INTERNATIONAL POTASH INSTITUTE

BALANCED USE OF FERTILIZERS IN PAKISTAN:

Status and Perspectives

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IPI Internship 2015

International Potash Institute (IPI)
Switzerland

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Prepared by

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PREFACE

Ever increasing population has signify the use of chemical fertilizers for food security, because high yielding varieties and intensive use of soils has deteriorate the natural resources especially soils in developing countries. Reduced soil fertility is one of many factors degrading soil quality and productivity. Therefore during green revolution in 1960's it was emphasized to use the chemical fertilizers for soil fertility improvements and a huge change was observed in food productions world-wide. The use of fertilizers, especially nitrogenous fertilizers, boosted up the crop growth, yield development and food production.

Pakistani agriculture was also supported by use of chemical fertilizers, however the use of fertilizers was limited nitrogen in 1970's and later on phosphatic fertilizers were also included in 1980's in the agricultural system of Pakistan. The use of these fertilizers is increasing every year to fulfill the agricultural requirements. Although Pakistani soils are rich in potassium (an essential macro nutrient for plants) due to presence of mica minerals and its weathered forms, however ~40% Pakistani soils are deficient in available potassium decreasing plant growth and nutrient stability. Canal water is good source of potassium, but availability of canal water is also not limited and the potassium gradient coming from canal water is reduced. Therefore it is great need to balance the fertilizer use for sustainable and economical agricultural practices in Pakistan. Imbalanced use of fertilizers, especially of nitrogen, phosphorus and potassium not only reduce the crops yields but has also great economic losses.

An internship program was launched in 2015 under international potash Institute Switzerland to emphasize the importance of potassium to balance its use with nitrogen and phosphorus for sustainable agriculture in Pakistan. Internees were selected from three universities in two province (agriculturally more important), and were in three regions in Pakistan after pre-internship training workshop held on 17th March 2015 at University of Agriculture Faisalabad, Pakistan. They contacted about ~ thousand farmers and collected > 700 soil samples from farmers field for analysis and then gave fertilizer recommendations to the farmers. They also interviewed the farmers for the agricultural practices they are using.

This internship report is based on the data collected by internees to present the facts and figures of use of fertilizers in Pakistan to signify the perspectives of balanced use of fertilizers in special reference to use of potash. This report will provide a view of Pakistani agriculture regarding balanced use of fertilizers to researchers, extension workers, progressive farmers and policy makers.

Abdul Wakeel

FORWARD

Invention of the Haber-Bosch process in 1913 to convert inert atmospheric nitrogen to produce nitrogen (N) fertilizer was a revolutionary change in agriculture to fulfill the growing food demands of ever-increasing global population. Increase in the use of nitrogenous fertilizers drastic and it improved the food production world-wide. The use of nitrogenous fertilizers is in excess in many parts of the world, especially developing countries such as China. Apart from the changes in the quantity of fertilizer used, there has also been a change in the nutrient ratio, especially the N to K ratio. The N to K ratio of fertilizer use in developed countries decreased continuously from a fairly balanced ratio of 1:0.8 in the 60s and 70s to a current N: K ratio of 1:0.36. The N to K ratio for fertilizer use in developing countries has changed little and remains very wide at 1:0.23. Exceptionally, South America has an N: K ratio of 1:0.96, because of the large amount of soybean cultivation that is very responsive to potash.

Nitrogen and K uptake by cereals is almost in equal amounts, whereas root and tuber crops, leguminous crops and vegetables take up even more K than N. In consequence of the wide N to K ratio in fertilizer use, the ratio of K input to K output has become highly unbalanced, which also indicates the considerable removal of soil K reserves. Potassium depletion due to negative K balance, soil does not have the capacity to meet the plant requirements decreasing the crops yields due to inadequate K supply, as well as the decreased efficiency of other inputs such as N fertilizers.

Balanced use of fertilizers is strongly recommended to improve fertilizer use efficiency and should be a common practice in farming. It not only helps to increase yield, but also farm income. Furthermore, it also needed for agricultural sustainability and to improve the image of farming. Quality agricultural produce is now becoming a major concern for stakeholders for which K is required to be balanced with other fertilizers.

All stakeholders should efforts to search for economical and better use efficiency of fertilizers. The internship program to convey the message for promotion of balanced use of fertilizers is an excellent program in Pakistan and I hope to continue it in future. I expect long-term results of this joint effort of industry, academia and farmers. This report will be a potential document for updated information about fertilizer use in Pakistan.

Hillel Magen

CONTENT

1. Introduction

Pakistan is an agricultural country, where agriculture is not only feeding a huge and eve-increasing population but also is a backbone of Pakistan economy contributing about 23% to national economy. However, most of the agricultural practices are conventional with less use of technology due to small land holdings, unawareness, and limited resources of farmers. Imbalanced use of fertilizers is among major issues of Pakistan agriculture decreasing crops yields and profit margin for famers. Awareness about the use of nitrogen and phosphorus is enough and farmers are using according to their economic resources, although not according to crop demand and soil analysis. Deficiency of micronutrients such as zinc (Zn) and boron (B) has also been observed in different crops. In aerobic rice cultivation B deficiency has been reported and application of B in these conditions has decreased the sterility of rice panicles. Furthermore, micronutrient deficiency in human diets has also emphasized the application of micronutrients for biofortification of staple crops with special consideration for Zn and iron (Fe). Use of micronutrients such as Zn and B have also been observed for selected crops since last decade, but the use of potassium (K) is still neglected, although K is macronutrient and more than 40% soils are considered K deficient.

Potassium is crucial for three important functions: enzyme activation, charge balance and osmotic regulation in the higher plants. Potassium is the most abundant macronutrient in most Pakistani soils. But the presence of a huge amount of K in the soil does not fulfill plants' requirements because a large amount of the K is fixed by clay minerals present in these soils and is not available to achieve optimum plant growth. Inadequate K fertilization is among the factors responsible for crop yield gaps in many parts of the world, especially in developing countries. Potassium sorption on exchange sites and its fixation depend on the physicochemical properties of the soil, as well as the type and content of the clay minerals.

The major natural source of soil K is the weathering of K-containing minerals such as micas and alkali feldspars, which contain 6-9 and 3.5-12% K, respectively. The age of soil developed from such minerals determines the extent of weathering as well as the K dynamics. While taking up K, plants reduce its concentration in the immediate vicinity of roots, which releases K-ions from the minerals. High yielding crop genotypes and intensive use of agricultural land decreased the available K contents in the soil as compared early eighty's, because addition of K fertilizer to soils was negligible whereas the removal was more which is very dangerous for sustainable agriculture in Pakistan. Continuity of this negligence will lead to high input agriculture farming which will be very tough to pursue due to poor resource farmers having small land holdings. Comparing other important macronutrients N and P, K has different behavior in soil. N and P are not majorly achieved from clay minerals rather external sources are utilized to feed the plants in fields. Therefore, it is more critical for K to formulate correct K fertilizer recommendations and get response from crops.

Sometimes uses of K fertilizers do not give huge increase in crops yields; however role of potassium in improving produce quality may increase the export potential of agricultural commodities. Furthermore K effect under environmental stresses must be highlighted to all the stakeholders including policy makers. Therefore there is a great need to aware the farmers, extension workers and policy makers about the significance of K fertilizers use for food security future generations and quality produce combating the environmental issues.

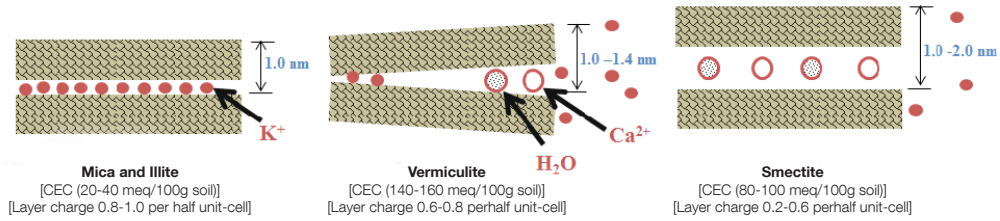


Figure 1. Properties of four types of clay minerals often present in agricultural soils (adapted from Wakeel et al., 2013).

Precise recommendation of K is also required to attract the famers towards more profitable agriculture. The release of K converts micas to secondary 2:1 clay minerals - illite and then vermiculite. In such soils not only plant available K contents are reduced, but applied K fertilizers are also more prone to be fixed by soil minerals and become slowly available for plants. The fate of K fertilizer also depends on the age of the soil; application of K fertilizer to soils containing illite and vermiculite clay minerals leads to fixation of some of its fraction by soil particles. The fixed K may become available to plants by its release from soil particles into soil solution when the concentration of K in the soil falls, but in most cases this release is too slow to meet the plant-growth requirements.

2. Use of fertilizers in Pakistan

After the green revolution of the 1960s, chemical fertilizer use was promoted in Pakistan, as in many other parts of the world particularly in developing countries. Beginning with the use of nitrogenous (N) fertilizer, phosphatic (P) fertilizer was introduced later in 1970s, with amounts increasing over time. Nitrogenous fertilizer use was significantly higher due to better, quicker and more cost-effective crop responses at that time. A slow and steady increase in P fertilizer use continued, up until the last few years (Fig. 1). However, application of potash (K) has been discouragingly low in most of the crops except potato where potash has been used for yield and quality produce. Imbalance fertilization, especially macronutrients (NPK), is not only deteriorating natural resources but also results in low economic returns.

Therefore it is of great importance to work on multiple fronts to promote the K fertilization in Pakistan keeping in view all the aspects responsible for low K use in Pakistan. Among others, poor farmers' awareness contributes significantly to low K use in Pakistan. To

spread the K fertilization message among farmers different steps are being taken by various government as well as private agencies. International Potash Institute has offer an internship program to have direct connection with farmers spreading the message of balanced use of fertilizers with special reference to potassium. This program is actual a joint venture of Pakistan fertilizer industry and international Potash Institute, however support from agricultural universities was also very important in selection of internees as well as their pre-internship training.

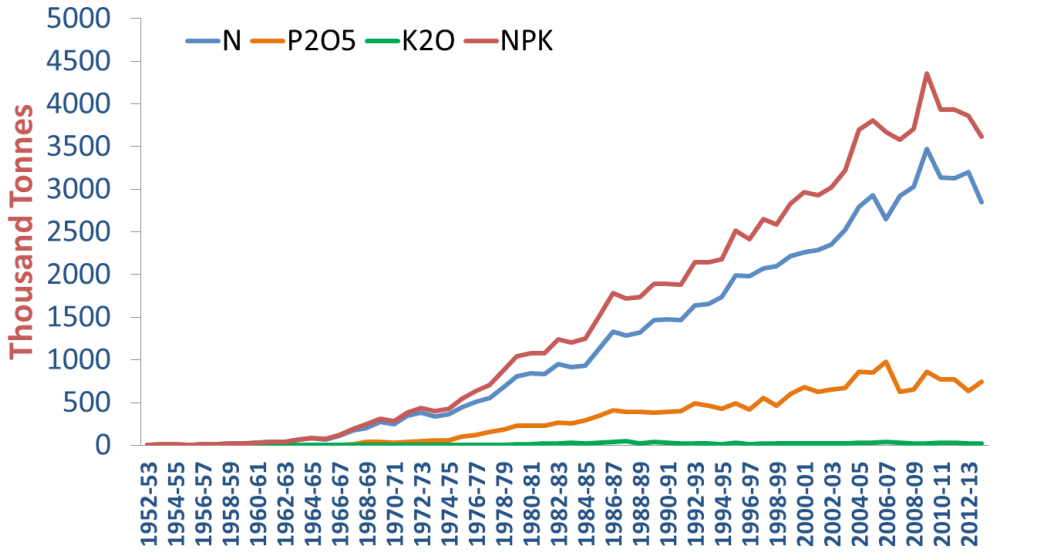


Figure 2. Chemical fertilizer use (nitrogen, phosphorus and potassium) in Pakistan from 1952-2011 (NFDC)

3. Internship program 2015

A comprehensive outreach program for promotion of balanced fertilization with special emphasis on K fertilization is planned to convey the message to balanced fertilization to farmers. In this activity International potash institute in collaboration with fertilizer industry of Pakistan support the agriculture students to the farming community, to hear their consequences and to advise him fertilizer recommendations after the analyses of his fields. A combine message based on research and fertilizer industry experiences will be conveyed to farmers through the students of soil science and agronomy. The objectives of this internship program are, to trained graduate student for field activities and interaction with farmers, to equip farmers with significance of balance fertilization with special reference to potassium. Agriculture graduates from Punjab and Sind are selected through a transparent selection procedure in the presence of Engro and FFC representatives and fourteen internees have been selected. Among these four are from Sind province selected from Sind Agriculture University Tando Jam, three were selected from BZU, Multan and seven from University of Agriculture Faisalabad.

3.1. Fauji Fertilizer Corporation

Fauji Fertilizer Company has been providing agricultural advisory services to the farming community throughout Pakistan since 1981, to increase the agriculture production in general and the farmers' economic returns in particular. The organization in pursuit of its national commitment and moral obligation maintains regular contact with farmers and agricultural institutions to ensure constant and efficient transfer of latest technology. This department is headed by senior manager (Agri Services). The department is providing quality farm advisory services all over the country through its five farm advisory centers and 14 regional offices. Each farm advisory centre has a team of four agricultural experts, providing diverse advisory services through seminars, demonstration plots, field days, farmer meetings, blitz meetings and farm visits. All the centers are fully equipped with modern sophisticated computerized soil & water testing laboratories and high-tech extension equipment.

Moreover, these also have plant tissue analysis laboratory at farm advisory centre, Shahkot having Atomic Absorption Spectrophotometer and other analytical instruments to determine the macro and micronutrients concentrations in plants. Soil Testing is a valuable tool to propagate appropriate and balanced use of chemical fertilizers and to identify soil problems. Soil/water samples are collected from farmers' fields and analyzed in the laboratories. Fertilizer recommendations are developed on the basis of soil analysis and recommendation reports are delivered to the growers for proper and balanced fertilizer use. The soil and water testing and micronutrient analysis facility is offered free of cost. Besides these five farm advisory centers, there are seventeen agri services officers based at 14 regional offices working under this department spread all over the country extending these services in their respective areas.

To further strengthen the advisory services and facilitate our farmers, the department also publishes literature including crop, vegetable and orchard brochures, posters and pamphlets containing latest information regarding production technologies of crops, and orchards grown in Pakistan.

Farm Advisory Centers

Fauji Fertilizer Company (FFC) is providing free of cost farm advisory services. There are a total of 5 farm advisory Centre which are as follows;

- FAC-Shahkot
- FAC-Bahawalnagar
- FAC-Mandi Bahaudin
- FAC-Muzaffargarh
- FAC-Sukkar

In conclusion FFC is very clear that farmers advisory services are very critical to improve their economic returns, therefore a comprehensive advisory system is working in a much disciplined way.

3.2. Engro Fertilizers

ENGRO chemical Pakistan limited is the second largest producer of urea fertilizer in Pakistan and the company was incorporated in 1965. ENGRO is a public limited company listed on the stock exchanges of Karachi, Lahore and Islamabad. The company has gone from strength to strength, reflected in its consistent and enviable financial performance, growth of core fertilizer business and successful business diversification into fields. Its performance and outlook is following the declared vision.

"To be the premier Pakistani enterprise with a global reach, passionately pursuing value creation for all stake holders"

Mission Statement

- To help farmers maximize their farm produce by providing quality plant nutrients and technical services upon which they can depend.

- To create wealth by building new businesses based on company and country strengths Petrochemicals, Information Technology, Infrastructure and other Agricultural sectors.

ENGRO Fertilizers Limited is one of the leading fertilizer manufacturer and marketer in Pakistan and has been in this business for the past forty years. ENGRO Fertilizers Limited has successfully developed a loyal customer base all across Pakistan, not only by providing farmer community with quality fertilizer but also through extensive market development activities. Following is the list of primary and secondary fertilizers that we market.

- Engro Urea
- Engro DAP
- Engro Zorawar
- Engro Zarkhez (contains N, P and K)
- Zingro (Zinc)

ENGRO holds a vast nationwide production and marketing infrastructure and produces leading fertilizer brands optimized for local cultivation needs and demand. ENGRO Fertilizers Limited enjoys loyal customer base across Pakistan owing to its trusted fertilizer brands and continual farmer assistance in training and education. Agri Services is core business driver.

Agricultural Services Activities

ENGRO is providing Agri. Services to farmers for increasing the agriculture production in general and the farmers' economic returns in particular.

- Farm visits and crop inspection for advisory services
- Group discussions to address the farm issues and their solution

- Crop demonstrations and field days to promote balanced use of fertilizers and best practices. Team of 40 agronomists supported by field staff work closely with farmers to educate on balanced use of fertilizer and best practices.
- Mass contact activities:
- Crop specific seminars / farmer meetings
- Training of "fertilizer dealers" so that they able to guide farmers at their shops
- 3000 dealers act as ENGRO ambassadors to educate farmer
- Printing of crop specific literature (+25,000 each)
- "Behter Zindagi Mag" (Kharif and Rabi 9000 copies each) for the farmers
- Website" www.ENGROzarai.com" provide agricultural information to farmers
- Fertilizer Placement for increased nutrient use efficiency seed cum fertilizer planter for Potato sowing designed by ENGRO – 10 Planters given free of cost to farmers

Soil testing for site specific fertilizer recommendations

Agri. services activities of ENGRO also includes soil testing for site specific fertilizer recommendations. Two soil and water testing laboratories (one each at Hyderabad and Multan) headed by soil science graduates are established by ENGRO.

- Soil sampling and testing facility is free of cost
- Labs are dedicated for farmer's service analyze ~9,000 samples per year
- 54K Samples tested during last six years

YEAR	HYDERABAD LAB	MULTAN LAB	TOTAL
2014	3514	4041	7555
2013	3433	4031	7464
2012	4704	7080	11784
2011	2745	5467	8212
2010	4490	4574	9064
2009	5432	4633	10065
Grand Total	54144		

3.3. Pre-internship Workshop

One day workshop was arranged at University of Agriculture Faisalabad for the training and orientation of internees. All the selected internees participated in this workshop, where they got the information about balanced use of fertilizers and methods of soil fertility evaluation. They were also told about the objectives of internship and the assignments they will have to perform in the field during their three months. The concluding session was presided by Dean Faculty of agriculture Prof. Dr. Muhammad Arshad accompanied by Prof. Dr. Javaid Akhtar, Director Institute of Soil and Environmental Sciences and Prof. Dr. Ehsanullah, Chairman Department of Agronomy University of Agriculture Faisalabad.

3.3.1. Objectives and program of workshop

The workshop is being arranged to acquaint the internees for field by providing them enough knowledge to communicate with farmers on balanced fertilizer use and importance of potash fertilization, to get soil samples from farmers' field for analyses to make recommendations for balanced fertilizer use.

After this workshop Internees will join FFC and Engro teams to perform their work for three months till mid of June 2015.

3.3.2. Program

Tuesday, March 17, 2015

Welcome Session

Recitation of Holy Quran		08:45
Welcome Address	IPI Coordinator	08:50
Overview of Pakistan agriculture and its issues	Dr. Muhammad Yaseen	09:00
Importance of P fertilization in Pakistan agriculture	Dr. Tariq Aziz	09:20
Importance of K fertilization in Pakistan agriculture	Dr. Abdul Wakeel	09:40
Tea Break		10:00
Practical Session		
Soil Fertility Evaluation (Visual)	Dr. Hafeez ur Rehman	10:15
Soil Fertility Evaluation (Soil Analysis)	Dr. M. Aamer Maqsood	10:45
Soil Fertility Evaluation (Plant Analysis)	Dr. M. Sana Ullah	11:45
Lunch Break		12:45
Internship Session		
Explanation of soil survey Performa	Mr. Dawood Khizer	13:30
Overview of fertilizer advisory service by FFC	Mr. Muhammad TAriq	13:50
Overview of fertilizer advisory service by Engro	Mr. M. Mujtaba Watto	14:05
Concluding session		
Recitation from Holy Quran		14:30
Naat-e-Rasool (SAWW)		14:35
Objectives of Internship	Dr. Abdul Wakeel	14:40
Introduction of Participants		14:50

Distribution of Internship kits to Internees		15:00
Chief Guest Address	Dr. Muhammad Arshad (T.I.)	15:15
Vote of Thanks	Dr. Javaid Akhtar	15:30

Group Photo/Tea

Pre-internship Workshop Snaps

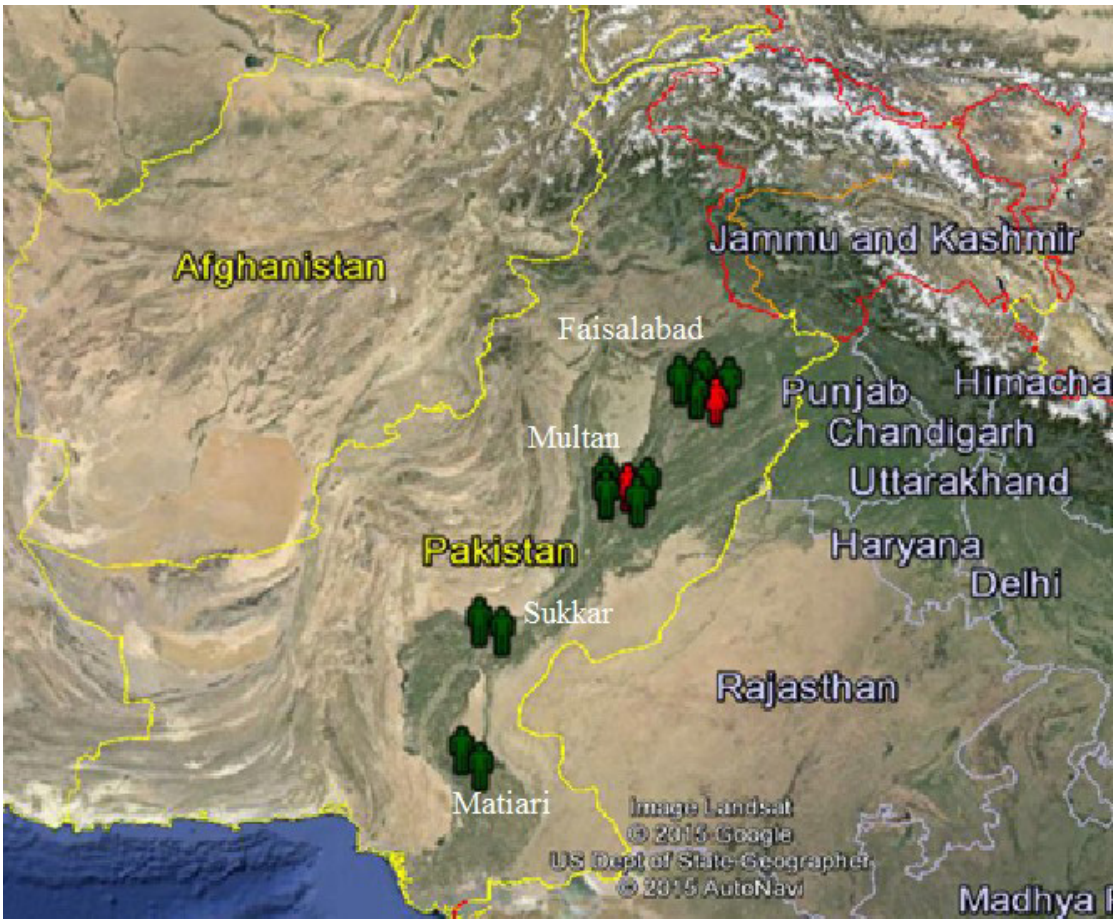
3.4. Objectives of Internship Program

The internship program was launched basically to convey the message of potash fertilization directly to the famers at their door step. The internees were supposed to spend sufficient time with each farmer to know their problems related to plant nutrition, to observe the nutrient deficiency at their farms, to get soil samples from farmer's field to provide them recommendations for fertilizers application after getting analysis from FFC/Engro soil testing laboratories.

3.5. Results/information generated

Internees started their internship from mid of March 2015 and was ended in the mid of June 2015. All the internees, except, one Mr. Kumar from Sind who left after one

month due to his domestic obligations. He was paid one month stipend only, however he fulfill the given assignments during this period. During the internship period all the internees were push regularly to complete our given assignments, although FFC and Engro officers were already guiding them properly. After every month each internee submitted his monthly report, mentioning all his activities during that period. In the end of internship all the internees submitted their three month report along with excel data form and hard copies of those forms. Two female internees mostly worked in laboratories and analyzed the soil samples sent by internees appointed in Punjab province. However they have also submitted detailed reports of three months and farmer information proformas based on information collected by themselves from farmers visiting the laboratories for their soil analysis. I have got the reports including information about 700 farmers in four zones of Pakistan (Figure 1).



Internees' distribution in two main agricultural provinces of Pakistan. Red color shows female internees while green color mentioned the male.

Survey Proforma for internees for IPI Internship 2015

Name: _____

Address: _____

Tehsil: _____ District: _____ Phone No:_____

Email: _____, Facebook ID:_____

Cultivated Area: Own _____acres, Rented _____ acres

Cropping system: _____

Irrigation: _____% Canal, _____% Tube well

Equipment: Tractor, Thresher, Trolley, Harvester, Sowing Drill, Combine harvester,

Fertilizer used last 5 years:

Urea @ _____bags acre-1, DAP @ _____ bags acre-1, NP @ _____bags acre-1, NPK @ _____ bags acre-1, MOP @ _____ bags acre-1, SOP @ _____ bags acre-1 Zn @ _____ bags acre-1, B @ _____ bags acre-1, Others @ _____

Fertilizer used last year:

Urea @ _____bags acre-1, DAP @ _____ bags acre-1, NP @ _____bags acre-1 NPK @ _____ bags acre-1, MOP @ _____ bags acre-1, SOP @ _____ bags acre-1 Zn @ _____ bags acre-1, B @ _____ bags acre-1, Others @ _____

Soil Analysis: From which Lab. (if yes) _____, Year: _____

Status: N _____, P _____, K_____, Micro.

Crops	Maximum yield acre-1	Minimum Yield acre-1	Average Yield acre-1

Soil Sample (2015):

Status: N _____, P _____, K_____, Micro. _____

Recommendation

Based on the information collected on above mentioned proforma, the results obtained are presented in graphs and discussed where needed. Results have been elaborated in four regions (mentioned in white text in Figure 1) Faisalabad, Multan, Sukkar and Matiari separately and then final conclusion is made on overall nutrient status and potash use in surveyed regions.

3.5.1. Fertility Status, Water Use and Land Holding Size in Faisalabad Region

In Faisalabad region, majority (52%) of the farmers being contacted during the internship by internees have land holding size of >25 acres, while less than 17%have land holding < 12 acres and 31% of farmers have land holding size of 25 acres (Fig 3). It shows that mostly progressive farmers were taken on board covering about 2000 ha out of ~ 3000 ha of cultivated land covered by internees (Fig. 3).

Underground water in most parts of this region contains excessive soluble salts which is the major reason of land degradation (Fig. 4). Only few farmers (9%) are using canal water for irrigation purposes, while 80% farmers are using canal and tube well water in different ratios. Whereas 10% farmers only rely on tube well water. Majority of farmers (50%) are using the canal and tube well water in 1:1 ratio to meet the crop water demands. Slightly less than 1/5 (17%) farmers are using tube well water and canal water in the ratio of 3:1 (Fig. 4). About 226 soil samples were analyzed in this region for nutrient recommendation. Soils of this region seem not severely deficient in potash as only 6% of the soils have K contents less than 80 ppm, while 1/3 (34%) of the soils have K concentration less than 120 ppm (Fig. 5) which shows need of K fertilization. However, slightly more than ¼ (27%) soils have K concentration up to 160 ppm (Fig. 5) and about 1/3 (32%) of the soils have K contents >160 ppm (Fig. 5). Overall 47% soils required potash fertilization in Faisalabad region. Phosphorus deficiency is prevalent in the soils of Faisalabad region as majority of soils (66%) have low phosphorus i.e. <8 ppm. Only few soils (31%) have phosphorus in the range of 8-15 ppm while 3% soils have P contents >15ppm (Fig. 6).

Most of the farmer in this region are using nitrogen and phosphorus fertilizers while very small proportion of the farmer (18%) are using K fertilizer (Fig. 7). Among those, 28% are using NPK as source of K fertilizers, while ~22% are using SOP. However, majority (50%) of famers use MOP as K fertilizer source in this area (Fig. 8).

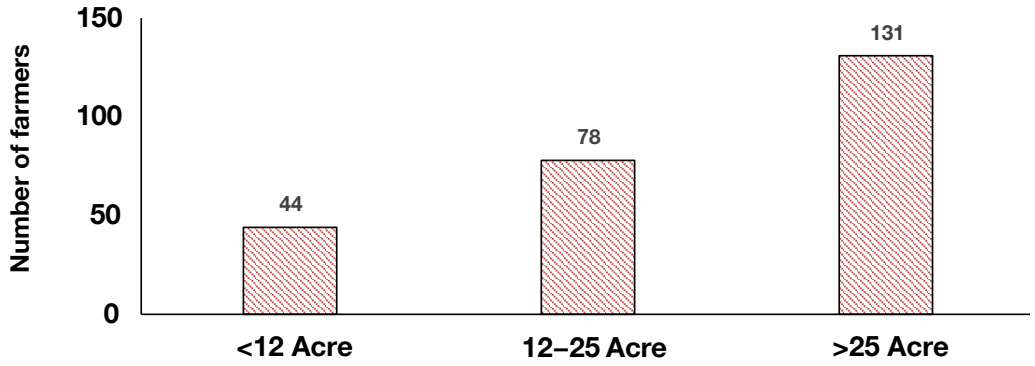


Fig. 3. Average land holding of farmers surveyed by the internees in Faisalabad region

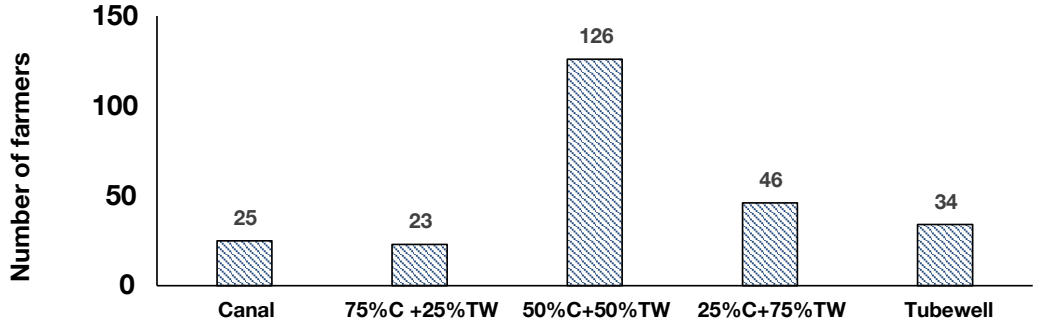


Fig. 4. Ratio of use of tubewell and canal irrigation water used by farmers in Faisalabad region (C= Canal; TW= Tube well)

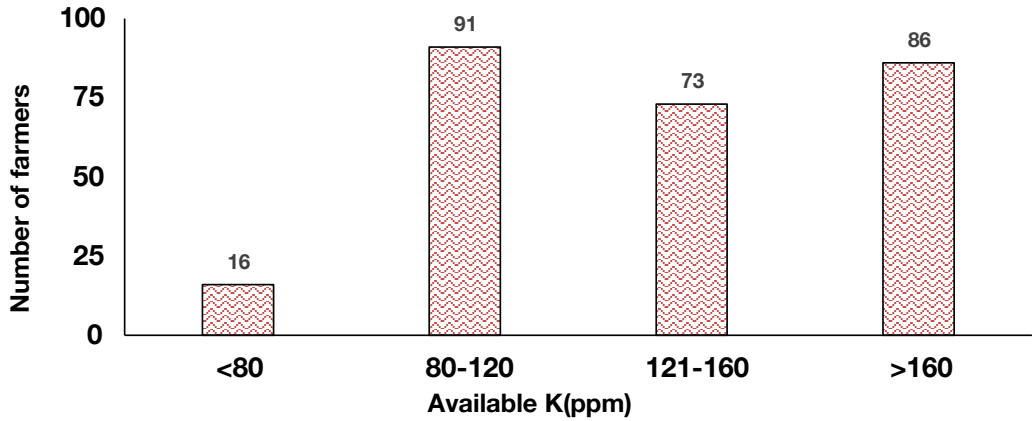


Fig. 5. Potassium (K) contents in soils of farmers' fields of Faisalabad region. One soil sample was taken from each farmer's farm

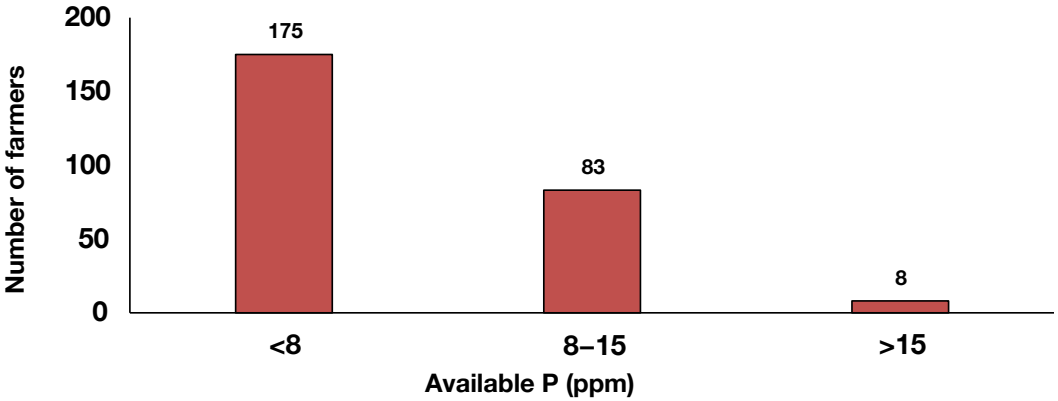


Fig. 6. Phosphorus (P) contents in soils of Faisalabad region. One soil sample was taken from each farmer's farm

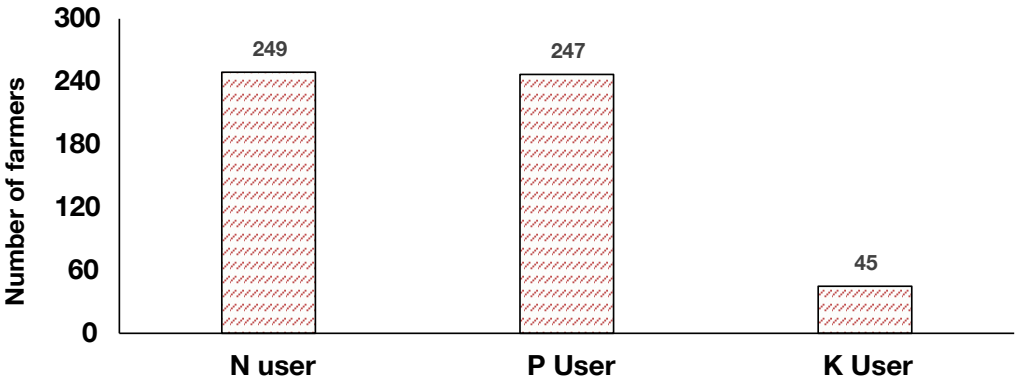


Fig. 7. Farmers using nitrogen (N), phosphorus (P) and potash (K) in Faisalabad region

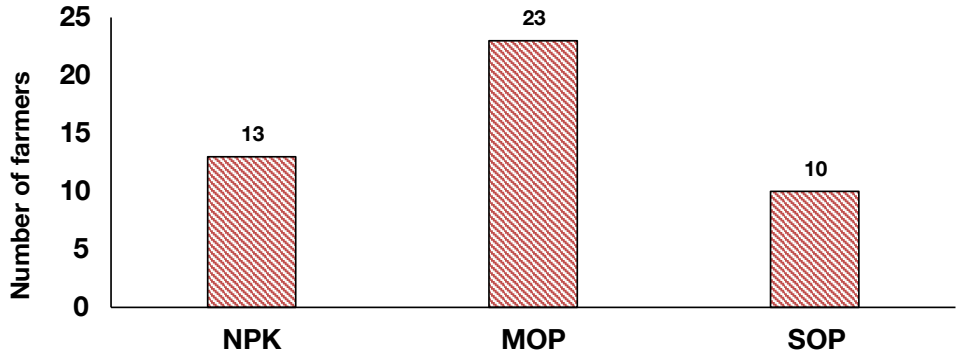


Fig. 8. Different potassium sources used by farmers in Faisalabad region.

3.5.2. Fertility Status, Water Use and Land Holding Size in Multan Region

In Multan region, majority (45%) of the farmers being contacted during the internship by internees have land holding size of >25 acres while 29% of the farmers having land holding up to 25 acres. Moreover, 25% of the farmers have land holding <12 acres, showing that mostly progressive farmers were taken on board covering about 5500 ha out of ~ 7400 ha of cultivated land covered by internees (Fig. 9).

Underground water in most parts of this region contains excessive soluble salts which is the principal reason for land degradation. Very small number of farmers (8%) are using canal water for irrigation purpose. However, 24% of the farmers are fully dependent on tube well water to fulfill crop water requirement. Whereas 69% farmers are using canal and tube well water in different ratios. Among these, very few farmers (8%) in this region using canal and tube well water in 3:1 ratio, while 43% of the farmers are using canal and tube well water in equal proportion to fulfill crop water demand and 18% of the farmers are using tube well and canal water in 3:1 ratio (Fig. 10). About 263 samples were analyzed in this region for nutrient recommendation. Potash deficiency is higher in Multan region compared to other areas as 13% soils of Multan region are highly deficient in plant available K (<80 ppm), while one fourth (24%) of soils of the region are having K content 80-120 ppm, showing need of K fertilization while 1/4 (22%) soils have K contents up to 160 ppm and 42% soils have K contents >160ppm (Fig. 11). Overall 37% soils of Multan region require potash fertilization. Phosphorus deficiency is widely prevalent in the soils of Multan regions as majority of soils have low phosphorus i.e. <8 ppm, while 1/4 (27%) of the soils have phosphorus in the range of 8-15 ppm. Only few (8%) soils have P contents >15 ppm (Fig. 12).

Most of the farmers in Multan region use Nitrogen and phosphorus fertilizers while very few farmers (19%) are using K fertilizers (Fig. 13). Among these 52% are using NPK fertilizer as K source while ¼ (28%) are using SOP and (20%) using MOP as K fertilizer source in this area (Fig. 14).

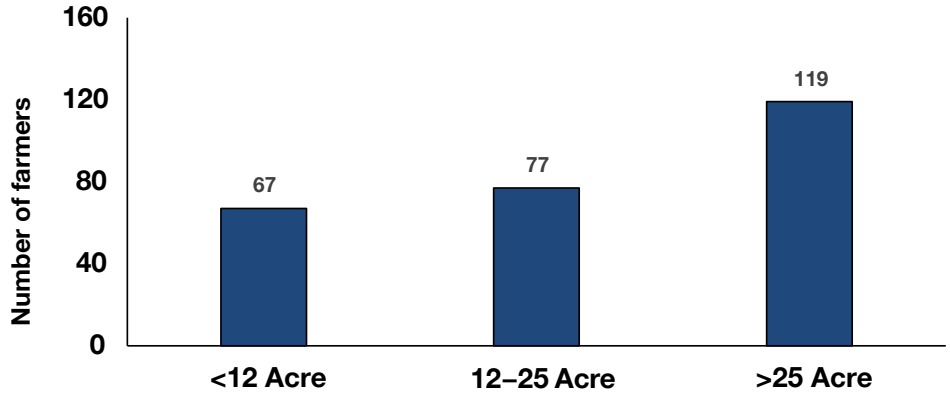


Fig. 9. Average land holding of farmers surveyed by the internees in Multan region

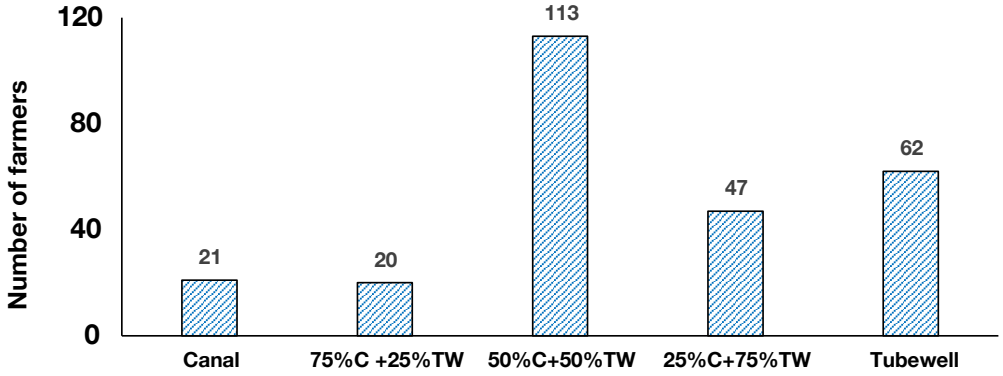


Fig. 10. Ratio of use of tubewell and canal irrigation water used by farmers in Multan region (C= Canal; TW= Tube well)

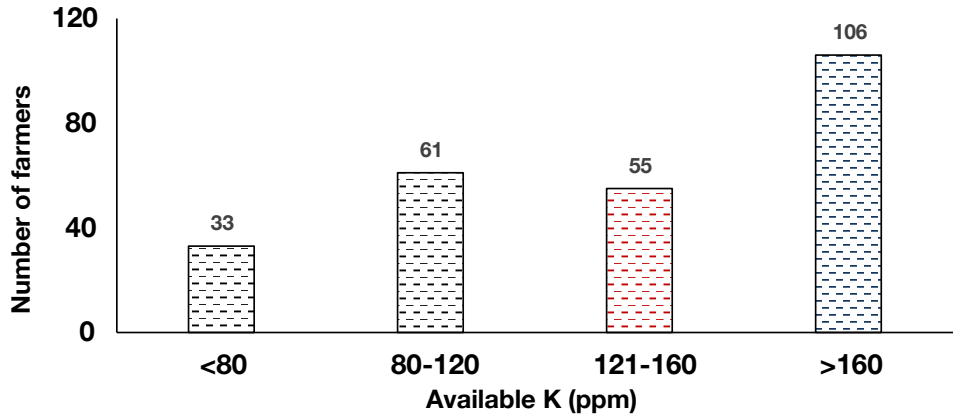


Fig. 11. Potassium (K) contents in soils of farmers' fields of Multan region. One soil sample was taken from each farmer's farm

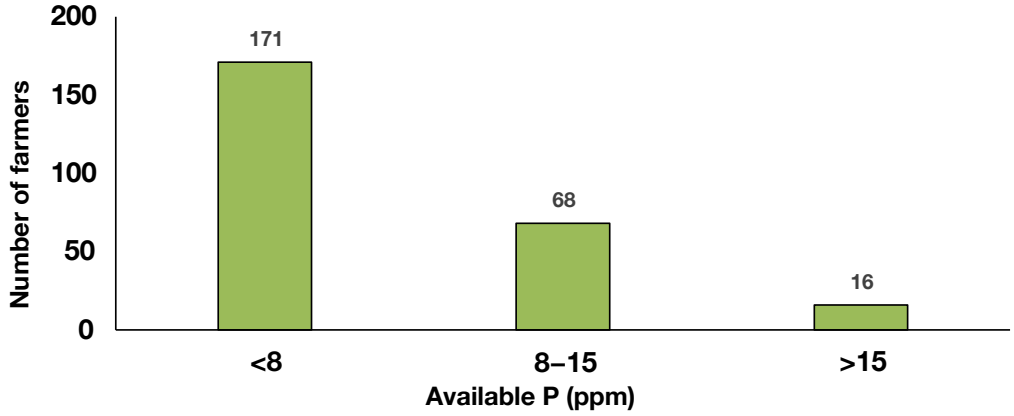


Fig. 12. Phosphorus (P) contents in soils of Multan region. One soil sample was taken from each farmer's farm

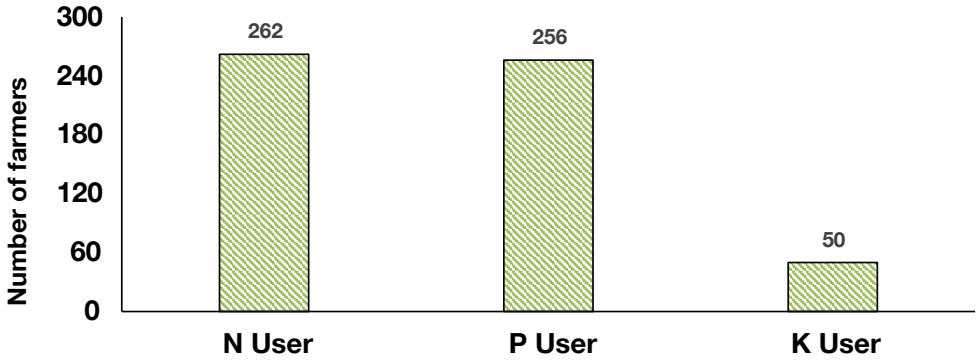


Fig. 13. Farmers using nitrogen (N), phosphorus (P) and potash (K) in Multan region

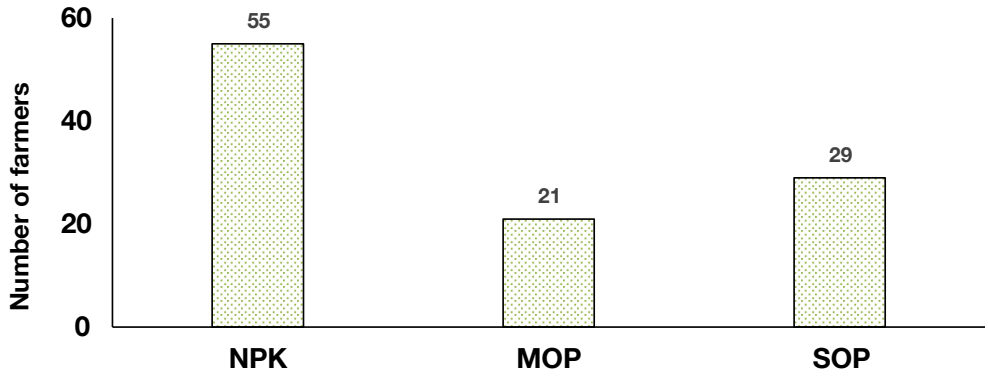


Fig. 14. Different potassium sources used by farmers in Multan region.

3.5.3. Fertility Status, Water Use and Land Holding Size in Sukkur Region:

In Sukkur region, majority of the farmers (45%) contracted during internship by internees have land holding size < 12 acres, while 22% of the farmers have land holding 12-25 acres. Moreover, 1/3 (33%) of the farmers have land holing more than 25 acres. It shows that mostly small farmers were taken on board covering about 2000 ha out of ~ 2800 ha of cultivated land covered by internees (Fig. 15).

Underground water in most part of the Sukkur region is unfit for consumption and irrigation purposes as it contains excess of soluble salts. Half (50%) of the farmers are irrigating their lands using canal water while only few farmers (5%) are using sole tube well water for irrigation purposes. Moreover, 45% of the farmers are using canal and tube well water in different ratios. Among these most of the farmers (35%) are using canal and tube well water in 3:1 ratio for irrigation purpose; very few (8%) of the farmers are using both canal and tube well water in equal proportion. On the other hand, a negligible number (2%) of farmers are fulfilling the crop water demand by applying the canal and tube well water in 1:3 ratios (Fig. 16). About 100 samples were analyzed in this region for nutrient recommendation. Soil of this region seem not severely deficient in potash as only few (6%) of the soils have K contents < 80ppm, while ¼ (27%) of the soils have K content 80-120ppm. Moreover, 28% of soils have K concentration up to 160 ppm while about 39% soils of the region having K concentration >160 ppm (Fig. 17). Overall 33% of the soils in Sukkur region required K fertilization (Fig. 17). Phosphorus deficiency is highly prevalent in this region as an overwhelming majority (99%) of the soils has P contents i.e. < 8 ppm, while only 1% of the soils have P content in the range of 8-15 ppm (Fig. 18).

Most of the farmers in this region are using nitrogen and phosphorus while only 17% of the farmers are using K fertilizer (Fig. 19). Among those ¾ (76%) are using SOP while remaining 24% are using MOP (Fig. 20).

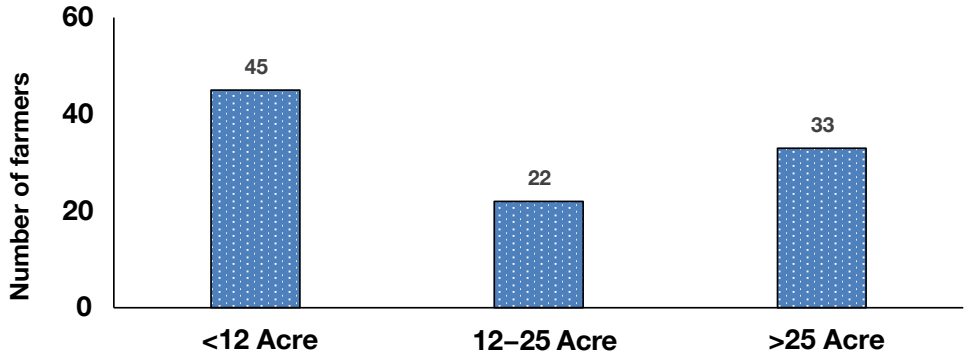


Fig. 15. Average land holding of farmers surveyed by the internees in Sukkur region

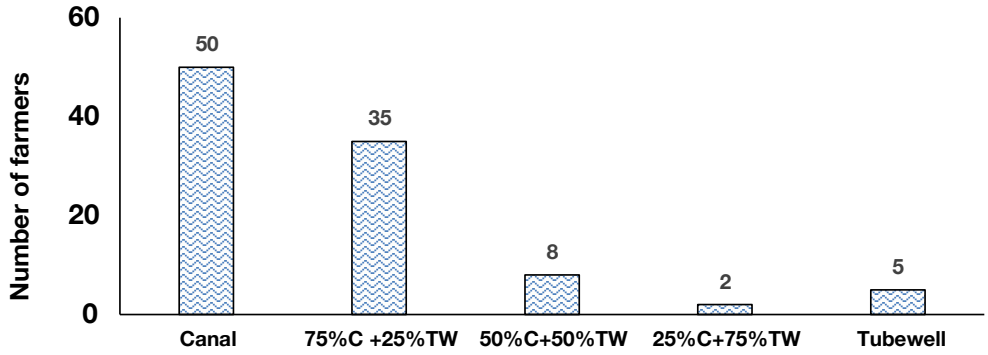


Fig. 16. Ratio of use of tubewell and canal irrigation water used by farmers in Sukkur region (C= Canal; TW= Tube well)

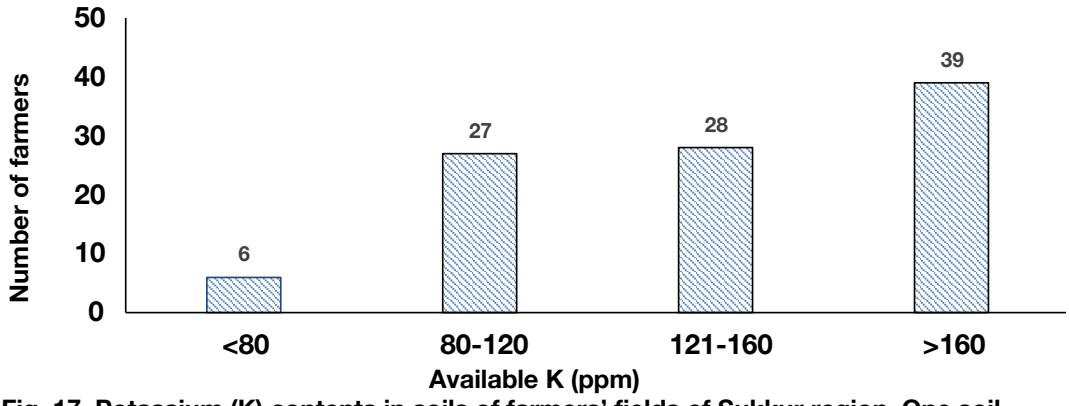


Fig. 17. Potassium (K) contents in soils of farmers' fields of Sukkur region. One soil sample was taken from each farmer's farm

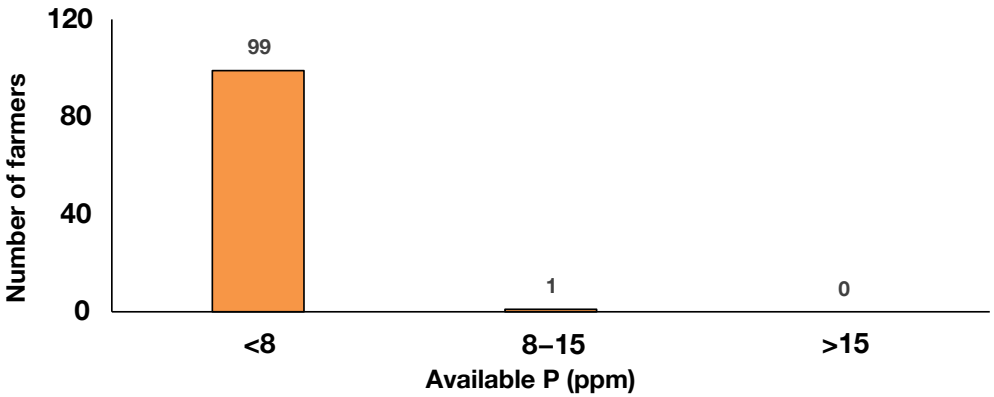


Fig. 18. Phosphorus (P) contents in soils of Sukkur region. One soil sample was taken from each farmer's farm

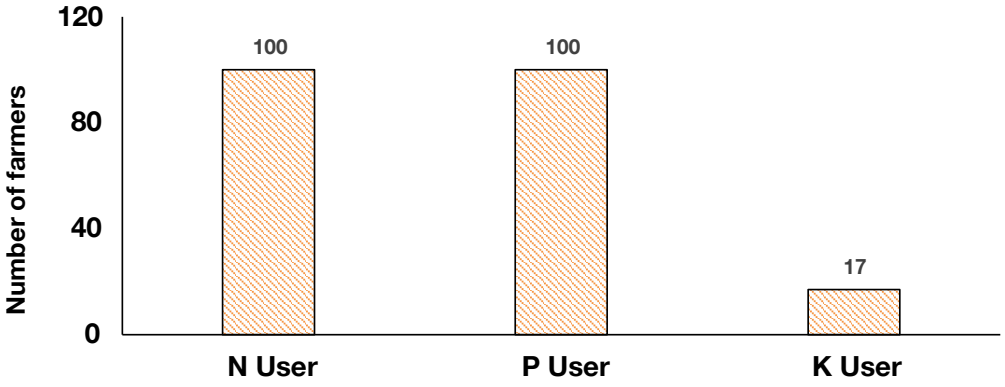


Fig. 19. Farmers using nitrogen (N), phosphorus (P) and potash (K) in Sukkur region

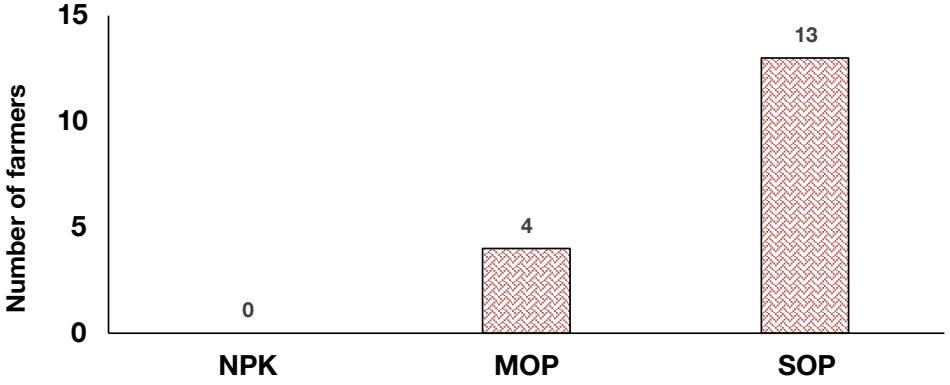


Fig. 20. Different potassium sources used by farmers in Sukkur region.

3.5.4. Fertility Status, Water Use and Land Holding Size in Matiari Region

Majority of farmers (50%) being contacted during the internship by internees in Matiari region have very small land holding (<12 acres), while 22% have land holding up to 25 acres. Moreover, ¼ (28%) of the farmers have land holding more than 25 acres (Fig. 20). It shows that mostly small farmers were taken on board covering about 900 ha out of ~ 1200 ha of cultivated land covered by internees (Fig. 21).

Underground water is most parts of this area contains excessive soluble salts which is the major reason of land degradation. Very small (12%) number of farmers are using canal water for irrigation purposes, while 1/3 (34%) of the farmers are irrigating their lands using only tube well water. (Fig. 22). About 54% of the famers are using both canal and tube well water in different rations. Among those, about 15% of the famers are using canal and tube well water in the ration of 3:1, while ¼ (28%) of the farmers are using both canal and tube well water in equal proportion. Very few famers (11%) are using canal and tube well water in the ratio of 1:3 (Fig. 22). In Matiari region about 94 soil samples were analyzed for nutrient recommendation. Potassium deficiency is not prevalent in this region as only 3% soil have K contents <120 ppm, while (45%) of soils in this region have K contents up to 160. About ½ (52%) of the soils have K contents > 160ppm (Fig. 23). This shows that only 3% soil of this region needs K fertilization (Fig. 22). Soils of this region are highly deficient in phosphorus as 95% soils of the region have P content < 8 ppm while, only few (4%) soils have P contents up to 15 ppm. Whereas, a negligible (1%) number of soils have P content > 15ppm (Fig. 24).

All the farmers survey by internees in Matiari region are using nitrogen fertilizers while a vast majority (84%) of them is using P fertilizers. A negligible number (1%) of farmers are using K fertilizers (Fig. 25).

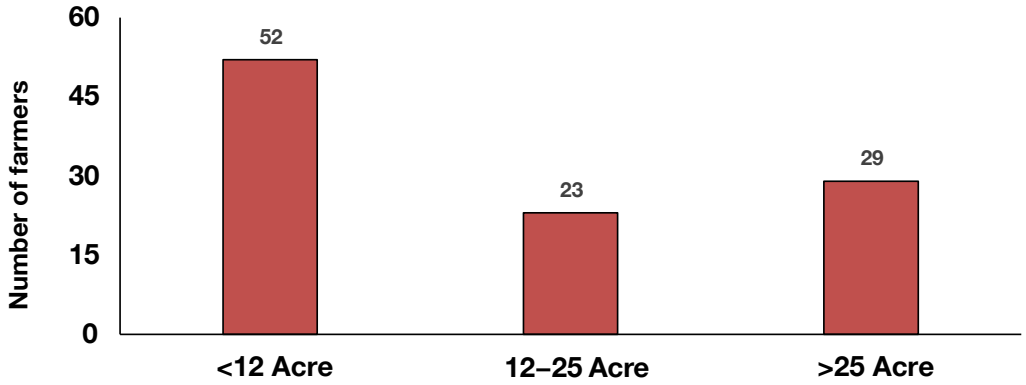


Fig. 21. Average land holding of farmers surveyed by the internees in Matiari region

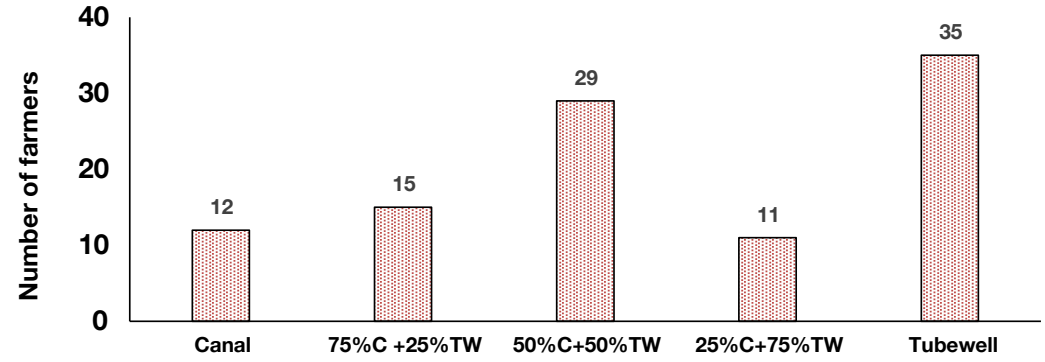


Fig. 22. Ratio of use of tubewell and canal irrigation water used by farmers in Matiari region (C= Canal; TW= Tube well)

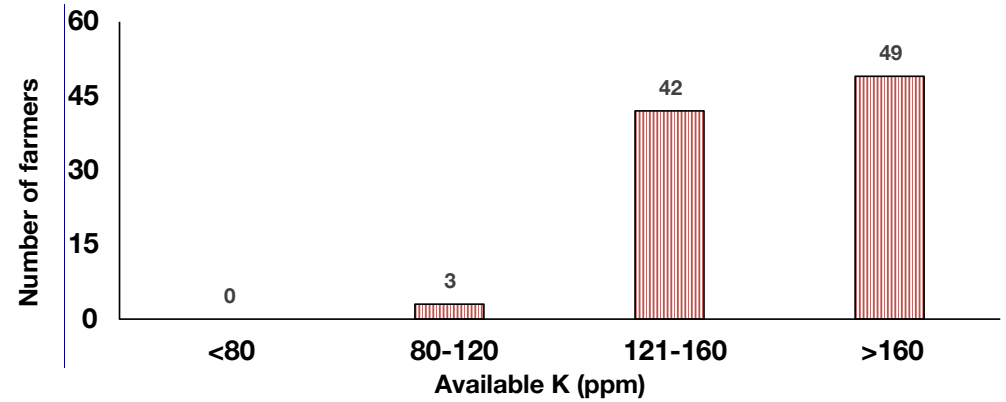


Fig. 23. Potassium (K) contents in soils of farmers' fields of Matiari region. One soil sample was taken from each farmer's farm

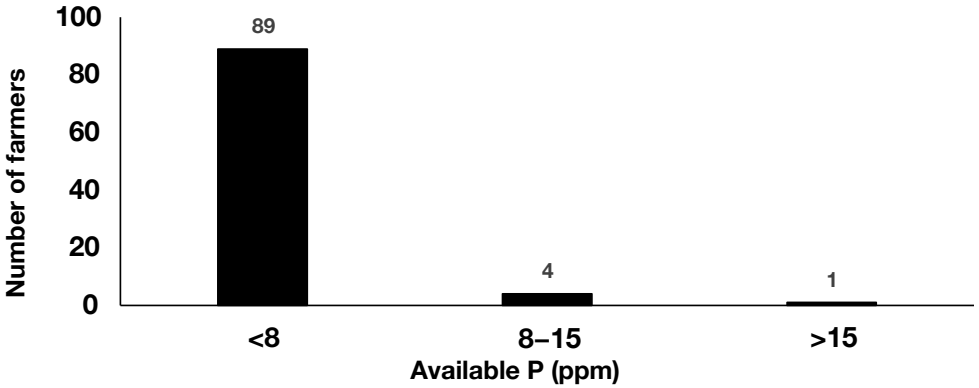


Fig. 24. Phosphorus (P) contents in soils of Matiari region. One soil sample was taken from each farmer's farm

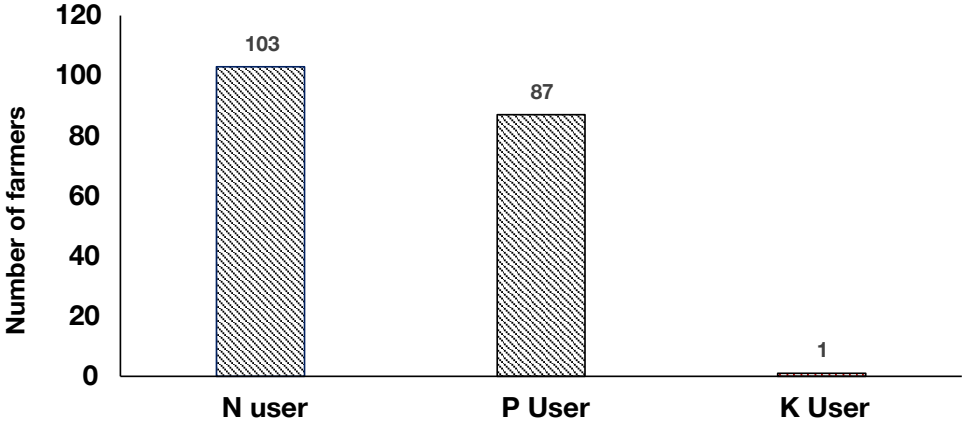


Fig. 25. Farmers using nitrogen (N), phosphorus (P) and potash (K) in Matiari region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4. Potential of use of potash in Pakistan

The report suggests that ¼ (25%) of the famers being contacted during the internship by internees in the country have land holding less than 12 acres. Moreover, similar number of farmers (25%) have land holding up to 25 acres while majority (50%) of the farmers have land holding above 25 acres (Fig. 26). It shows that both small and progressive farmers were taken on board each group covering about 7750 ha out of ~ 15000 ha of cultivated land covered by internees (Fig. 26).

Underground water in most parts of the county contains excessive soluble salts which is the major reason of land degradation. Very few famers (15%) of farmers are using only the canal water for irrigation purposes, while 19% of the farmers are solely dependent on tube well water for irrigation. About 2/3 (64%) of the farmers are using both canal and tube well water in different proportions. Among those, 13% are using canal and tube well water in 3:1 ratio while majority of the farmers (36%) are using canal and tube well water in equal proportion for irrigation purposes. Only (13%) of the farmers are using canal and tube well water in 1:3 ratio to meet the irrigation demand (Fig. 27). About 715 samples were analyzed by the internees from all over the country for nutrient recommendation. Only (8%) soils of the county are highly deficient in potash < 80ppm, while one fourth 1/4 (25%) of the soils have K contents < 120 ppm. About (28%) of the soils have K contents up to 160 ppm. Whereas, (39%) of the soils are having K concentration > 160 ppm (Fig. 28). Likewise, majority of soils (75%) of Pakistan are deficient phosphorus as P contents in these soils is < 8 ppm. Whereas, about (22%) have P content i.e. 8-15 ppm, while only few (3%) soils have P contents > 15 ppm (Fig. 29).

Most of the farmers in Pakistan are using nitrogen and phosphorus fertilizers while very small number of (16%) farmers are using K fertilizers (Fig. 30). Among those, about 41% of the farmers are using NPK, while MOP and SOP is being used as K source by 28 and 31% farmers respectively to meet the crop K demand (Fig. 31).

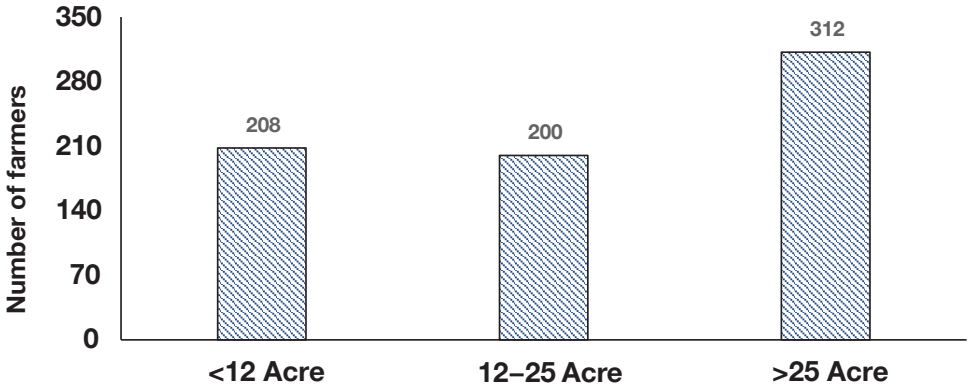

Fig. 26. Average land holding of farmers surveyed by the internees in Pakistan

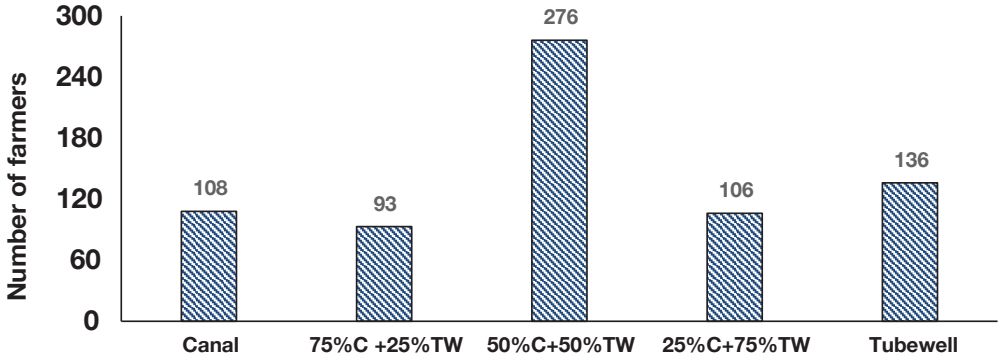

Fig. 27. Ratio of use of tubewell and canal irrigation water used by farmers in Pakistan (C= Canal; TW= Tube well)

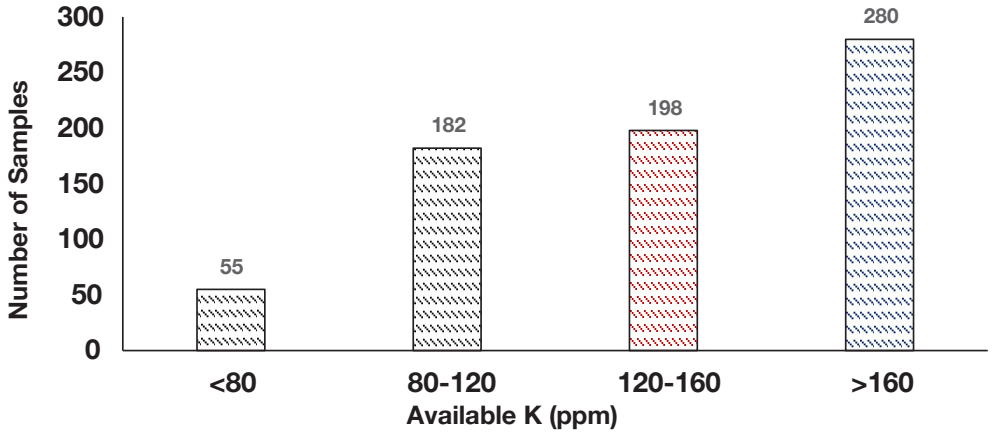

Fig. 28. Potassium (K) contents in soils of Pakistan. One soil sample was taken from each farmer's farm

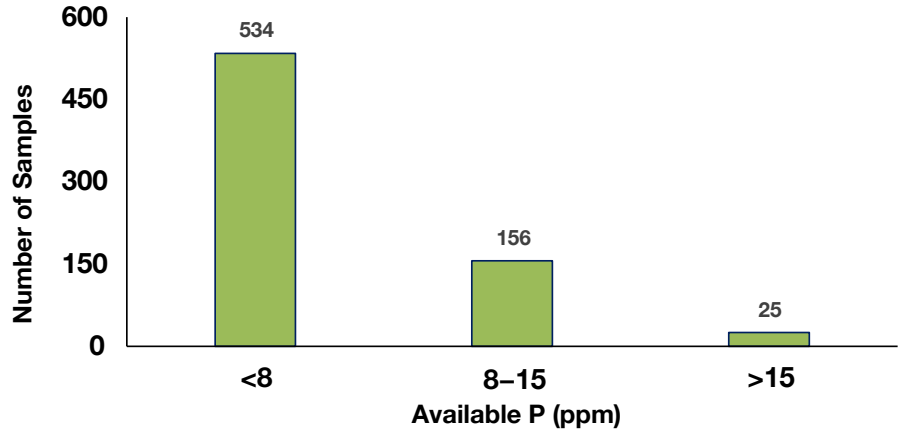

Fig. 29. Phosphorus (P) contents in soils of Pakistan. One soil sample was taken from each farmer's farm

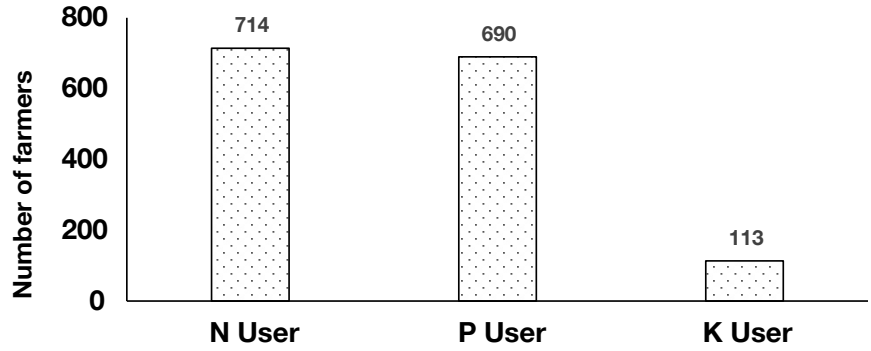

Fig. 30. Farmers using nitrogen (N), phosphorus (P) and potash (K) in Pakistan

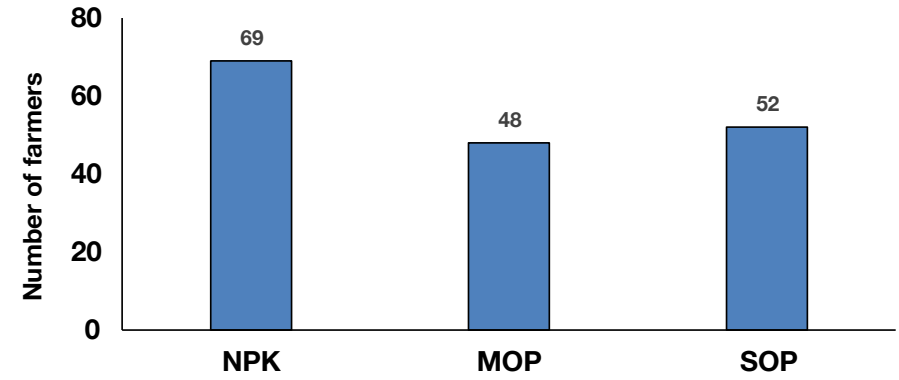

Fig. 31. Different potassium sources used by farmers in Pakistan

5. Recommendations and Outlook

Imbalanced fertilization, especially use of nitrogen, phosphorus and potassium, not only causes deterioration of natural resources but also results in low economic returns. In Pakistan, use of chemical fertilizers (mostly nitrogen and phosphorus) started during 1960-70. Nitrogenous fertilizers use is significantly higher than phosphorus due to its better, quicker and more economic crop responses. Our survey and soil analyses conducted by our internees (about 43% data is from farmers having land holding > 25 acres) it has revealed that most of our soils are deficient in available nitrogen and phosphorus, fortunately ~100% farmers are using nitrogen while ~97% are using phosphatic fertilizers. However the use of phosphatic fertilizers is not up to the mark in most cases. Recent data revealed that potash usage is very low i.e. less than 16%, although the 34% (in other reports ~40 % agricultural soils of Pakistan are considered as K deficient) soil samples analyzed have less than 120 ppm potassium and considered as deficient. Few decades back, the available potassium may be sufficient for low yielding crop varieties due to indigenous soil potassium, however recently entry of high yielding varieties in agricultural system, especially maize hybrids, and intensive cropping have depleted the soils to a great extent and increased the potash demand for better yield. Canal water was also considered a significant source of potassium but the decreased availability of canal water has limited this source too. Our present reports revealed that about 40% farmers are using canal and tube-well water at the ratio of 50:50. Only 15 % farmers not using tube-well water at all, otherwise tube-well water is being used in different ratios with canal water. Therefore the possible gradient coming from irrigation water is also reduced. Among potash users about 40% are using potash as NPK compound fertilizers, where as 30% each are using potash as KCl (MOP) and K_2SO_4 (SOP). It shows that use of compound fertilizer may be easy to promote as compared to only MOP and SOP, furthermore differentiate between MOP and SOP is not much among the farmers using potassic fertilizers. The production of high quality agricultural produce is required for export purpose which is demanded by the international market. Low use of K may deteriorate the quality affecting exports of agricultural produce.

From the survey of farmers it was also observed that high prices and availability of potassic fertilizer is issue throughout the country. Otherwise farmers are willing to use potassic fertilizers if they can sell their commodities in officially announced prices. Although still the market for potash is not boosted up, however the awareness has been improved and Fatima fertilizer, an emerging large group in Pakistan fertilizer industry has also started potassic fertilizers.

The scenario is very clear and there is a great potential for potash use in Pakistan, however a thorough and innovative campaigns are required to highlight the significance of potassic fertilizers in Pakistan. The IPI internship program launched this year was very fruitful and results can be seen in the market regarding awareness of potassic fertilizers. There is great need to emphasize the government to subsidize the potassic fertilizers for agricultural sustainability and food security keeping in view the decreasing concentration of potassium in Pakistani soils. Subsidy in tax can decrease the fertilizer price without decreasing the net income to government as the increase in import of potassic fertilizers.

Based on feedback collected from internees, farmers and fertilizer industry it is highly recommended to continue the internship program. This internship program can be made more effective in future based on feedback information.

Acknowledgements

All praises are for almighty ALLAH who is the creator and sustainer of this universe. He is very kind to His creations and sent a number of prophets from Adam to Muhammad (peace be upon him) for the guidance of humanity to run the matters of this universe partially. Offering an internship program to send a number of internees in field to convey the message of balanced use of fertilizers was a challenging job for me, but it became much easier with the help and support by various organizations as well as individuals.

It is really a matter of pleasure to acknowledge the logistic support provided by Fauji Fertilizer Corporation (FFC) and Engro Fertilizer Limited Pakistan. The enthusiastic support by Mr. Riaz Ahmad Ghumman and Rao Tariq from FFC and Mr. Asif Ali and Dr. Zaheer Ahmad from Engro Fertilizer Limited was of great significance to run the internship program-2015. I also acknowledge the FFC and Engro team working in field are laboratories and guided IPI internees to perform their duties. It will be unfair if I don't acknowledge the expert team from Institute of Soil and Environmental Sciences, University of Agriculture Faisalabad who participated in the pre-internship workshop as resource persons. I greatly acknowledge the efforts by Dr. Zia-Ul-Hassan Shah from Sind Agriculture University, Tando Jam for his support in selection of right candidates for internship in Sind province. Dr. Muhammad Farooq Qayyum and Dr. Ahmad Naeem Shahzad from Bahauddin Zakrya University, Multan are also acknowledged for selection of internees. Special thanks are to Mr. Abdul Rehman, PhD scholar, Department of Agronomy for his services to conduct the pre-internship workshop and preparation of this report.

I would also thank all the internees worked day and night to convey the message of balance nutrition for crops and to generate the information on prescribed format.

Abdul Wakeel

Appendices

List of Internees selected for IPI internship in Pakistan during 2015

FFC		ENGRO FERTILIZERS	
Name	**Internship Area**	**Name**	**Internship Area**
Hinnan Khalid	Faisalabad-Lab	Muhammad Ashar Ayub	Faisalabad
Imran Ramzan	Faisalabad	Jabir Riaz	Faisalabad
Dawood Khizer Khan	Faisalabad	Muhammad Waqas	Multan
Umar Farooq	Multan	Zulfiqar	Multan
Muhammad Khalid	Multan	Maria Mehmood	Multan-Lab
Mansoor Iqbal Ansari	Khairpur Mirs	Mahendar Kumar	Tando Allahyar
Mujeeb-ur-Rehman	Ghotki	Nizakat Abbas aghari	Matiari

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