

Research Findings



IPI intern in a meeting with a farmer. Photo by authors.

Promoting Precise and Balanced Use of Fertilizers in Pakistan at Farm-Gate Level

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Introduction

Pakistan is an agricultural country where the agriculture sector is not only feeding a huge and perpetually increasing population, but it also provides significantly (~21%) to the GDP of Pakistan (Economic Survey of Pakistan, 2014-15). The use of chemical fertilizers, especially nitrogen (N) and phosphorus (P), began in Pakistan after the Green Revolution (1960-1970) and is continuing to increase every year to fulfil crops' nutritional requirements. The majority of the farming community in Pakistan relies upon N and P fertilizers, according to their economic resources and awareness, while the use of potash is severely neglected.

Potassium (K) is considered an indispensable element for plants due to its role in enzyme activation, charge balance and osmotic regulation (Reddy *et al.*, 2004; Marschner, 2012; Wakeel, 2013). In addition, K improves the quality of agricultural products and extends shelf life.

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Although Pakistani soils are rich in K due to the presence of mica and illite clay minerals (Bajwa, 1994), ~40% of Pakistani soils are deficient in available K for plant growth and development (Akhtar *et al.*, 2003). Canal water is considered a good source of K and could partially fulfil potash requirements, however, canal water availability is inadequate in Pakistan's major cultivation areas. Furthermore, high yielding crop varieties/hybrids are also removing more K than is annually applied to the soil (Ranjha *et al.*, 1990). The per ha yield increase for rice, wheat and maize is 100%, 40% and 200%, respectively when compared to 1994 (Economic Survey of Pakistan, 2014-15). As a result of these high yielding varieties/hybrids and intensive agricultural practices, it is estimated that approximately 0.265 million Mt of K are depleted annually from Pakistani soils (Bajwa, 1994), while the annual addition of K fertilizers is ~0.03 Mt K₂O. This is very precarious for sustainable agriculture. Therefore, there is an immediate need to promote the use of K fertilizers for sustainable and economical agricultural production in Pakistan.

Unawareness of the importance of potash and the lack of soil analysis facilities are among the major constraints to balanced fertilizer use. The need to communicate the important aspects of K fertilization to farmers is dire, especially considering the significance of K fertilization during biotic and abiotic stresses which are very common in Pakistan. A number of private and public sector organizations are providing advisory services to farmers, however, the focus is not on K fertilizer use as the market share of K fertilizers is much less than N and P.

Objectives of internship

- To convey the significance of potash fertilization directly to farmers at the farm gate.
- To observe the nutrient deficiency symptoms of various crops and inquire about fertilizer use and cropping patterns.
- To obtain soil samples, carry out analyses and provide the farmers with fertilizer recommendations based on soil analysis.

Internship program 2015

A three month internship program was launched in 2015 by the International Potash Institute (IPI), Switzerland, purely dedicated to highlighting the importance of K and the balanced use of fertilizers in different areas of Pakistan. Interns were sent to four selected regions (Faisalabad, Multan, Sukkur and Matiari) in collaboration with Engro Fertilizers and Fauji Fertilizer Company (FFC) to interact with farmers, collect important on-farm information and soil samples, and to provide farmers with fertilizer recommendations based on soil analysis reports. Positive impacts were observed and an increase in K fertilizer demand occurred following the internship program. The 2015 internship report has been published on the IPI website: <http://www.ipipotash.org/publications/detail.php?i=453>.

Internship program 2016

In 2016, the internship program was carried out again with slight modifications based on experiences of the previous year. The interns - agricultural graduates selected from two Pakistani universities - were sent to a cotton growing area where they interacted with the farmers. They were allocated to the district of Vehari and Multan after a pre-internship training workshop held on 12 February 2016 at the University of Agriculture Faisalabad, in coordination with IPI.

Representatives of FFC, Engro Fertilizer and the Fatima Fertilizer Company were invited for an introductory lecture where they explained to the interns the advisory systems provided to their respective farmers. An introduction to IPI and the field experiences of the previous year were also presented. The purpose of the workshop was to acquaint the interns with the required knowledge to communicate fertilizer use, and specifically the importance of potash fertilization, to farmers. At the end of the workshop, IPI kits (field bag with literature and other accessories) were distributed to selected interns.

During the program, interns were expected to obtain soil samples and file these for analysis to make precise fertilization applications in cotton growing areas of Pakistan.



IPI intern collecting soil samples at farmer's field. Photo by authors.

Each intern was assigned to interview at least 75 farmers individually and collect their basic farm-data such as the total area of land under cultivation, the source of irrigation, fertilizer use during the last five years, cropping pattern, per acre yield, previous soil analysis report (if any) and fertilizer recommendations. In addition, they were required to collect and analyze soil samples and provide the farmers with soil fertility status and fertilizer recommendations. Each farmer interviewed was also provided with the booklet 'Potassium - A Nutrient Essential for Life' (translated to Urdu).

The program commenced in mid-February and ended in mid-May, 2016. All interns completed their assigned work within the specified timeframe. Interns were encouraged to carry out field visits on a regular basis, guided by FFC, Engro and Fatima Fertilizer Company (third leading fertilizer company of Pakistan) field officers. Performance reports were submitted at the end of each month detailing all the activities for that period. On completion of the internship, interns submitted a hard copy of their three month report as well as their excel data files. A meeting was conducted before the end of the internship program on 14-15 April 2016 to monitor intern performance. At Vehari, a city in southern Punjab, three interns working with Engro and Fatima

Fertilizers Company were interviewed. Their performance in the field, working schedules and recent activities were evaluated. Each intern was then questioned about their particular farmer's cropping pattern, total land holding area and soil samples collected and analyzed.

The IPI coordinator recommended the interns keep in touch with the small land holder to encourage the farmers in balanced use of fertilizers after the soil analysis. He also suggested the interns should cover various cultivated areas with different cropping patterns. Following this, there were discussions about the interns' working schedules, farmer responses and problems encountered. Similarly, the remaining five IPI interns were interviewed by the IPI coordinator at the FFC regional office at Jail Road, Multan. Dr. Sajid Fareed (FFC executive marketing officer) explained the company's major achievements and recent activities. He described FFC as a leading fertilizer organization in Pakistan, possessing basic farming data (fertilizer use, cropping pattern, per acre yield etc.) for various farmers from different regions of Pakistan. The organization collects soil samples according to a precise schedule with the help of a GPS coordinated system. Following analysis, FFC advise farmers on their soil's fertility status and provide fertilizer recommendations. Dr. Fareed also explained that recently FFC has been finalizing data regarding the metrological conditions of different regions in order to facilitate farmers more accurately. One intern added that, with FFC collaboration, he had recently reached roughly 1,500 farmers in farmer meetings and collected 58 soil samples from different villages. There had been a great response from farmers, another intern told. At the end of the meeting IPI interns were given time for questions which were jointly answered by IPI coordinator and FFC representatives. During questioning there was also a general discussion on the decline of cotton yields and the associated impacts on fertilizer demand.

Results

Both small and progressive farmers (having >10 ha land holdings performing mechanized farming) were contacted by IPI interns in cotton growing regions of Pakistan. More than 700 farmers holding a total of ~8,740 ha were reached. The land holding data indicated that out of the total cultivated area covered, roughly 21% was held by smallholders who owned less than 5 ha each and 31% was cultivated by farmers with 5-10 ha each. The majority (48%) of the area covered was owned by the farmers who owned more than 10 ha each (Fig. 1).

Underground water in most parts of the cotton growing regions of Pakistan contains excessive soluble salts which is a major contributor to land degradation. Approximately 6% of farmers in this region are only using tube-well water, while 9% of the farmers are dependent on canal water for irrigation. Roughly 87% of farmers are using both canal and tube-well water in different



IPI intern interviewing a farmer during internship in Multan District.
Photo by authors.

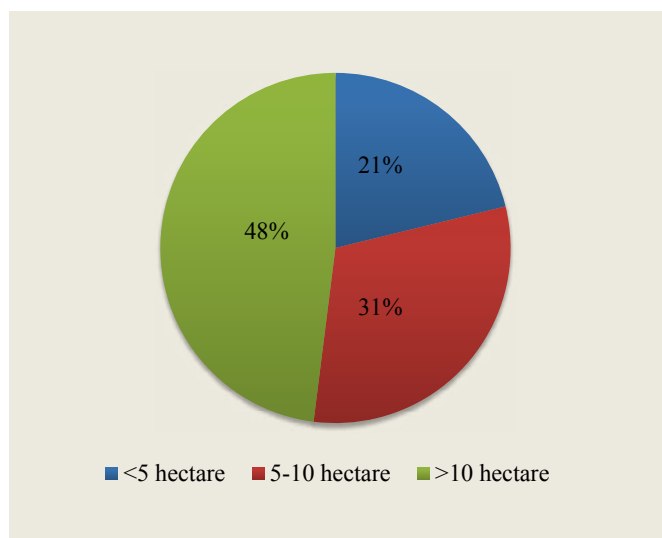


Fig. 1. Average land holding of farmers surveyed by interns in cotton growing areas of Pakistan.

proportions. Among those, the majority of farmers (30%) are using canal and tube-well water in 1:3 ratio, 29% use canal and tube-well water in equal proportion, and 28% use canal and tube-well water in 3:1 ratio to meet the irrigation demands of their crops (Fig. 2).

One composite soil sample was collected from each farmer's land and a total of 727 samples were analyzed by the interns. Samples were examined in the respective soil and water testing laboratories developed by the Fauji, Engro and Fatima Fertilizer Company. It was found that only 6% of soils in the cotton growing areas were severely deficient in available K (<80 mg kg⁻¹), while 15% of the soils have available K contents <120 mg kg⁻¹. Based

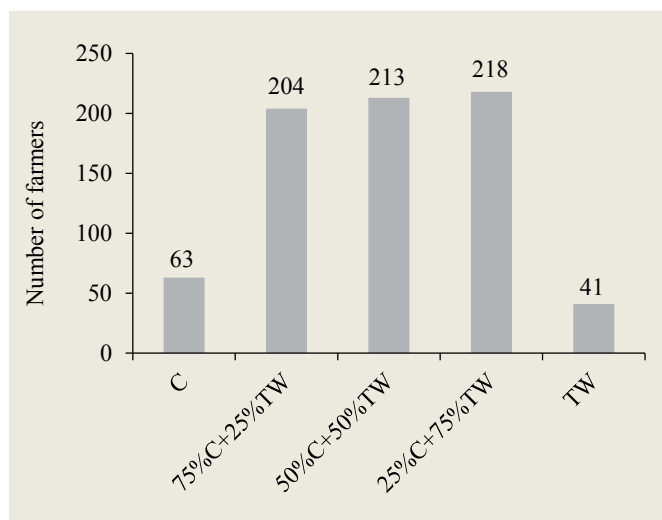


Fig. 2. The ratio of canal and tube-well irrigation water used by farmers in cotton growing areas of Pakistan (C=canal; TW=tube-well).

on previous experiences, most fertilizer companies consider soils containing less than 160 mg kg⁻¹ available K are deficient, and K fertilization would be beneficial. From soil sample analyses, it was observed that 44% of the sampled soils have K contents less than 160 mg kg⁻¹, whilst 56% contain >160 mg kg⁻¹ K (Fig. 3). The majority of soils in the identified areas are deficient in P with 67% demonstrating <8 mg kg⁻¹ P contents, ~30% possessed 8-15 mg kg⁻¹ P, while only 2.2 % soils showed a sufficient P content for crop growth of >15 mg kg⁻¹ (Fig. 4).

Many farmers in cotton growing regions of Pakistan are using N and P fertilizers, while a small minority (16%) are using K fertilizers (Fig. 5). Among those, the majority (60%) use sulfate of potash as a K source, while 24%, 8% and 7% farmers are applying

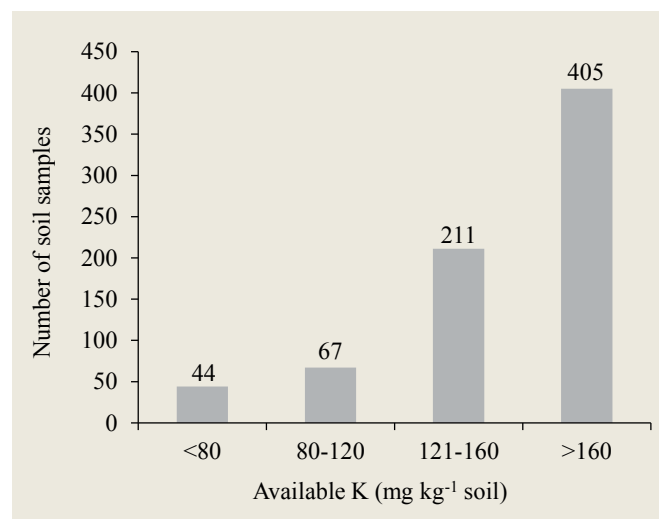


Fig. 3. Soil-potassium (K) content in cotton growing areas of Pakistan.

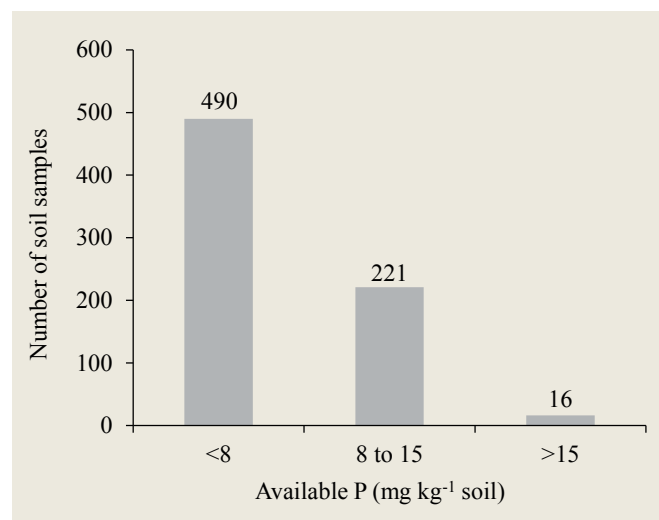


Fig. 4. Phosphorus (P) soil content in cotton growing areas of Pakistan.

NPK, muriate of potash and potassium nitrate, respectively (Fig. 6).

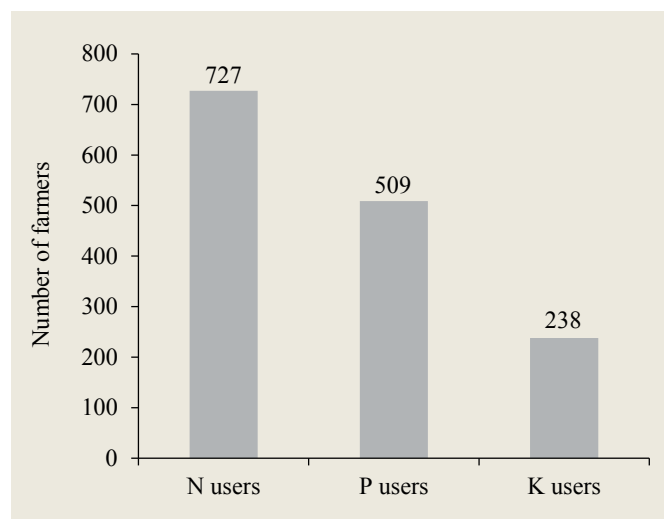


Fig. 5. Farmers using N, P and K in cotton growing areas of Pakistan.

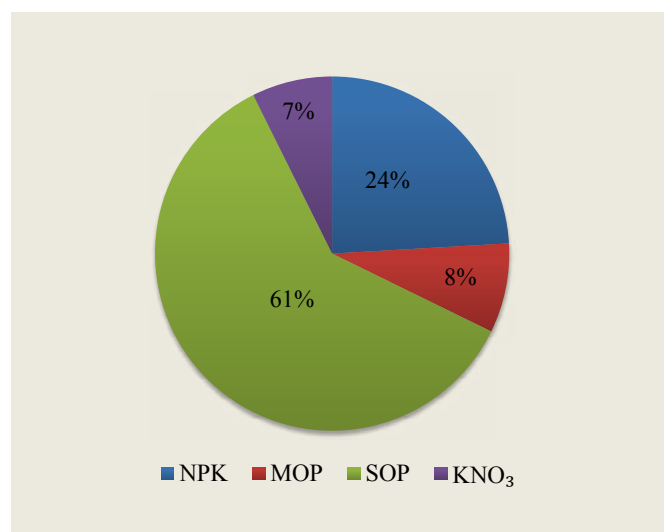


Fig. 6. Different K sources used by farmers in cotton growing areas of Pakistan.

Discussion and conclusion

The imbalanced use of fertilizers, especially N, P and K, not only has environmental implications but also results in low economic returns. The farming community in Pakistan applies N fertilizers significantly more than P, due to its quicker and more economic crop responses. In some cases, the overuse of N fertilizers has been reported in Pakistan. Soil analysis conducted by the IPI interns demonstrated that the majority of soils in the cotton growing areas of Pakistan are deficient in available N and P. Roughly 100% of farmers are using N and ~70% are using P fertilizers. However, potash usage is very low at 16%, despite 44% of soil samples analyzed being K deficient with less than 160 mg K kg⁻¹ soil.

Pakistani soils are alluvial and developed from mica, therefore several decades ago the indigenous soil K may have been sufficient for low yielding crop varieties. However, due to intensive agricultural practices and the cultivation of high yielding varieties, particularly maize hybrids, soil K content has been greatly depleted. Canal water is considered a significant source of K but its availability is limited.

This report revealed that approximately 29% of farmers are using canal and tube-well water at a 1:1 ratio. Only 6% are using 100% tube-well water, else tube-well water is being used in different ratios with canal water, therefore due to the limited availability of canal water, K from canal irrigation water is also decreased. Among potash users, around 24% use an NPK compound fertilizer and 8% and 61% use KCl and K₂SO₄, respectively. NPK fertilizers are significantly contributing to K use with less effort; this should be further promoted to optimize K use.

The evidence of the benefits of K application to crops is clear and there is great potential for enhanced potash use in Pakistan. However, there is a need to promote potash use in a strategic way. The rapid depletion of available K from soils is a threat to agricultural sustainability in Pakistan. The benefits of K use in agriculture must be highlighted, and policymakers should consider subsidizing fertilizer prices for agricultural sustainability. Furthermore, accurate and balanced use of K fertilizers is critical to increase the economic returns, therefore fertilizer recommendations should be revised according to soil characteristics. In the instance of Pakistan, the following benefits of K fertilization have been noted:

- a) The application of K to K deficient crops increases growth and yield.
- b) Potassium enhances the quality of produce increasing protein, oil and vitamin C content in cereals. In fruits and tuber crops, K increases the size and improves color, flavor, storage and shipping quality.
- c) Potassium improves resistance against drought, salinity, frost and pests.
- d) Synergistic effect of K to N and P improves the efficiency of nitrogenous and phosphatic fertilizers.

The internship program launched by IPI has been encouraged by all stakeholders (fertilizer companies, progressive farmers, agriculture extension department etc.). Direct communication with farmers via agricultural graduates is reliable, cheap and preferred by farmers over conventional methods of dissemination. This internship program will continue to run every year in collaboration with the local fertilizer industry with modifications where necessary.

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The paper "Promoting Precise and Balanced Use of Fertilizers in Pakistan at Farm-Gate Level" also appears on the IPI website at:

[Regional activities/WANA](#)



An intern at a farmers gathering providing advisory services. Photo by authors.



Group photo of the interns and other resource persons together with the Director of the Institute of Soil and Environmental Sciences, University of Agriculture Faisalabad, Pakistan. Photo by A. Wakeel.