CHAPTER VI

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK
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SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH WORK

There has been a wrong notion that pulse crops are meant for the poor and marginal lands and that they can be grown without much care and inputs. It is true that there has not been a quantum jump in yield of pulses, it can be achieved through the introduction of the crops in non-traditional pulse growing areas with increase in cropping intensity, better utilization of agro-resources and their management. Rajmash is not a common crop for Chhattisgarh agro-climate and cultivation of this crop either after harvest of different rice varieties or after the harvest of soybean or in kharif fallow can pave the way in increasing the land area and productivity through better use of rain water, fertilizer and other management practices.

In the diversification era of agriculture of Chhattisgarh, growing of rajmash or inclusion of rajmash in the existing cropping system would be appropriate to boost up farmers income and fulfills the nation's demand. The present cropping system i.e. rice-lathyrus or rice-linseed or other oilseeds and pulses unable to provide very good remuneration to the farmers. Whereas, under same farming and management practices a remunerating crop like rajmash can be grown successfully to increase farmers income substantially after rice/soybean. Irrigation is the main constraints during rabi season to grow such type of crops under various rice based cropping system.
Under such conditions, proper management of irrigation can pave the way for getting maximum production potential and income. Another important input in the cultivation of rajmash are nitrogen, FYM and zinc, which needs to be investigated to economize their uses. The information on the appropriate dose of FYM, nitrogen and zinc in *Vertisols* to boost the productivity of rajmash will help in formulation of package of practices for rajmash cultivation for this agro-climatic condition.

Keeping the above facts in view, an experiment entitled "Effect of organic and inorganic nutrition on productivity potential, economics and energetic of rajmash (*Phaseolus vulgaris* L.) under *Vertisols* of Chhattisgarh plains" was conducted during the *rabi* seasons of 2004-05 and 2005-06 at the Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (CG). The soil of the experimental field was clayey in texture (*Vertisols*) with low nitrogen, medium phosphorus and high in potassium contents. Climate of the region is dry moist, sub-humid with an average rainfall of 1326 mm. The crop received 135.4 mm and 2.8 mm rainfall during 2004-05 and 2005-06, respectively. During 2004-05, the maximum temperature was 22.0 to 33.4°C and minimum temperature was 9.6 to 16.6°C, while, during 2005-06, the temperatures were 25.8 to 35.9°C and 7.7 to 18.2°C, respectively.

The experiment was laid out in randomized block design with three replications. The treatments consisted of two FYM levels i.e. 0 and 5 t
ha\(^{-1}\), three nitrogen levels i.e. 0, 60 and 120 kg N ha\(^{-1}\) and two zinc levels i.e. 0 and 20 kg ZnSO\(_4\) ha\(^{-1}\).

Rajmash variety 'HUR-137' with a seed rate of 120 kg N ha\(^{-1}\) was sown on November 5, 2004 and November 11, 2005 with a row spacing of 30 cm. Harvesting was done on February 23-26, 2005 and March 02-04, 2006. Observations on plant population m\(^{-2}\), plant height, number of branches, dry matter accumulation plant\(^{-1}\), days to flower initiation, 50% flowering and maturity, dry matter accumulation of pods plant\(^{-1}\), pod and seeds plant\(^{-1}\), number of seeds pod\(^{-1}\), pod and seed weight plant\(^{-1}\), seed and stover yields (kg ha\(^{-1}\)) were recorded and statistically analyzed. The computations and statistical analysis were done for leaf area index, crop growth rate, relative growth rate, chlorophyll content, light interception, light transmission ratio, pod and seed setting index, pod growth rate, relative pod growth rate of pod, productivity rating indices, economic efficiency, production efficiency, energy output-input ratio, energy use efficiency, energy productivity, energy intensiveness, growing degree days and heat use efficiency. Nitrogen, phosphorus and potassium contents and their uptake, content and yield of protein and economics were also worked out. The recorded data were statistically analyzed and tabulated for interpretation of results.
The salient findings are presented as follows:

6.1 Pre-harvest studies

- Plant population at 20 DAS and at harvest was unaffected by the different levels of FYM, nitrogen and zinc during both the years and on mean basis.

- Plant height at 30 DAS remained unaffected by FYM levels during both the years. However, on the basis of mean at 30 DAS, during both the years and on mean basis at 60 DAS, during 2004-05 and on mean basis at 90 DAS and during 2005-06 at harvest, application of 5 t FYM ha\(^{-1}\) gave significantly higher plant height than 0 t FYM ha\(^{-1}\). Whereas, FYM levels could not give significant impact on plant height at 90 DAS during 2005-06 and at harvest during 2004-05 and on mean basis. As regards to nitrogen levels, use of 120 kg N ha\(^{-1}\) produced significantly taller plants than lower levels during both the years and on mean basis. The impact of nitrogen levels on plant height at 60, 90 DAS and at harvest was similar to 30 DAS.

- The number of branches plant\(^{-1}\) increased sharply from 30 DAS to 90 DAS in comparison to 90 DAS to at harvest. At 30 DAS in mean data, at 60 DAS during 2004-05 and in mean data, and at 90 DAS and at maturity during both the years and on mean basis, the
number of branches plant$^{-1}$ was recorded significantly higher than 0 t FYM ha$^{-1}$. Application of 120 kg N ha$^{-1}$ gave significantly higher number of branches plant$^{-1}$ than lower levels of N during both the years and on mean basis at all the stages of observation, however, during 2004-05 at 30 DAS, it remained unaffected. Application of zinc failed to show any significant impact on number of branches plant$^{-1}$ at all the stages of observation.

Application of 5 t FYM ha$^{-1}$ gave maximum LAI in almost every stages during both the years and on mean basis except at 30 DAS during 2005-06, at 90 DAS and at harvest during 2005-06 where it was found non-significant. Nitrogen levels also significantly influenced the LAI at all the stages during both the years and on mean basis. Nitrogen @ 120 kg ha$^{-1}$ produced maximum LAI at all the stages of observations during both the years and on mean basis. In case of zinc levels, non-significant effect on LAI was observed at all the stages of growth during both the years and on mean basis.

The DMA was significantly affected by different levels of FYM and nitrogen at all the stages of observation. However, application of zinc produced significant impact on DMA only at 30 DAS during 2005-06 and at 60 DAS during both the years and on mean basis. The maximum DMA was noted under 5 t FYM ha$^{-1}$ and
under 120 kg N ha\(^{-1}\) at all the stages of growth during both the years and on mean basis. The lowest DMA was noted under no application of FYM, N and Zn.

The maximum CGR values between the periods 30-60 DAS and 60-90 DAS was noted with the highest level of FYM, nitrogen and zinc in comparison to their respective lower levels during both the years and on mean basis. The CGR values at both the period of observations showed increasing trend with the increase in level of FYM, nitrogen and zinc during both the years and on mean basis. However, the lowest CGR value was obtained in no application of FYM, nitrogen and zinc.

The values of RGR between the periods 30-60 DAS and 60-90 DAS showed increasing trends with the increase in the subsequent levels of FYM, nitrogen and zinc during both the years as well as on mean basis. The lowest RGR value was noted under no use of FYM, nitrogen and zinc.

Significantly higher chlorophyll content was recorded under 5 t FYM ha\(^{-1}\) at 65 DAS during 2004-05 and 2005-06 than 0 t FYM ha\(^{-1}\). Application of 120 kg N ha\(^{-1}\) gave significantly higher chlorophyll content in later both the stages of growth during 2004-05, 2005-06 and on mean basis as compared to lower levels.
Whereas, at 55 DAS, significantly higher chlorophyll content was observed with 120 kg N ha$^{-1}$ than other lower levels only during 2005-06.

Application of 5 t FYM ha$^{-1}$, 120 kg N ha$^{-1}$ and 20 kg Zn ha$^{-1}$ had maximum light interception, whereas, no application of FYM, nitrogen and zinc had minimum light interception during both the years and on mean basis. In general, light interception increased from 60 DAS to 80 DAS in all the treatments.

Application of 5 t FYM ha$^{-1}$ showed higher LTR values than 0 t FYM ha$^{-1}$ at both 60 and 80 DAS during both the years and on mean basis. The maximum light interception ratio was noted with 120 kg N ha$^{-1}$ at 60 and 80 DAS and the minimum was noted with 0 kg N ha$^{-1}$ during both the years as well as in mean. Use of 20 kg Zn ha$^{-1}$ gave slightly higher LTR values as compared to 0 kg Zn ha$^{-1}$ during both the years and on mean basis.

Application of 5 t FYM ha$^{-1}$ slightly delayed days to flower initiation and days to 50% flowering, whereas, it could not give impact on days to maturity. Increasing dose of nitrogen slightly delayed days to flower initiation, days to 50% flowering and days to maturity. As regards to zinc application, almost not much impact was noted on days to flower initiation, days to 50%
flowering and days to maturity on the basis of two years average. However, days to flower initiation during 2005-06 and days to 50% flowering during 2004-05 was one day delayed under 0 kg Zn ha$^{-1}$ as compared to 20 kg Zn ha$^{-1}$. On the contrary, days to 50% flowering was one day delayed under 20 kg Zn ha$^{-1}$ than 0 kg Zn ha$^{-1}$ during 2005-06.

FYM @ 5 t ha$^{-1}$ and 120 kg N ha$^{-1}$ accumulated significantly more heat to come to flower initiation as compared to their respective lower levels during both the years as well as in mean. Application of 20 kg Zn ha$^{-1}$ accumulated significantly more heat to come to flower initiation as compared to 0 kg Zn ha$^{-1}$ only during 2005-06. FYM @ 5 t ha$^{-1}$ accumulated significantly more heat to come to 50% flowering than 0 t FYM ha$^{-1}$ only during 2005-06. Nitrogen application interacted significantly for 50% flowering during 2005-06 and on mean basis and for maturity during both the years as well as in mean. Use of 120 kg N ha$^{-1}$ accumulated maximum heat to come to 50% flowering as well as maturity. To come to 50% flowering, 20 kg Zn ha$^{-1}$ accumulated maximum heat during both the years.

The higher dry matter accumulation of pods was recorded in 5 t FYM ha$^{-1}$ as compared to 0 t FYM ha$^{-1}$ at 90 DAS during 2005-06 and at harvest during 2005-06 as well as on mean basis.
DAS and at harvest, use of nitrogen @ 120 kg N ha\(^{-1}\) showed significantly higher dry matter accumulation in pods plant\(^{-1}\) as compared to 0 and 60 kg N ha\(^{-1}\) during both the years and on mean basis.

The pod growth rate between 10-20 DAF was significantly higher in 5 t FYM ha\(^{-1}\) during 2005-06 and in 120 kg N ha\(^{-1}\) and in 20 kg Zn ha\(^{-1}\) during both the years as well as on mean basis as compared to their respective levels. Similarly, between 20-30 DAF, pod growth rate was significantly higher under 5 t FYM ha\(^{-1}\) during 2004-05 and under 120 kg N ha\(^{-1}\) during 2004-05 and on mean basis and under 0 kg Zn ha\(^{-1}\) during both the years and on mean basis as compared to their respective levels. Application of 0 kg FYM ha\(^{-1}\) recorded significantly higher pod growth rate than others during 2004-05 between the period 10-20 DAF and during 2005-06 between the period 20-30 DAF.

The relative growth rates of pods showed the similar trend to that of pod growth rate under different levels of FYM, nitrogen and zinc during both the years and on mean basis. On the contrary to pod growth rate, the relative pod growth rate declined from 10-20 DAF to 30-40 DAF.
6.2 **Post-harvest studies**

- Significantly higher number of pods plant\(^{-1}\) was observed under 5 t FYM ha\(^{-1}\) as compared to 0 t FYM ha\(^{-1}\) during 2005-06 and on mean basis. Use of 120 kg N ha\(^{-1}\) gave significantly higher number of pods plant\(^{-1}\) than rest of the nitrogen levels during both the years and on mean basis. Both the levels of zinc could not produce any significant impact on number of pods plant\(^{-1}\) during both the years and on mean basis.

- Use of 5 t FYM ha\(^{-1}\) recorded significantly higher number of seeds plant\(^{-1}\) than 0 t FYM ha\(^{-1}\) during both the years and on mean basis. In case of nitrogen levels, number of seeds plant\(^{-1}\) was significantly higher under 120 kg N ha\(^{-1}\) as compared to 0 and 60 kg N ha\(^{-1}\) during both the years and on mean basis.

- The number of seeds pod\(^{-1}\) showed non-significant difference due to various levels of FYM, nitrogen and zinc. The maximum number of seeds pod\(^{-1}\) was observed under highest level of FYM, nitrogen and zinc during both the years and on mean basis. On the contrary, the lowest number of seeds pod\(^{-1}\) was observed under no application of FYM, nitrogen and zinc during both the years and on mean basis.
Maximum pod weight plant \(^{-1}\) was observed under 5 t FYM ha\(^{-1}\) during 2004-05 and on mean basis. However, during 2005-06, FYM levels could not give significant effect on pod weight plant \(^{-1}\). Application of 120 kg N ha\(^{-1}\) showed significantly higher pod weight plant \(^{-1}\) as compared to 0 and 60 kg N ha\(^{-1}\) during both the years and on mean basis. Use of zinc produced significant effect only during 2004-05, where 20 kg Zn ha\(^{-1}\) recorded significantly higher pod weight plant \(^{-1}\) over 0 kg Zn ha\(^{-1}\).

Application of 120 kg N ha\(^{-1}\) recorded significantly higher seed weight plant \(^{-1}\) as compared to 0 and 60 kg N ha\(^{-1}\) only on the basis of mean data. In general, increasing trend in seed weight plant \(^{-1}\) was observed due to subsequent increase in levels of FYM, nitrogen and zinc. The highest level of FYM, nitrogen and zinc recorded the maximum seed weight plant \(^{-1}\) during both the years and on mean basis.

Significantly higher 100-seed weight was recorded under 5 t FYM ha\(^{-1}\) than 0 t FYM ha\(^{-1}\) during both the years, however, on the basis of mean, the differences between the FYM levels for 100-seed weight were non-significant. Similar trend was also witnessed in case of nitrogen levels, where application of 120 kg N ha\(^{-1}\) gave significantly higher 100-seed weight during both the years only. Both the levels of zinc could not produce significant
difference for 100-seed weight during both the years and on mean basis.

Use of 5 t FYM ha\(^{-1}\) recorded significantly higher pod setting index as compared to 0 t FYM ha\(^{-1}\) during both the years and on mean basis. Significantly higher pod setting index was noted in 120 kg N ha\(^{-1}\) than others during both the years and on mean basis. Application of 20 kg Zn ha\(^{-1}\) gave significantly higher pod setting index as compared to 0 kg Zn ha\(^{-1}\) during both the years as well as in case of mean data.

Application of 5 t FYM ha\(^{-1}\) recorded significantly higher seed setting index as compared to 0 t FYM ha\(^{-1}\) only during 2004-05 and on mean basis. The seed setting index was observed to be significantly highest under 120 kg N ha\(^{-1}\) and the lowest was noted under 0 kg N ha\(^{-1}\) during both the years and on mean basis. Both the zinc treatments failed to produce significant impact on seed setting index during both the years as well as on mean basis.

Application of 5 t FYM ha\(^{-1}\) gave significantly higher seed yield as compared to 0 t FYM ha\(^{-1}\) during both the years and on mean basis. Use of 120 kg N ha\(^{-1}\) produced significantly higher seed yield than lower levels of N during both the years as well as in mean. The lowest seed yield was recorded under 0 kg N ha\(^{-1}\).
Application of 0 and 20 kg Zn ha$^{-1}$ could not give significant variation in seed yield during both the years of experimentation and on mean basis. Interaction among FYM + nitrogen + zinc was noted to be significant during 2005-06 and on mean basis. Whereas, in 2004-05, non-significant effect was noted due to FYM + nitrogen + zinc. During 2005-06, use of 120 kg N ha$^{-1}$ + 5 t FYM + 20 kg Zn ha$^{-1}$ recorded significantly higher seed yield of rajmash than other treatment combinations, though it was at par to 5 t FYM ha$^{-1}$ + 120 kg N ha$^{-1}$ + 0 kg Zn ha$^{-1}$. On the mean basis, treatment combination 5 t FYM ha$^{-1}$ + 120 kg N ha$^{-1}$ + 20 kg Zn ha$^{-1}$ recorded significantly higher seed yield than other treatment combinations.

The maximum stover yield was obtained under 5 t FYM ha$^{-1}$ and 120 kg N ha$^{-1}$ treatment, which was significantly superior over their other respective levels during both the years and on mean basis. The lowest stover yield was reported under 0 kg N ha$^{-1}$ during both the years. Different zinc levels i.e. 0 and 20 kg Zn ha$^{-1}$ did not give any significant variation in stover yield of rajmash during both the years and on mean basis.

The variation in the values of harvest index (HI) of rajmash remained non significant under different levels of FYM, nitrogen and zinc during both the years as well as on mean basis.
The productivity rating index of 5 t FYM ha\(^{-1}\) remained statistically superior to 0 t FYM ha\(^{-1}\) during both the years as well as in mean data. The highest PRI was obtained under 120 kg N ha\(^{-1}\) during both the years and on mean basis. The PRI did not differ significantly due to both zinc levels during both the years as well as in mean data.

Application of 5 t FYM ha\(^{-1}\) and 120 kg N ha\(^{-1}\) showed significantly higher production efficiency than their respective levels during both the years and on mean basis. The interaction among different levels of FYM, nitrogen and zinc was found to be non-significant.

The maximum economic efficiency was found with no application of FYM, nitrogen and zinc. There was declining trend with higher levels of FYM, nitrogen and zinc during both the years as well as in mean.

Significantly higher HUE in terms of dry matter accumulation was recorded in 5 t FYM ha\(^{-1}\) in comparison to 0 t FYM ha\(^{-1}\) during both the years and on mean basis. Similarly, significantly higher HUE in terms of dry matter accumulation was recorded in 120 kg N ha\(^{-1}\) than lower levels during both the years and on mean basis. The HUE in terms of seed yield was significantly higher under 5 t
FYM ha$^{-1}$ in comparison to 0 t FYM ha$^{-1}$ during both the years and on mean basis.

6.3 Nutrient concentration and their uptake

- Application of 5 t FYM ha$^{-1}$ and 120 kg N ha$^{-1}$ recorded significantly higher N concentration in seed and stover as compared to their respective lower levels during both the years and on mean basis. Significantly higher N content was noted in 20 kg Zn ha$^{-1}$ than 0 kg Zn ha$^{-1}$ during 2004-05 and on mean basis only.

- The total uptake of nitrogen by rajmash was significantly the highest under 5 t FYM ha$^{-1}$, 120 kg N ha$^{-1}$ and 20 kg Zn ha$^{-1}$ during both the years and on mean basis.

- The P concentration in seed of rajmash was significantly influenced by different levels of FYM and zinc only. Significantly higher P content in seed was noted under 5 t FYM ha$^{-1}$ and 20 kg Zn ha$^{-1}$ as compared to no application of FYM and Zn, respectively during both the years and on mean basis. P concentration in stover remained unaffected due to different levels of FYM, nitrogen and zinc during both the years and on mean basis.
The total uptake of phosphorus was significantly influenced by various levels of nitrogen and zinc only during both the years and on mean basis. Application of 120 kg N ha$^{-1}$ and 20 kg Zn ha$^{-1}$ gave significantly highest total uptake of phosphorus as compared to others during both the years as well as in mean data.

The potassium content in seed and stover of rajmash was non-significantly influenced by different levels of FYM, nitrogen and zinc during both the years and on mean basis.

Various FYM and zinc levels had no significant influence on total potassium uptake by rajmash during both the years. However, application of 120 kg N ha$^{-1}$ had significantly higher potassium uptake than others. The lowest uptake of potassium was noted under 0 kg N ha$^{-1}$.

Use of 5 t FYM ha$^{-1}$ recorded significantly higher protein content in rajmash over 0 t FYM ha$^{-1}$ during 2005-06 and on mean basis. As regards to nitrogen levels, significantly higher protein content in rajmash was noted under 120 kg N ha$^{-1}$ over 0 and 60 kg N ha$^{-1}$ during both the years and on mean basis. Use of 20 kg Zn ha$^{-1}$ recorded the highest protein content and the lowest was noted under 0 kg Zn ha$^{-1}$ during both the years and on mean basis.
Application of 5 t FYM ha\(^{-1}\), 120 kg N ha\(^{-1}\) and 20 kg Zn ha\(^{-1}\) recorded significantly the highest protein yield as compared to their respective levels during both the years as well as in mean data.

6.4 Energetics of production

The maximum energy input was noted in 5 t FYM ha\(^{-1}\), 120 kg N ha\(^{-1}\) and 20 kg Zn ha\(^{-1}\), whereas, the lowest energy input was observed in no application of FYM, nitrogen and zinc. Significantly highest energy output was recorded under 5 t FYM ha\(^{-1}\) and 120 kg N ha\(^{-1}\) during both the years as well as on mean basis. In case of zinc, the highest energy output was noted with 20 kg Zn ha\(^{-1}\) during both the years only.

The maximum energy output-input ratio was obtained under 5 t FYM ha\(^{-1}\). Application of 0 kg N ha\(^{-1}\) recorded significantly higher energy output-input ratio than the higher levels during both the years and on mean basis. Similarly, 20 kg Zn ha\(^{-1}\) recorded significantly higher energy output-input ratio over 0 kg Zn ha\(^{-1}\) only during 2004-05 and on mean basis.

The maximum energy use efficiency and energy productivity was recorded with 0 t FYM ha\(^{-1}\) during 2004-05, whereas, during 2005-06 and on mean basis, maximum values was noted with 5 t
The maximum energy use efficiency was recorded under 0 kg N ha$^{-1}$ and the lowest was noted 120 kg N ha$^{-1}$ during both the years and on mean basis. Whereas, energy intensiveness, was significantly highest under 120 kg N ha$^{-1}$, though it was at par to 60 kg N ha$^{-1}$ during 2005-06 and on mean basis. However, energy productivity, was significantly highest under 60 kg N ha$^{-1}$ during 2004-05 and under 0 kg N ha$^{-1}$ during 2005-06 and on mean basis, though it was at par to 0 kg N ha$^{-1}$ during 2004-05 and 60 kg N ha$^{-1}$ during 2005-06 and on mean basis, respectively.

6.5 Economics of production

The gross realization was the highest with 5 t FYM ha$^{-1}$ and 120 kg N ha$^{-1}$ during both the years and on mean basis. Both the levels of zinc did not produce any significant difference in gross realization. The net realization and profit Re$^{-1}$ invested under different levels of FYM, nitrogen and zinc followed the pattern of gross realization.

The interaction between FYM with nitrogen or nitrogen with zinc gave significant impact on net realization during both the years and on mean basis. Application of 5 t FYM with 120 kg N ha$^{-1}$ recorded significantly higher net realization than other treatment
combinations of FYM and nitrogen. Similarly, use of 120 kg N ha\(^{-1}\) with 20 kg Zn ha\(^{-1}\) gave significantly higher net realization than other treatment combinations of nitrogen and zinc.

- Application of 120 kg N ha\(^{-1}\) + 5 t FYM + 20 kg Zn ha\(^{-1}\) recorded significantly higher net realization of rajmash than other treatment combinations.

- Use of 120 kg N ha\(^{-1}\) + 5 t FYM ha\(^{-1}\) + 20 kg Zn ha\(^{-1}\) resulted in significantly higher net realization Re\(^{-1}\) invested over other treatment combinations. Whereas, in 2005-06 and on mean basis, treatment combination of 120 kg N ha\(^{-1}\) or 60 kg N ha\(^{-1}\) + 5 t FYM ha\(^{-1}\) + 0 kg Zn ha\(^{-1}\) and 0 kg N ha\(^{-1}\) + 5 t FYM ha\(^{-1}\) + 20 kg Zn ha\(^{-1}\) were also found to be statistically similar.
CONCLUSION

The findings on rajmash under Vertisols of Chhattisgarh plains clearly visualized that application of 5 t FYM ha\(^{-1}\) along with 120 kg N ha\(^{-1}\) and 20 kg Zn ha\(^{-1}\) not only produced the highest seed yield (1208 to 1525 kg ha\(^{-1}\)) but also gave the highest net realization (Rs 22,048 to Rs 31,551 ha\(^{-1}\)) and net realization Re\(^{-1}\) invested (1.53 to 2.17). These treatments not only enhanced the growth, yield attributes and pod setting but also improved the nutrient uptake by rajmash.

So the farmers in Chhattisgarh plains can successfully harness 12-15 q ha\(^{-1}\) of rajmash with the application of 5 t FYM + 120 kg N + 20 kg Zn ha\(^{-1}\) provided irrigation facilities are available after the harvest of rice or soybean in Vertisols condition.
Suggestion for future research work

Considering the findings of the study, superior performance of higher levels of FYM, nitrogen and zinc needed further refinement to explain and generate more scientific information and make them farmer's friendly technology. The suggestions for further work are as follows:

1. Irrigation scheduling needs to be studied along with different nutrient levels under *Vertisols* and *Alfisols* in rice or soybean based cropping system.

2. Rajmash need to be tried after early, medium and late duration rice under different nutrient and water management treatments.

3. Experiments should be conducted with cereal based and legume based cropping system in unbunded *Vertisols* considering the various aspects of improved agro-techniques.

4. Soil nutrient dynamics under cereal-rajmash based crop sequence should be further studied under different soil types of Chhattisgarh.

5. A standard ratio of integration of FYM or blending with cow dung should be formulated from farmer's point of view.