crop, the rate of spread of the disease is slow as compared to late planted crop. The pattern of DPCs are determined largely by the local weather conditions and age of the crop. The shift from nearly stationary disease development to an exponential curve occurred early in late planted crops and it took a relatively longer period for middle and early plantings.

• A set of meteorological factors influencing initiation and spread of brown spot disease are identified. Increase in number of wet nights i.e., nights with precipitation either in the form of rain or dew, increase in sunshine hours per day and decrease in day time RH, during September and October months, are identified as 'critical factors' influencing the spread of the disease and subsequent damage to the leaf harvested during that period.
• The brown spot disease prediction equations developed through multiple regression analysis (MRA) further confirmed the role of above mentioned meteorological factors in the disease development. Values of partial regression coefficient indicated that brown spot severity is negatively correlated with day time RH and positively correlated with wet nights and sunshine hours per day. These values have high degree of contribution in MRA equations. The values of coefficient of determination ($R^2$) accounted for variation of around 90 per cent in brown spot PDI.

• A total of six stages are identified in the development of brown spot, commencing from the water soaked lesion of pin head size and ending with 'shot-hole' appearance. From stage one to stage four, there is a steady increase in conidial production. Stage three and four are identified as acute stages of infection in terms of secondary inoculum production in the post-inoculation period.

• Among the three major nutrients, N has a significant effect on brown spot incidence as higher levels of N predispose the plants to brown spot disease. So, special attention should be given to N application in brown spot endemic regions. K deficiency aggravates disease severity. So, application of adequate quantity of potassium (80 kg/ha) in two split doses is essential to limit the damage. Unlike N and K, P has less significant effect on brown spot severity. Phosphorous should be applied in sufficient quantity along with potassium (in split doses) and optimum nitrogen for the effective management of brown spot disease.

• The host range studies confirmed that common weeds of tobacco field, viz., Cassia occidentalis, Crotalaria calycina, Crotalaria mucronata, Cyperus sp., Euphorbia pulcherrima and Trianthema decandra act as collateral hosts for Alternaria alternata.

• Infected tobacco stubble are found to be better source for the pathogen's survival than the dried, infected leaf trash. The pathogen survived in these residues for 14 and 10 months, respectively, when buried in soil to a depth of 15 cm. Irrespective of type of crop residue, the fungus survived for longer period (22 to
26 months) and produced more conidia when stored in laboratory. Though a gradual decrease in the extent of survival and perpetuation capacity is noticed with time, the infected crop residues play a vital role as primary source of inoculum for the following season. Healthy crop residues as well as cured tobacco from infected leaf did not indicate any survival of the pathogen.

- **Higher levels of root-knot infection predispose the plants to brown spot infection.** In FCV special, a variety susceptible to both brown spot and root-knot, the overall incidence of brown spot increased with increase in root-knot infection. But under epiphytotic conditions, all the plants are equally susceptible to brown spot disease irrespective of their root-knot infection levels. In a brown spot resistant variety like Beinhart 1000-1, there was no break down of resistance by root-knot infection.

- **Yield and quality parameters of tobacco are adversely affected by the brown spot disease.** With the increase in spotted area of leaf, reduction in yield of green leaf, total cured leaf and bright grade is more. Important chemical and physical constituents of cured leaf are also altered. As the disease severity increased, nicotine content increased and reducing sugars decreased drastically. EMC also decreased and filling value increased as compared to healthy tobacco. These adverse effects in turn affected the market value of tobacco, leading to economic loss. In seed crop, besides these effects, brown spot disease caused severe reduction in seed yield.

- The disease can cause complete loss in yield of FCV tobacco at a particular harvest, if congenial weather conditions for the disease exist with the susceptible stage of crop growth.

- The leaf extracts of *Lawsonia inermis*, *Leucas aspera*, *Ocimum sanctum*, *Thevetia peruviana* and *Azadirachta indica* are effective in inhibiting the mycelial growth of the fungus, indicating presence of highly fungitoxic active principles in them. The leaf extract of *Thevetia peruviana* is effective even at lower concentration.
The findings help in the development of non-chemical and eco-friendly management schedule for Alternaria diseases.

- 12 fungicides are found promising by inhibition of either mycelial growth or conidial germination. They are Baycor, Bayleton, Beam, Cuman L, Foltaf, Indofil M 45, Punch, Raxil, Ridomil MZ, Score, Thiram and Tilt. Among them, Indofil M 45, Ridomil MZ, Score and Tilt are most effective in mycelial inhibition, and Foltaf, in arresting the conidial germination.

- Tilt, Score, Foltaf and Indofil M 45, in that order, are effective in controlling the brown spot and minimising the economic loss. They are more effective under timely harvest conditions. Their efficacy reduced under delayed harvest conditions, more so in protectant fungicides, Foltaf and Indofil M 45. For economic efficiency, Tilt and Indofil M 45 are better than Foltaf. A six spray schedule where sprays are given soon after each harvest gave best disease control but maximum net returns and ICBR are obtained with five sprays at 60, 70, 78 DAT and other two soon after subsequent harvests.

- Among the 375 entries of Nicotiana tabacum screened under epiphytotic conditions, Beinhart 1000-1 and L 1128 (SR) are identified as resistant donors for brown spot disease resistance breeding programme. The previously released varieties for KLS region are highly susceptible but the pipeline variety, K 326 (NLS-4), is moderately tolerant to brown spot. The other pre-release variety, FCH 6534, is moderately susceptible.

- Recessive genes, possibly duplicate, non-allelic gene action may be involved in brown spot resistance in the variety, Beinhart 1000-1.

- These studies have helped in developing a comprehensive brown spot management strategy, which is being proposed by CTRI for FCV tobacco farmers of KLS region. The strategy in a nutshell is presented here.
COMPREHENSIVE BROWN SPOT MANAGEMENT STRATEGY FOR KLS REGION

- Use strictly the certified seed only
- Raise nurseries early (first fortnight of March) and take up early plantings (May/first week of June)
- Ensure complete removal and destruction of crop residues like stalks and leaf trash or avoid fields having past history of disease epiphytotics
- Avoid fields with heavy / humus soils and K deficient soils in zones endemic to the disease
- Also, strictly avoid root-knot sick soils for raising the crop
- Use healthy seedlings, free from root-knot infection
- Monitor nitrogen nutrition and avoid excessive N application
- Ensure application of K @ 80 kg/ha in two splits
- Keep the fields and immediate surroundings absolutely weed-free
- Never allow matured leaves to over-ripe by delaying the harvests
- Harvest at a faster rate if high disease spread is noticed
- Cultivate the variety, K 326, in zones endemic to brown spot disease
- Under favourable conditions, in zones endemic to brown spot, spray Tilt @ 0.1% or Indofil M 45 @ 0.3%, depending on disease pressure
- Intensified sprays should be given during interrupted wetting period