AICRP - LONG TERM FERTILIZER

Objectives

1. To study the effect of continuous application of plant nutrients; singly and in combination with organic or inorganic forms including secondary and micronutrients as per need of crops.
2. To monitor the changes in physical, chemical and biological properties of soils as a result of continuous use of chemical fertilizers and manures.
3. To assess sustainability and soil quality under continuous use of fertilizer nutrients in Mollisols.

1. Significant Achievements:

The results of long term fertilizer experiments under rice-wheat-cowpea / rice-wheat cropping system continued since last forty five years (1971) on Uttrakhand Tarai Mollisols in Northern India to study the effect of continuous application of plant nutrients through inorganic and organic sources and their combination on crop yields, nutrients dynamics and changes in soil environment and soil quality. The salient findings summarized as follows:

1. The results showed that fertilizers are key input for increasing and sustaining crop productivity in tarai soils of Uttrakhand. In these soils, maximum productivity of crops can be achieved through application of fertilizers or incorporating FYM with fertilizers .
2. Highest productivity of rice and wheat was continuously maintained with application of optimal dose of NPK (100%) with Farmyard manure @ 15.0 t ha^{-1} in Tarai Soils of Uttrakhand. It suggest that optimal dose of fertilizer is to be applied in addition to manure for sustaining the crop production at higher level and hence considered as most sustainable practice in case of ric and wheat cultivation in tarai soils of Northern India.
3. To sustain productivity of rice and wheat in Tarai belt of Uttar Pradesh and Uttrakhand, application of $ZnSO_4$ @ 50 kg ha^{-1} is essential as basal dose once in four-five years before rice transplanting.
4. During last few years, crop responded to sulphur application through single super phosphate in comparison of yields recorded on supply of P through DAP in Pantnagar and nearby area.
5. In tarai soils of uttrakhand and Uttar Pradesh, phosphorus became limiting factor for crop productivity after 5-6 years of continuous application of N alone. Thus, N alone application can not the crop yields in Mollisols of Uttrakhand.
6. In tarai soils, continuous cultivation without proper fertilizers and manures adversely affected crop yields and fertility status of soil. Initially it had medium fertility status (392 kg/ha N, 18 kg/ha P and 105 kg/ha K) and decline was recorded in available N and P but reverse was noted in available K.
7. Balanced fertilization of nutrients as per crop requirement was best practice and fertilizers are the key inputs for increasing the crop yields in rice wheat cropping system.
8. Higher apparent negative balance of K in soil shows that rice-wheat cropping system utilized extra potassium from soil reserve. But decline in none forms of K was recorded. In fact, in some of the fractions change in K was not noted which means K is supplied from other sources. At Pantnagar only, irrigation water is main source of K. So in near future, K may not be a limiting factor.
9. Response of N and FYM was remarkable in both crops since beginning of the experiment whereas response to P, K, S and Zn was improved with the passage of time due to reduction in their availability in soil. However till date response of

K was not recorded.

10. Pattern of rice yield in Ist 15 years showed declining trend which later on stabilized whereas wheat yield were more or less stable. Rice and wheat grain yields of 5.0 q/ha as sustainable for both crops.

11. Soil Organic carbon declined to about one third (0.56%) from the initial status of 1.48% during a period of forty five years of cropping without using any nutrient input however its original status was restored by conjoint use of optimal NPK fertilizers and FYM.

12. Use of S-free fertilizers continuously (DAP) and absence of Zn reduced the availability of these nutrients and their addition enhanced the availability of these nutrients in Tarai soils of Uttrakhand.

13. Intensive cropping with high yielding cultivars using large amount of S-free fertilizers over the years generally depletes S reserve of soil and thus limits yield potential of the crop. Thus, intensive cropping with high yielding cultivars using S-free fertilizers over the years may threat to the sustainability of system.

14. Build-up of nutrient status (P and K) in soil through continuous application of manures and fertilizers over the years was not reflected in crop yield. Rather, a decreasing trend in crop yields was observed even in integrated use of optimal NPK and Farm yard manure (100%NPK+FYM). We should not allow to build up of these nutrients unnecessarily.

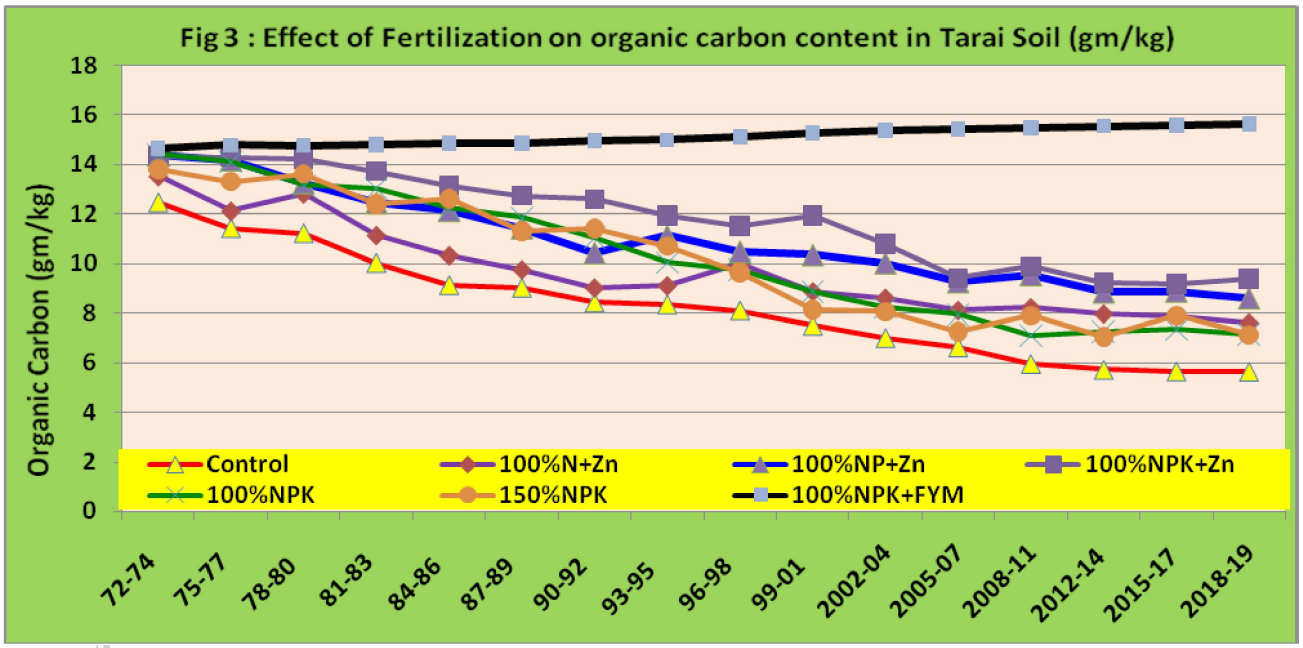
15. Zn was found to limit crop productivity when its availability dropped below threshed hold value (<1.0 mg/kg). Its basal application in soil @ 50 kg $ZnSO_4$/ha was sufficient to meet Zn need for 4-5 years under rice wheat intensive cropping in tarai soils (Fig 4).

16. The carbohydrate, Starch, protein content in rice and wheat grain were higher with balanced fertilizer and integrated use of chemical fertilizers and manure compared with alone chemical fertilizers and without fertilizers (control).

17. Baking quality of wheat flour was found marginally more in balanced use of fertilizers and it further improved with integrated use of 100%NPK+FYM@15 t/ha.

18. Integrated use of organic and inorganic source of nutrients (100%NPK+FYM@15t/ha) increased hydraulic conductivity, water holding capacity and mean weight diameter but decreased the bulk density of Tarai soils of Uttrakhand.

19. Soil Microbial biomass, microbial mineral –N,



and microbial population significantly incrased with balanced fertilizers over unbalanced use of fertilizers(100%N and 100%NP treatments) But maximum increase was recorded with integrated use of 100%NPK+FYM@15 t/ha.

20. Highest water soluble carbon content and carbohydrate and dehydrogenase activity was observed under 100%NPK+FYM 15 t/ha application in rice and wheat cropping in Tarai soils of Uttrakhand.

21. There is considerable build up of inorganic fraction of NO_3-N, NH_4-N and amino acid-N with continuous use of NPK fertilizers either alone or in combination with manure.

22. Long term application of phosphate fertilizers showed appreciable build up in total–P, Ca-P, Al-P, Fe-P and saloid–P. Among P Fractions, Ca-P was highest followed by Al- P, Fe-P and saloid-P in Mollisols of Uttrakhand.

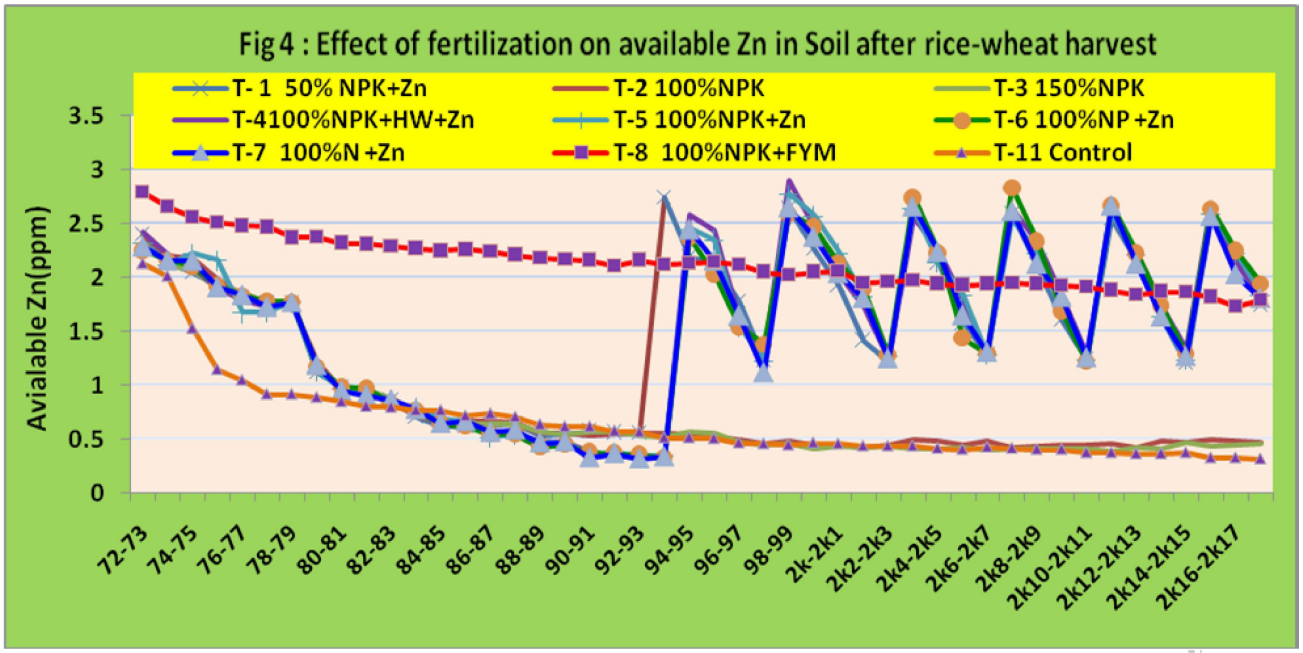
23. Long Term application of Potash fertilizers enhanced water soluble and exchangeable-K but it did not show significant influence on non exchangeable-K. However application of 100%NPK+FYM increased water soluble as well as exchangeable-K and kept non exchangeable K intact.

24. As far as soil quality concern, there was decline in soil quality if we compared with initial soil quality due to decline of organic carbon. Tarai soils of Uttrakhand / foothill soiils of Himalaya were brought under cultivation from forest ecosystem resulted oxidation of organic carbon and its fraction which declined the crop productivity.

25. Application of chemical fertilizers tried to resist soil productivity to some extent but not at original level. In spite of maintaining the organic carbon in 100%NPK +FYM, the crop yields of rice and wheat were not sustained similar to initial years which means there is deterioration in soil quality (Fig 5).

3.Production technology developed :

1. **A**dopt Integrated Nutrient Management (INM) for soil fertility maintenance and increasing crop production:. Status of organic carbon in soil from the initial level of 1.48 percent declined to one third without any fertilizer use or manure in rice and wheat crops over a period of 45 years, Even optimal use of NPK fertilizers could not arrest decline in organic matter. However, integrated use of NPK in rice and wheat and 15 t ha $^{-1}$ y $^{-1}$ farmyard manure restored the decline in soil organic matter and improved the availability of P and K. The INM gave maximum increase in yields of both the crops.



2. **Apply Zinc@ 50 kg ha^{-1} $ZnSO_4$ after every 4-5 years in Mollisols of Tarai Region:** Application of Zn in soil @ 50 kg ha^{-1} $ZnSO_4$ was found sufficient to meet crop Zn needs for 4-5 years. Therefore, application of Zn in soil along with optimal NPK fertilizer schedule is suggested when Zn in soil becomes deficient. It gives maximum increase in yields of both crops over without Zn.

3. **Monitoring of soil quality:** Continuous use of chemical fertilizers deteriorate soil health and its quality which need regular monitoring to conserve our soils for prolonged use. Build-up of nutrient status in soil through continuous application of manures and fertilizers over the years was not reflected in crop yields. Rather, a decreasing trend in yield was observed with alone application of mineral fertilizers.