CHAPTER VI

SUMMARY AND CONCLUSION

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A field experiment was conducted at the Horticulture Experimental Farm, College of Agriculture, Central Agricultural University, Imphal during the period of March to November in 2007 and 2008 to study the growth and productivity of ginger (*Zingiber officinale* Rosc.) as influenced by crop variety and biofertilizer. Two experiments were conducted – one on crop variety (Experiment no.1) and the other on biofertilizer (Experiment No. 2). The first experiment was laid out in randomized block design with four ginger varieties ('Manipur local', 'Bhaisey', 'Gorubathan' and 'Nadia') in five replications and the second experiment was also conducted in randomized block design with three biofertilizers (*Azotobacter, Azospirillum* and *Phosphotica*) each at three levels (2.50, 3.75 and 5.00 kg ha^{-1}) along with a common control in three replications. Altogether there were 28 treatment combinations in the second experiment. The results obtained from the investigation have been presented and discussed in details in the previous chapters. The findings are summarized in this chapter to have a valid conclusion.

5.1 Effect of variety

The ginger variety showed positive and significant effect on improving almost all the growth attributes recorded under the study during both the years. The growth attributes of ginger such as sprouting time, plant height, number of shoots per clump, number of leaves per clump, canopy spread, leaf area index, dry matter accumulation and crop growth rate were influenced markedly by the crop variety and the variety 'Bhaisey' showed superiority in most of the cases, but were closely followed by 'Gorubathan'. 'Manipur local' showed very poor performance in respect of most of the growth attributes which were comparable to those of 'Nadia' in most instances under study.

The variety also significantly influenced the yield attributes, yield and quality of ginger. The rhizome growth, rhizome bulking rate, rhizome productivity and crude fibre content in rhizome varied markedly among the varieties. In term of rhizome growth, 'Bhaisey' recorded the maximum rhizome weight, but was followed by 'Gorubathan' at all the growth stages during both the years. It produced higher weight of rhizomes than that of

'Manipur local' which produced the lowest rhizome weight and was comparable to that of 'Nadia' under study. 'Bhaisey' also recorded the highest rhizome bulking rate (24.7 and 24.1g m^{-2} day^{-1} during the period of 90-150 DAP in 2007 and 2008 respectively) which was significantly greater than that of all other varieties. The other varieties did not differ much in rhizome bulking rate among them in both the years. The highest rhizome yield in term of g $clump^{-1}$ (234 and 231 g $clump^{-1}$ in 2007 and 2008 respectively) and t ha^{-1} (20.51 and 20.41 t ha^{-1} in 2007 and 2008 respectively) was produced by 'Bhaisey' and was closely followed by 'Gorubathan' (222 g $clump^{-1}$ and 18.92 t ha^{-1} in 2007 and 219 g $clump^{-1}$ and 19.33 t ha^{-1} in 2008). 'Manipur local' produced the lowest rhizome weight (211g $clump^{-1}$ and 16.45 t ha^{-1} in 2007 and 208g $clump^{-1}$ and 17.23 t ha^{-1} in 2008 respectively).

The harvest index, oleoresin content and specific gravity of rhizome did not vary among the varieties but, dry matter content and crude fibre content in rhizome varied greatly among the varieties. The highest dry matter content was recorded in 'Bhaisey' (20.4%) followed by 'Gorubathan' (19.7%) which was significantly higher than 'Nadia' (18.2%) and 'Manipur local' (17.4%). 'Manipur local' contained the highest crude fibre in its rhizomes (7.52%) and was closely followed by 'Bhaisey' (6.75%). Both the varieties recorded significantly higher percentage of crude fibre in rhizomes than that of 'Nadia', which contained the lowest crude fibre in its rhizomes (5.09%) comparable to that of 'Gorubathan' (5.75%).

5.2 Effect of biofertilizer

Use of biofertilizer at different levels exhibited significant effect on growth attributes like sprouting of rhizome, plant height, number of shoots per clump, number of leaves per clump, canopy spread, leaf area index, dry matter accumulation and crop growth rate over control during both the years. Seed treatment with high dose (5.00 kg ha^{-1}) of *Azotobacter* showed significant improvement of all the growth attributes over their lower levels. Similarly, seed treatment with medium dose (3.75 kg ha^{-1}) of both *Azospirillum* and *Phosphotica* caused marked increase in all of these growth attributes at most of the growth stages over those of their higher and lower levels during both the years. The sprouting of rhizome, however, did not vary much among the different levels of *Phosphotica* during both the years under the study.

Biofertilizer seed treatment also showed positive effect on influencing yield components like rhizome growth and rhizome bulking rate that ultimately influenced the rhizome yield over control plots during both the years. The highest value of all these yield attributes and yield was found in crop having the highest level (5.0 kg ha^{-1}) of *Azotobacter* treatment which was highly superior to those obtained under its lower levels. The medium level (3.75 kg ha^{-1}) of both *Azospirillum* and *Phosphotica* treatment also showed markedly greater yield and yield components as compare to its high and low levels at most of the growth stages during both the years. The harvest index, however, did not vary much among the different biofertilizer treatments during both the years under the study.

The N, P and K contents in rhizome increased markedly over control due to the seed treatment with different biofertilizers. It was further observed that seed treatment with *Azotobacter* increased N content in both rhizome and shoot; but it did not increase P and K contents in rhizome and shoot of this crop. Use of *Azotobacter* for seed treatment at higher level (5.0 kg ha^{-1}) significantly increased the N content in rhizome and shoot over that of its lower level (2.5 kg ha^{-1}) only. The seed treatment with *Azospirillum* at different levels did not influence the N, P and K contents in rhizome and shoot of this crop. The seed treatment with *Phosphotica* at medium level (3.75 kg ha^{-1}) significantly increased the P contents in both rhizome and shoot over those of its higher (5.0 kg ha^{-1}) and lower (2.5 kg ha^{-1}) levels. But it had no effect on N and K contents in rhizome and shoot of ginger.

Application of high level of *Azotobacter* (5.0 kg ha^{-1}) increased N, P and K removal by rhizome, shoot as well as total removal by the crop over those of its lower levels (3.75 and 2.50 kg ha^{-1}) during both the years. The seed treatment with medium dose (3.75 kg ha^{-1}) of *Azospirillum* and *Phosphotica* also had marked effect on increasing the N, P and K removal by rhizome, shoot and total removal by the crop over those of their higher (5.0 kg ha^{-1}) and lower (2.5 kg ha^{-1}) levels.

The seed treatment with different biofertilizers increased the dry matter content, specific gravity and oleoresin content in rhizome over control; but biofertilizer treatment decreased the crude fibre content in rhizome under the study. Application of high (5.0 kg ha^{-1}) and medium (3.75 kg ha^{-1}) dose of *Azotobacter* increased the dry matter, specific gravity and oleoresin content in rhizome over that of its low level (2.50 kg ha^{-1}). But crude fibre content in rhizome decreased with increasing dose of *Azotobacter.* Use of medium dose (3.75 kg ha^{-1}) of *Azospirillum* and *Phosphotica* increased the specific gravity and oleoresin content in rhizome over those of their higher (5.0 kg ha^{-1}) and lower (2.5 kg ha^{-1}) levels. The dry matter content was also increased by the application of medium level of *Phosphotica* over its high and low levels. The crude fibre content in rhizome did not vary much among the different levels of *Azospirillum*; and *Phosphotica*. The highest value of dry matter content (21.3%) was obtained with the combined use of medium dose (3.75 kg ha^{-1}) of *Azospirillum* and *Phosphotica.*

Use of biofertilizers at different levels had no effect on the available N and K contents in soil after two years of the experiment. However, available P content of the experimental soil increased considerably by biofertilizer application over control. The available P in soil increased with increasing the dose of *Azotobacter* treatment. Use of medium level (3.75 kg ha^{-1}) of both *Azospirillum* and *Phosphotica* increased the available P content of the experimental soil over their higher (5.0 kg ha^{-1}) and lower (2.5 kg ha^{-1}) levels. Inspite of 10.0 t ha^{-1} FYM used per year, a slight decrease in available N content and a sharp decrease in available K content of the experimental soil from its initial values were noticed after two years of ginger cultivation.

The results showed significant increase in gross return, net return and return per rupee invested on ginger cultivation due to seed treatment with different biofertilizer over control. But the cost of cultivation did not differ much due to biofertilizer treatments over control. Seed treatment with high dose of *Azotobacter* increased the gross return (Rs 218741/- ha^{-1} in 2007 and Rs 214281/- ha^{-1} in 2008) over that of its medium (Rs 201622/- ha^{-1} in 2007 and Rs 194996/- ha^{-1} in 2008) and low (Rs 194166/- ha^{-1} in 2007 and Rs 187352/- ha^{-1} in 2008) levels during both the years. The net return and return per rupee invested followed a similar trend. High dose of *Azotobacter* treatment paid maximum profit (Rs 157227/- ha^{-1} in 2007 and Rs 153213/- ha^{-1} in 2008) and return per rupee invested (2.56 in 2007 and 2.51 in 2008) which were significantly greater than those of its medium and low doses. The low dose of *Azotobacter* treatment paid the lowest gross return (Rs 194166/- ha^{-1} in 2007 and Rs 187352/- ha^{-1} in 2008), net return (Rs 134830/- ha^{-1} in 2007 and Rs 128697/- ha^{-1} in 2008) and return per rupee invested (2.27 in 2007 and 2.19 in 2008) indicating its less efficiency in ginger productivity. *Azospirillum* and *Phosphotica* also exerted significant effect on gross return, net return and return per rupee invested in ginger cultivation. The gross return from ginger cultivation increased due to the application of medium dose of both the biofertilizers over their high and low levels. The net return and return per rupee invested followed a trend similar to that of gross return during both the years. Application of medium dose of both the biofertilizers (*Azospirillum* and *Phosphotica*) paid markedly higher net return and return per rupee invested over their high and low levels.

Combined use of *Azotobacter* and *Phosphotica* showed significant interaction effect on influencing most of the growth attributes, yield attributes and yield of this crop among all other interaction effects. The highest values of most of the growth and yield parameters were recorded with the combination of high level (5.0 kg ha^{-1}) of *Azotobacter* with medium level (3.75 kg ha^{-1}) of *Phosphotica* which was significantly higher than those obtained with other treatment combinations except the combinations of high level of *Azotobacter* with other levels of *Phosphotica* in most of the cases. This treatment combination ultimately produced the highest rhizome yield (22.06 t ha^{-1} in 2007 and 22.09 t ha^{-1} in 2008) which was markedly higher than that obtained with most of the other treatment combinations. Application of low level (2.50 kg ha^{-1}) of both the biofertilizers produced the lowest values of these parameters as compare to those of the other treatment combinations at most of the growth stages. This treatment combination produced the lowest rhizome yield (18.12 t ha^{-1} in 2007 and 17.62 t ha^{-1} in 2008) under the study.

The interaction effect of only *Azotobacter* and *Phosphotica* was found significant on influencing the N, P and K removal by rhizome, shoot and total N, P and K removal by the crop. The highest N, P and K removal by rhizome, shoot and total removal by the crop was recorded with combined application of high level *Azotobacter* along with medium level of *Phosphotica.* This treatment combination removed significantly higher N, P and K than those obtained with all other treatment combinations except the combinations of high level of *Azotobacter* with other levels of *Phosphotica*. Use of low dose (2.50 kg ha^{-1}) of both *Azotobacter* and *Phosphotica* recorded the lowest N, P and K removal by rhizome, shoot as well as total N, P and K removal by the crop and was markedly lower than those of most of the other treatment combinations used in this study.

The combined use of *Azotobacter* and *Phosphotica* exerted significant interaction effect on gross return, net return and return per rupee invested in ginger cultivation during both the years. The highest gross return (Rs 220745/- ha^{-1}), net return (Rs 158630/- ha^{-1}) and return per rupee invested (2.55) in ginger cultivation were recorded with the application of high level of *Azotobacter* along with medium level of *Phosphotica*. This treatment combination paid significantly higher gross return, net return and return per rupee invested in ginger cultivation than those obtained with most of the other treatment combinations. The lowest gross return (Rs 178450/- ha^{-1}), net return (Rs 121220/- ha^{-1}) and return per rupee invested (2.09) were obtained with combined use of low level of both *Azotobacter* and *Phosphotica*.

6.3 Conclusion

From the above results it may be concluded that crop variety and use of biofertilizer at appropriate dose play an important role on influencing the growth and productivity of ginger. The variety 'Bhaisey' recorded markedly higher growth and yield attributes that ultimately helped in producing higher crop productivity than those of 'Nadia' and 'Manipur local'. 'Gorubathan' also showed better performance comparable to that of 'Bhaisey'. Use of *Azotobacter* seed treatment with 5.0 kg ha^{-1}, *Azospirillum* 3.75 kg ha^{-1} and *Phosphotica* 3.75 kg ha^{-1} improved most of the growth attributes, increased yield components and yield of rhizome, improved crop quality like specific gravity, oleoresin and crude fibre content of rhizome. These treatments also enhanced N, P and K contents in rhizome and shoot, recorded higher removal of N, P and K through both rhizome and shoot as well as greater total N, P and K removal and paid higher return as compared to those of the other treatment combinations. The control plots receiving no biofertilizer showed very poor performance. Use of biofertilizer improved the P status of the experimental soil; but it had effect on improving the N and K status of the soil. Biofertilizer also helped in improving the quality of rhizome. Combined application of high level of *Azotobacter* along with medium level of *Phosphotica* was found the best treatment combination which improved growth and yield attributes of ginger and ultimately recorded markedly higher productivity (22.08 t ha^{-1}) of the crop. This treatment combination removed significantly higher N, P and K from the soil and paid the highest gross return (Rs 220745/- ha^{-1}), net return (Rs 158630/- ha^{-1}) and return per rupee invested (2.55) in ginger cultivation.