Chapter 5

Conclusions and researchable issues

5.1 Summary and conclusions

The intricacies of potassium management research in soils that are rich in potassium containing minerals ($\geq$ 1% K) lies in deciphering relationships that exist between forms of potassium and its dynamics, occurrence and state of soil minerals, and crop-response to applied potassium. The soils of Punjab, in the "Green Revolution" era that has been coined for the period lasted over the last half-a-century, experienced huge depletion of potassium from soils by the bumper harvests. The exhaustion of potassium from soils during this period possibly exceeded total K exhaustion for all preceding periods taken together. The situation is further worsening because at one hand no-K is returned back to soils, and on the other hand new crops branded with advanced varieties and exploitative agronomic practices are depleting soil's K reserves at a pace faster than ever before. This threatens collapse of the entire eco-system of the state. The situation could not be addressed earlier, say about a decade back, because the conceivable predicament demanded convincible paradigms and stake-owner oriented experimental set-ups that restricted goals of K dressing experiments in terms of increase in yields of crops only. The situation, however, has changed recently because remedial measures to break yield-plateaus observed for major crops brought to the lime light issues of environmental security of which maintenance of soil health is a core issue. Keeping it in mind, we redrawn objectives of experiments, choose multiple sites across the vulnerable regions of the state on the basis of the status of available potassium in soils, and organized response experiments with new doses of K-fertilizers for 5 years (instead of conventional 2 years experiments) on maize, sunflower and peas. These experiments combined with other nutrients and attempted to address K depleted soils. Additionally, some explorative experiments were chosen to establish relationship between occurrence and weathering-state of soil minerals with status of potassium.

Since, there is a general aversion of application of potassium fertilizers, bottom line doses (0, 30, 60, and 90 kg K_2O ha^{-1}) of K were selected. Standard methodologies were followed for conducting response experiments. Randomized Block Design was applied and data were analyzed statistically. Quantity-intensity (Q/I) parameters of potassium were determined by following the methodology suggested by Beckett (1964). For this, six soil samples with > 80 percent sand were depleted of K by successive cropping till K deficiency appeared. Secondary electron micrographs of coarse sand fractions were obtained by using Hitachi S-3400N Scanning Electron Microscope at 15 kV accelerated voltage.

Following are some of the salient observations:

1. The data on the changes in the Quantity-Intensity (Q/I) parameters of potassium depicted fall of available K status, and decrease of K release capacity due to K depletion through intensive cropping. It created edge-wedge sites, which had high K selectivity. It implies that K fertilizer requirement will be much higher in exhausted soils than un-cropped soils to maintain same solution K level.

2. Electron micrographs of coarse sand size mica grains (biotite and muscovite) illustrate irregular boundary along with broken planes and itch pits that are produced through dissolution. The macrocrystals were platy, often perturbed with foreign microcrystals. The grains were strained, and at edges were marked with cleavage opening. The micrographs illustrate advancing weathering front that confirm depletion of K from mineral grains.

3. On the basis of more than 0.307 million surface soil samples that were analyzed for available K at the soil testing laboratory of the Punjab Agricultural University during the period 1962-1992, about 57 percent samples fell into low and medium categories, and 43 percent samples were in high category. However, the data on soil tests of 2004 indicate that about 50 percent samples of Hoshiarpur district were low in available K, whereas it was only 12 percent in 1993. This demonstrates that soils are being depleted of available K at a very fast rate. With the passage of time, the K status of many soils have been going down to a lower levels. The data further show that K deficiency was much wide spread in the north-east than south-west parts of the state.

4. Out of the 7.9 million ha area of the state under field crops, ~0.6 million ha tested low, 3.47 million ha tested medium, and remaining area fell in high categories in available potassium. In a conservative estimate, even if the soils that were tested low two decades ago are considered, additional K_2O requirement would be about 36 000 t for field crops for maintenance of available K status in soils. Even today, no K is applied to field crops, and whatsoever little amount (42 000 t) of K_2O is consumed in Punjab, it is by the vegetables and fruits.

5. Data of a 13 year long fertilizer experiment on maize-wheat system that involved 26 crops showed that exchangeable and non-exchangeable forms of potassium decreased in the fields that did not receive potassium fertilizer. Alongside, there was substantial amount of release of K from the non-exchangeable sources.

6. In the absence of K-dressing, the net negative balance in soil was 136 kg K_2O ha^{-1} yr^{-1}. Even with the application of 83 kg K_2O ha^{-1} yr^{-1}, the removal of K was 179 kg K_2O ha^{-1} yr^{-1} and about 100 kg K_2O ha^{-1} yr^{-1} was contributed from the soil-reserve sources. Therefore, it could be inferred that the uptake of K by crop exceeds its addition to soils from all sources taken together.
7. It could be discerned that it may not be possible to sustain the present production level of crops in the long run without the application of K and proper management of crop residue in Punjab.
8. Application of potassium increased the nitrogen use efficiency in crops.
9. On an average, the application of K at the rate of 60 kg K_2O ha^{-1} gave response of 3.6 kg wheat grain, 7.8 kg paddy, and 3.3 kg maize grain per kg of applied K_2O.
10. Response of sunflower at farmers' fields was obtained up to an application of 60 kg K_2O ha^{-1}. Potassium application increased height and thickness of the plant, and made it strong enough to withstand lodging.
11. Both grain and straw yields of maize increased with the application of potassium. The increase in grain yield was significant up to 60 kg ha^{-1} of K application. Potassium application eliminated chances of lodging of the crop.
12. There was a substantial increase in the yield of fresh pods of green pea with the application of 60 kg ha^{-1} of K_2O. Longer and thicker pods were harvested from the fields that received K-dressing.

5.2 Research gap

The Bulletin highlights our concern that some of the research gaps on potassium management in soils rich in potassium-containing minerals envisioned by Dr. G.S. Sekhon in 1982 remain unrealized (Published by the Potash Research Institute of India, Gurgaon, India as a Research Review Bulletin entitled, "Mineralogy of Soil Potassium"). These issues are vital for the future of agriculture in Punjab, and therefore, we identify them as: (I) nature and abundance of potassium containing minerals, (ii) soil-environmental conditions responsible for the formation of secondary clay-minerals and pedochemical factors of weathering, (iii) role of alkali feldspars and zeolites in potassium management, (iv) defining soil-mineralogy on a large scale map, may be by taking soil series or an agro-ecological region as a base, (v) utilizing mineralogy of soils for probing soil test methods for potassium, and (vi) how weathering of potassium containing minerals meets the increasing need of crops for potassium. We sincerely hope that young researchers would undertake working on these issues and other hot topics that come out as information void in the Bulletin to further research on potassium. This arena has grossly been ignored in the past. The potassium deficiency is more prevalent in north-eastern districts of the state. The ammonium acetate extractable (available) potassium does not seem to be very reliable indices of potassium availability. It can be used for broadly classifying the area into categories of potassium. However, site specific application of potassium should be the ultimate aim of the researchers and growers. In the competitive market the role of potassium must be viewed in the light of yield and quality of crops. It would be our satisfaction if the Bulletin empowers researchers adequately to take care of potassium management issues.