Chapter 1

Introduction

Potassium supports soil-biodiversity through nutrition supply, cleans percolating water through ion exchange and specific adsorption on K-containing minerals, and checks emission of excess carbon dioxide, nitrous oxide, and other green-house gases by stirring organisms to thrive, and improving use efficiency of nitrogen and phosphate fertilizers. Its role as an essential nutrient in plants, animal and human beings, and carrying other functions of civilization are well documented. It is the only major plant-nutrient that does not cause pollution to soils, biotic organisms, aquatic bodies and atmosphere; even when it is present in soils in amounts excess of requirement of plant. It is no surprise that the bumper wheat harvest is received from the soils that are rich in potassium-containing minerals; especially in abundance with micas (micas in coarse fractions and illite in clay fractions, and their derivatives; ~ 5-8 % K) (Radosolvich, 1975). In fact, agricultural soils are productive only when either, they are thriving in potassium rich minerals or, are otherwise well supplied with K.

In the intensively cultivated irrigated farming system - as it is in Punjab - bloom of blossoms occurs at the expense of pedospheric nutrients that are steadily being depleted with every harvest, and potassium is no exception to it (Mukhopadhyay and Brar, 2006). The situation in Punjab demands special attention, as K depleted from farmers' field is not returned to soils at all. In some experimental fields or, in rare cases in some farmers' field, K is dressed in miniscule amounts. In either of the situations, there is severe potassium debit in the soils.

One of the reasons of continuation of such eco-threatening practice perhaps lies in the failure in visualizing relationships that exist between forms of potassium and its dynamics, occurrence and state of soil minerals, and crop-response to applied potassium. In the soils that are rich in potassium ($\geq 1\%$ K) i.e., in those soils where there is abundance of K-containing minerals, foundation of K management rests on mineralogical make-up, and weathering processes of these minerals. In the last few decades' scientific breakthroughs have demonstrated prodigious nature of soil minerals that are far greater in magnitude than its conventional role in controlling nutrient availability (Sparks and Huang, 1985; Jongmans et al., 1997; van Hees et al., 2004). For example, transformations of soil minerals are deciphered from the angle of attrition-accretion processes of nutrient ions that implies complex equilibrium ionic relationships between soil-solution and soil-solids. Whenever there is loss of ions from soil-solids due primarily by plant removal accompanied by absence of their compensation to soils, soil-solids would reach to a new steady state with altered ionic-composition that ultimately lead to formation of new minerals, or altered product. On the other hand, zeoponics have demonstrated that it is possible to support life forms by recycling nutrient ions without altering soil minerals (Allen, 1995; Ming, et al., 1995; Sutter, et al., 2002, 2003).

Many physical (e.g., texture, drainage, consistence, ground water composition), chemical (e.g., cation exchange, exchange acidity, release of nutrient and toxic elements, surface water quality, buffering acid-rain), and biological (e.g., controlling soil bio-diversity, intercalating and bonding of organic materials) processes influence the availability of plant nutrients including availability of potassium (Brady and Weil, 2002). All these processes are governed by the occurrence and state of soil minerals. The growing concern for healthy living in accordance to laws of nature and interconnected foundation of life has placed soil-minerals in the centre of nutrient management research. Soil is essentially composed of soil-minerals with miniscule amount of organic matter, and thereby its productivity becomes function of properties associated with soil minerals.

The agriculture in Punjab has made several strides in post-independence India. During Green Revolution Era (1960-2004) farmers have been cultivating new crops (e.g., rice), growing high yielding varieties, applying nitrogenous and phosphate fertilizers (occasionally zinc), and managing irrigation resources. During this time cropping intensity increased from 126 percent during pre-Green Revolution era (1960-61) to 189 percent in post-Green Revolution period (2004-05), and food grain production increased by 8 times. All such breakthroughs could be achieved because soils of Punjab could supply high levels of mineral nutrients, especially potassium to high yielding crops under intensively exploited soil resources. In an earlier review, Grewal and Kanwar (1973) opined that soils of Punjab were well supplied with potassium. Their report based on the samples they brought in early 1960's showed that the total potassium ranged from 1.15 to 2.27 percent with an average of 1.60 percent. Similarly, available potassium (estimated by Neubauer's method) ranged from 146 to 415 kg ha^{-1}, which implies that soils were either medium or high categories. The K status could not be the same almost after half-a-century. Apart from it, declining crop productivity, diminishing soil fertility, and decaying environmental qualities that have become cause of concern in modern Punjab have forced stake-holders and scientists alike to address the issues of K management on priority. One of the façade of these issues is to assess changes in the status of potassium in soils, and monitoring its rate of exhaustion from soils.

The writ on monitoring temporal changes in the status of potassium in the soils of Punjab could be assessed from the report of Yadvinder-Singh et al. (2004), who estimated that rice-wheat system alone depletes more than 300 kg ha^{-1} yr^{-1} of potassium from soils of Punjab. If this rate of depletion continues, soils will be left with no potassium in a few decades. The situation is getting aggravated, as farmers are yet to be convinced of the benefit of potassium application. To a tiller, the paradigm remains on gain in yields of crops first, and crop-quality next, that too if profit supports it. Henceforth, most of the earlier experiments on the farmers' fields were based on the application of fertilizers, where potassium formed a miniscule treatment composition. These experiments were conducted without peeping into the status of available potassium, and without any attempt to integrate them with eco-system. Therefore, we hypothesized that crop response experiments must be conducted on the priority at the vulnerable eco-systems, on multiple sites over 5 years (instead of conventional 2 years experiments), and on the soils, which are low in available potassium. Additionally, it was felt that some explorative experiments on the soils that were medium in available potassium were needed to establish linkage of K response with available status of potassium.