VI. SUMMARY AND CONCLUSIONS

1. All together 17 isolates of *Fusarium oxysporum* f.sp. *cubense* (E. F. Smith) from Maharashtra and Karnataka States of India were tested for their sensitivity to benomyl. There was variation in MIC of benomyl among the isolates on both the agar plates and on banana plant. MIC on agar plates ranged from 1µg/ml to 400µg/ml while it was 25µg/ml to 100 µg/ml on banana plant.

2. Culturing of sensitive *Fusarium oxysporum* f.sp. *cubense* isolate (FOC-4) on benomyl continuously for eight successive passages significantly increased the resistance. Use of benomyl alternately with carbendazim and kocide decreased resistance of the pathogen at 4th and 6th passage, while benomyl with mancozeb increased resistance in FOC-4 benomyl sensitive isolate.

3. Inoculation of *Fusarium oxysporum* f.sp. *cubense* on banana plant continuously for eight successive passages increased the benomyl resistance. But treatment of benomyl alternately with carbendazim and kocide protected the infection by *Fusarium oxysporum* f.sp. *cubense* at 6th passage. Use of benomyl in mixture with carbendazim protected infection at 5th passage followed by kocide and mancozeb at 6th and 7th passage of the pathogen on banana plant.

4. Benomyl when used in mixture with carbendazim, kocide and mancozeb reduced benomyl resistance in *Fusarium oxysporum* f.sp. *cubense*.

5. Treatment of EMS and SA gave 30 and 21 benomyl resistant mutants. Resistance factor ranged from 01 to 12. Mutants having high resistant factor showed high growth rate and all mutants persistent for benomyl resistance.

6. Resistant mutants showed higher infection percentage on banana plant when compared with wild sensitive *Fusarium oxysporum* f.sp. *cubense* (FOC-9)
isolate. EMS treatment gave highly resistant mutant (EMS-FOC-9) having MIC 600 µg/ml on agar plates and 400 µg/ml on banana plants.

7. There was highly significant increase in the growth of both the benomyl resistant and sensitive isolates on the carbohydrate sources except lactose.

8. Nitrogen sources such as sodium nitrate, ammonium nitrate, magnesium nitrate, potassium nitrate, peptone and calcium nitrate were used. Growth of the resistant isolate was higher than the sensitive isolate. Maximum growth of pathogen was observed on potassium nitrate and calcium nitrate in case of sensitive and resistant isolates respectively. As well as minimum growth of pathogen was observed in ammonium nitrate and sodium nitrate, in case of both sensitive and resistant isolates.

9. There was significant variation in the growth of Fusarium oxysporum f.sp. cubense isolates at various incubation periods and between the phosphate sources. Resistant and sensitive isolates showed maximum growth on ammonium dihydrogen orthophosphate and ammonium phosphate diabasic. sodium biphosphate was inhibitory to the growth of both isolates of Fusarium oxysporum f.sp. cubense.

10. Growth of resistant strain was found to be always higher than the sensitive one. Growth of sensitive and resistant isolates was completely inhibited by iron sulphate and zinc sulphate also slightly inhibited growth of both the isolates. Growth of sensitive and resistant isolates was maximum on calcium sulphate followed by magnesium sulphate, ammonium sulphate, barium sulphate and potassium sulphate.

11. Potassium chloride was more inhibitory to both sensitive and resistant isolates. Growth of both the isolates on salts i.e. magnesium chloride, sodium chloride and calcium chloride was maximum as compared to control.
12. All vitamins favour the growth of both sensitive and resistant isolates. All the vitamins increased the growth of the fungus over non-vitamin control.

13. There was maximum growth of sensitive and resistant isolates on manganese. Growth of sensitive and resistant isolates was completely inhibited on magnesium while boron also inhibited growth of both the isolates.

14. There was significant variation in the growth of the resistant and sensitive isolates on different amino acids. All the amino acids favour the growth of the sensitive and resistant isolates.

15. Banana plant infected with resistant isolate of *Fusarium oxysporum* f.sp. *cubense* showed reduction in total sugar, reducing sugar, DNA, RNA, starch, total ash, calcium, magnesium, iron, manganese and zinc when compared with healthy banana plant.

16. It was observed that benomyl with fungicides (Captan, Ridomyl and Roko), insecticides (Dunet, Dantotsu and Monosaan), herbicides (Krizin, Dhanuka, Mera-71 and Kleen-80), antibiotics (Streptomycin, Cefotaxime, Penicillin and Carbenicillin), salts (Potassium chloride, Sodium chloride, Calcium chloride, Ferric chloride and Magnesium chloride), fertilizers (Urea, Phosphate, Muriate of Potash and DAP(18:46:00)) and micronutrients (manganese, iron and zinc) inhibited the growth of resistant isolate which indicates reduction in the benomyl resistance *in vitro*.

17. *In vivo* studies indicated that all the agrochemicals when mixed with benomyl also prevented the infection of pathogen to banana plants.

18. Physical factors such as pH, temperature and various light colour indicated that resistant isolate had higher growth at pH 6.5 and at the temperature of 25°C than the sensitive one. Sensitive and resistant isolates showed their maximum growth under yellow light. It was seen that there was always higher
growth of resistant isolate than the sensitive at all temperature. Both isolates failed to grow at 10°C.

19. On the benomyl untreated banana plant resistant population in the mixture was reduced from passage to passage. On the contrary the benomyl treated banana plant, the population of resistant isolate was increased from passage to passage. Thus the benomyl treatment to plant imposed such a selection pressure on the population that only resistant population is able to survive at the fourth passage indicating it is more fit for its survival in the mixed population.

20. *Trichoderma pseudokoningii* showed maximum inhibition of sensitive and resistant isolates. It was effective in controlling growth of *Fusarium oxysporum* f.sp. *cubense* causing Panama wilt of banana.