Optimizing Crop Nutrition

INTERNATIONAL POTASH INSTITUTE

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Electronic International Fertilizer Correspondent (*e-ifc*). Quarterly correspondent from IPI.

## Editorial

Dear readers,

At IPI we often discuss the issue of "Food Security". These days, to the dismay and concern of many, during the latter part of 2010 and into 2011, we are seeing the commodity-price index rising rapidly once again, to beyond the peak levels of 2007/2008. Is the phenomenon of high food prices likely to become a more frequent occurrence?

Some claim that the sufficient amount of food produced globally is not adequately distributed; others show that the increase in cereal productivity is declining and is insufficient to meet the demands of an increasing population; others blame biofuels and commodity speculators in the hiking of prices. Most of these arguments will be used in the future and it is likely that there is more than one contributory factor. So what should be done? No silver bullets are available, at least not yet. From our point of view, IPI is convinced that improved management of existing crops will provide greater yields. For example, you can read in this edition of *e-ifc*, a paper on the wide-scale application of nutrient management to soybean in India (Dixit *et al.*) and the impact it can have at a regional level. Clearly, what can be achieved with "best management practices", instead of the practices used by uninformed farmers, has the potential to significantly increase productivity and food availability for the world. Improving food security means, from our perspective, appropriate application of fertilizers to achieve the yield potential.

*Photo by IPI.*

A report from Brazil on "Experiments on fertilization of no-till systems in the Brazilian Cerrado; Potash fertilization of cover crops and its potential for the following soybean crop", is featured in this issue along with a report from Pakistan on "Impact of Alluvial Deposits on Soil Fertility during the Floods of 2010 in Punjab, Pakistan". Updates of events and new scientific publications are provided.

We also have some exciting news about our IPI website (see the home page and the regional pages), where we have now posted all IPI projects on maps to allow readers to easily see where our projects are located and IPI is most active. Please contact the IPI regional coordinators if you wish to have more details on any specific project.

I wish you all an enjoyable read. ■

Hillel Magen

Director

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# Research Findings

## Experiments on Fertilization of No-Till Systems in the Brazilian Cerrado. Part I. Potash Fertilization of Cover Crops and its Potential for the Following Soybean Crop

*Naumov, A.*[(1)], *V. de M. Benites*[(2)], *M. Betta*[(3)], *and G.V. Gomez*[(3)].


*Location of IPI-EMBRAPA experiments in the Brazilian Cerrado.*

### Introduction

Since the 1970s, when Brazilian farmers started to practice no-till in the state of Parana, this form of cultivation has spread rapidly throughout the country. It currently accounts for approximately 26 million ha, or more than 40 percent of the total national area under seasonal crops (FEBRAPDP, 2008). The rapid expansion of no-till across states, which are the main producers of soybean and maize (Parana, Santa Catarina, Rio Grande do Sul in the Southern region and Goias, Mato Grosso, Mato Grosso do Sul in the Central-Western region of the country), has meant that Brazil has become one of the world's leaders in no-till practice, approaching that of the acreage in the United States of America in 2005/2006.

Despite these impressive statistics, official data on no-till area is often criticized by analysts. The critics consider that only 20-30 percent of the 26 million ha are under "real" no-till systems, i.e. without any preparation of soil before planting, with constant rotation of crops and/or with integration of planting and pasturing, and with permanent soil coverage by using crop residues (straw) or growing cover crops. Improving no-till practices, together with the spread of precise technologies for fertilization, herbicides application, and machinery use, has thus become a constant quest for Brazilian farmers and the agronomic scientific community. As Brazil is a country with a vast agricultural area (264 million ha; FAOSTAT, 2008), and with significant geographical differences between regions, improvement of no-till technologies strongly depends on the adaptability of these technologies to local soils and climatic conditions.

Since 2001, in cooperation with the National Soils Research Center of EMBRAPA (Empresa Brasileira de Pesquisa Agropequaria, or Brazilian Agricultural Research Corporation) and with several other regional units of EMBRAPA, the International Potash Institute (IPI) has been carrying out fertilization experiments (with special focus on potash) of no-till systems in various Brazilian states (see map above). All experiments were established in different parts of the *Cerrado* (the tropical savanna region), where some 60 million ha have been converted to cropping and pastures during the past three decades. Local farmers (mostly migrants from southern Brazil) initially followed no-till practices from their home states, which were not adapted to the conditions of the *Cerrado*. One of the crucial problems has been the low efficiency of mineral fertilizer use, which influences the profitability of soybean and other commercial crop production.

Whilst establishing these experiments, the following issues relating to no-till currently practiced in the *Cerrado* were taken into consideration:

1. Most farmers apply unique NPK formulas[(a)]. As soybean and maize export up to 80 kg ha$^{-1}$ potash $K_2O$ in the yields produced, farmers simply supply the soil with this amount of the nutrient, often neglecting to take into account geographical differences in soil characteristics including texture, acidity and soil cation exchange capacity. This creates an unequal balance of potash in soil, some fields receiving more and some less than is required (Naumov and Prado, 2008).

2. Potash fertilizers (mostly KCl) are usually applied at the same time as planting commercial crops (soybean or maize) as a basal dressing at row. Soybean planting usually starts in spring (September – October), which is a rainy season, when leaching of potash

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[(a)]*E.g., 02-20-18, typical for the area of Rio Verde, Goias state, described in this paper.*

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is a common occurrence. However, if potash, or at least part of that required, is applied in advance when planting the cover crops (a common practice in the *Cerrado*) it may be steadily released into the soil as the mulch decomposes.

3. Because of the "K hunger" phenomenon of soybean which is observed at about 30 DAE (days after emergence), soil should contain a maximum amount of potash by that period of its biological cycle. Possible ways to achieve this are to split potash application (pre-plant and top dressing), or to apply herbicide to desiccate the cover crop nearer to the time of main crop planting to capitalize on the available K in the mulch.

Although it is extremely important to adjust fertilization practices to the "cover crop + main crop" system, in relation to plant cycle and rainfall regime, additionally balancing fertilization according to local geographical conditions guarantees reduction of production costs through increasing efficiency of application of potash and other nutrients[b]. It is also important to protect the environment.

This paper is the first of a series of publications in the *e-ifc*, based on results from IPI-EMBRAPA joint experiments, carried out in the southeast of Goias state, close to the town of Rio Verde, one of the fastest growing centers of Brazilian agri-business. Local farmers mostly plant soybean, maize, cotton, and some have recently started planting sugarcane. Many farmers are members of the Centro Tecnológico da COMIGO (CTC), one of the leading agricultural cooperatives in Brazil. IPI-EMBRAPA experiments in the area of Rio Verde were established at CTC and then partially reproduced on the fields of local *fazendas* (farms) for verification[c].

Below, we report the results of an experiment, carried out during 2005/2006 at CTC, to evaluate the potassium response of various cover crops and to assess their capability as a potassium source for the main crop (e.g. soybean).

## Materials and methods

Geographical coordinates of CTC are 17° 45' 49'' S and 51° 02' 03'' W, at 878 m above sea level. The climate of the region is tropical (Aw by Köppen), with an annual rainfall of 1,500-1,600 mm, a dry winter and wet summer and a typical Cerrado landscape (tropical savanna). Dystrophic latosoils, mostly clayey, predominate on the CTC experimental fields. Chemical analysis and textural composition of the soil is given in Table 1.

**Table 1.** Result of chemical analysis and soil texture (0-20 cm) before the experiment was established (average data for 20 soil samples).

| Parameter | Unit | Value |
|---|---|---|
| pH | $CaCl_2$ | 4.2 |
| CEC | cmolc $dm^{-3}$ | 6.24 |
| Ca | cmolc $dm^{-3}$ | 1.55 |
| Mg | cmolc $dm^{-3}$ | 0.29 |
| Al | cmolc $dm^{-3}$ | 0.12 |
| H + Al | cmolc $dm^{-3}$ | 4.3 |
| V | % | 31.35 |
| OM | g $kg^{-1}$ | 22.10 |
| P | mg $kg^{-1}$ | 15.13 |
| K | mg $kg^{-1}$ | 40 |
| Clay | g $kg^{-1}$ | 390 |
| Silt | g $kg^{-1}$ | 90 |
| Sand | g $kg^{-1}$ | 530 |

In September 2005, six different cover crops were planted. As Brachiaria is the main cover crop used in the region, various analyses were performed to compare its value. The cover crops were: Niger seed (*Guizotia abyssinica)*, Pearl millet (the local plant name is Milheto; *Pennisetum glaucum* cv. ADR 500), Lucern (*Stylosanthes guianenses* cv. Campo Grande), Brachiaria (*Braquiaria ruzizienses* and *Brachiaria Brizantha* cv. Marandu) and Finger millet (the local plant name is Capim Pé de galinha; *Eleusine coracana).* Cover crops were seeded manually, without any fertilization, in experimental plots of 60 $m^2$. Potash (as KCl) was applied 15 DAE at four rates of application corresponding to 0, 40, 80 and 120 kg $K_2O$ $ha^{-1}$. All treatments were replicated four times. All cover crops were desiccated 45 days after planting during the last week of October. Before desiccation, soil analysis was performed to assess K removal by the various cover crops. Potassium content in the soil was measured using the Mehlich method (Silva, 1999).

To evaluate above ground biomass of cover crops, plants were cut from an area of 1.00 $m^2$ immediately before desiccation. The material was weighed on collection, then reweighed after drying. Concentration of K in the biomass was evaluated according to Silva (1999) and the total amount of K absorbed by the crop per unit area was calculated as the product of the K concentration in the dry plant material and the dry biomass yield. For statistical evaluation of the experiment results, the Tukey test based on Genes software was applied (Cruz, 2006).

## Results

Statistical analysis obtained as result of analysis of variation of the biomass of cover crops and potash absorption showed significant differences between treatments in biomass and absorbed potash (Table 2). Clearly, Pearl millet (*Pennisetum glaucum)* cv. ADR 500 had the highest fresh and dry biomass yield (Table 3). The reason for the large differences between the cover crops is the relatively short period of planting; most crops were not completely developed before desiccation, in contrast to the fast-growing Pearl millet. Of all the cover crops tested, Pearl millet produced the highest amount of dry biomass during this short period – 4.49 mt $ha^{-1}$ (Table 3). This value is

[b]*In 2005-2007, farmers' expenditures for mineral fertilizers corresponded to 30% and more of total production costs, and 7-9% for potash fertilizers. In 2008, the share of fertilizers in total production costs grew to 40-50%.*

[c]*Scientists from the Federal University of Rio Verde (FESURV), and from the Center for Technical Education (CEFET), were also involved in the experiments.*

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more than 2.5 fold greater than any of the other five crops. Apart from Pearl millet, the other cover crops did not produce amounts of biomass comparable with the biomass yield reported by other authors[(d)]. The K concentrations in the dried biomass of the six tested crops ranged from 2.93 to 3.97 percent K, this range being much lower than that for biomass production. Thus, although the K concentration in the biomass in *Braquiaria brizantha* (the main cover crop used in the region) ranked first among six tested cover crops, the quantity of K absorbed per hectare, was only about 52 kg $ha^{-1}$ as compared with Pearl millet with the highest value of all the crops at 138 kg $ha^{-1}$. This greater than 2.5 fold difference in K uptake stresses again the importance of the higher biomass production of Pearl millet of the six crops. Pearl millet was the fastest of the six tested crops to develop during the 45 days after planting, at which stage all the crops were simultaneously desiccated. By comparison, Finger millet, according to Boer *et al.* (2007), can take up substantial amounts of potash in its biomass corresponding to 55.3 kg K $ha^{-1}$ but only 66 days after being planted, which is still a much lower K uptake than that for Pearl millet.

In relation to doses of potash fertilizer, there was no effect to increasing doses of potash on the biomass yield of all cover crops, even though there was a significant effect on K concentration in biomass and for the total absorbed K (Table 2). As an example, a linear correlation is shown for K application rate and K concentration and uptake by Brachiaria (Fig. 1).

**Table 2.** Statistical analysis (F value) obtained as result of analysis of variation of biomass of cover crops and potash absorption as a function of different treatments.

| Reasons variation | Fresh biomass | Dry biomass | Concentration of K in biomass | Total absorbed K in biomass |
|---|---|---|---|---|
| Cover crop (C) | 56.32** | 59.06** | 11.68* | 39.36** |
| K doses (D) | 2.06 ns | 2.06 ns | 15.03* | 4.52** |
| C x D | 0.88 ns | 0.88 ns | 1.54 ns | 0.97 ns |
| CV% | 43.45 | 40.48 | 13.29 | 43.49 |

*Notes:* CV – coefficient of variation. *significant at the level of 5%; **significant at the level of 1%; ns – not significant.

**Table 3.** Average values (for all K doses) of biomass and K content in biomass of different cover crops.

| Cover crops | Fresh biomass yield | Dry biomass yield | Concentration of K in biomass | Total absorbed K in biomass |
|---|---|---|---|---|
| | -----------*mt* $ha^{-1}$----------- | | % | *kg K* $ha^{-1}$ |
| Brachiaria *(Braquiaria brizantha)* cv. Marandu | 5.37 bc | 1.13 bc | 3.97 a | 51.64 b |
| Brachiaria *(Braquiaria ruzizienses)* | 9.38 b | 1.82 b | 3.72 ab | 48.88 b |
| Finger millet *(Eleusine coracana)* | 8.13 bc | 1.49 bc | 3.54 abc | 42.14 b |
| Pearl millet *(Pennisetum glaucum)* cv. ADR 500 | 25.85 a | 4.49 a | 3.09 bc | 138.00 a |
| Niger seed (*Guizotia abyssinica)* | 12.69 b | 1.67 bc | 3.64 ab | 45.87 b |
| Lucerne *(Stylosanthes guianenses)* cv. Campo Grande | 1.13 c | 0.31 c | 2.93 c | 10.57 c |

*Note:* The values, matched with the same minor letters do not differ statistically according to the statistical test (Tukey method) at the level of 5% of probability.

Soil tests, made once cover crops are full grown but before desiccation, showed significant differences in K content in the soil as a result of different cover crops, at the depth of 10-20 and 0-40 cm (Table 4). Uptake of K by Pearl millet significantly decreased K in the soil profile (0-40 cm) and reduced available K from 40 to 17 ppm only. In all cover crops, due to their extensive root zone, no significant change in K soil was found at the 0-10 cm layer.

The lowest value of K content in the soil was verified for Pearl millet for all doses of potash fertilizer. This can be explained by the highest extraction of soil K resulting from the high biomass produced through its well developed root system. There was no evidence of high accumulation of K in the soil with increased doses of potash fertilizer. Potash absorption from the soil by Lucerne was low, which correlated to the small amount of biomass production. At higher doses of applied potash fertilizer, more potash accumulated in the soil under this crop (data not presented).

### Discussion

Biomass production to provide vegetative cover for the soil is one of the fundamental elements for no-till systems. These plants, which grow rapidly and produce a high amount of biomass, are essential for sustaining crop rotations in no-till systems. Besides providing organic matter to the system, these plants facilitate recycling

[(d)] *Values of dry biomass of Pearl millet and of Braquiaria brizanta were similar to those observed by Torres* et al. *(2005), when cover crops were planted during decreased rainfall (3.6 and 2.1 mt* $ha^{-1}$*). Sodré Filho* et al. *(2004) obtained even lower values of the dry biomass than in the described experiment (1.89 mt* $ha^{-1}$*) because of adverse climatic conditions.*

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of nutrients, often extracted from deep soil layers.

The results of this experiment show that Pearl millet is the best cover crop for local no-till systems, from the viewpoint of its ability to extract large amounts of K from deeper soil layers and to make it available to the following target crop (soybean); for Pearl millet this was 4.49 mt $ha^{-1}$ with K absorption of 138 kg $ha^{-1}$ (both values were more than 2.5 fold greater than any of the other five cover crops tested). This conclusion takes into account the short period available for cover crop growth (approx. 60 days).

The increase of K contents in biomass as a function of potash fertilization shows that such plants as Pearl millet and different kinds of Brachiaria are efficient in transferring potash from fertilizer to the biosystem. Once absorbed by the cover crop, potash may be rapidly recycled into the soil, as it is retained almost totally as K ions in cells and tissues. It is also known that the potash turnover rate after cover crops are grown is very fast (Boer *et al.*, 2007). The quantity of potash absorbed and taken up into the biomass of Pearl millet exceeded that needed for soybean. The release of this potash occurs slowly but fast enough to enable its absorption by the main crop (soybean). The use of cover crops as recyclers of potash may be a good strategy to increase the efficiency of the use of potash fertilizers in (geographical) regions, where the precipitation regime allows adoption of this practice. Superficial application of potash fertilizer also reduces the risk of salinization of the root environment, which happens when fertilizer is applied in rows.

In terms of "recycling" K, and other nutrients, from cover crop to target crop, it is also important to take weather conditions (rainfall regime) into consideration. In the case of low rainfall during the cover crop cycle, biomass production of the cover crop (and nutrients contents in mulch) may be low because of dry soil conditions. On the other hand, high rainfall at the end of the cover crop cycle may cause nutrient losses by leaching. Another important aspect to be considered is the presence of diseases and pests. Nematodes are a typical problem which, depending on crop species, could be controlled by the cover crop. In this respect, special attention needs to be given to the selection of crop species used.

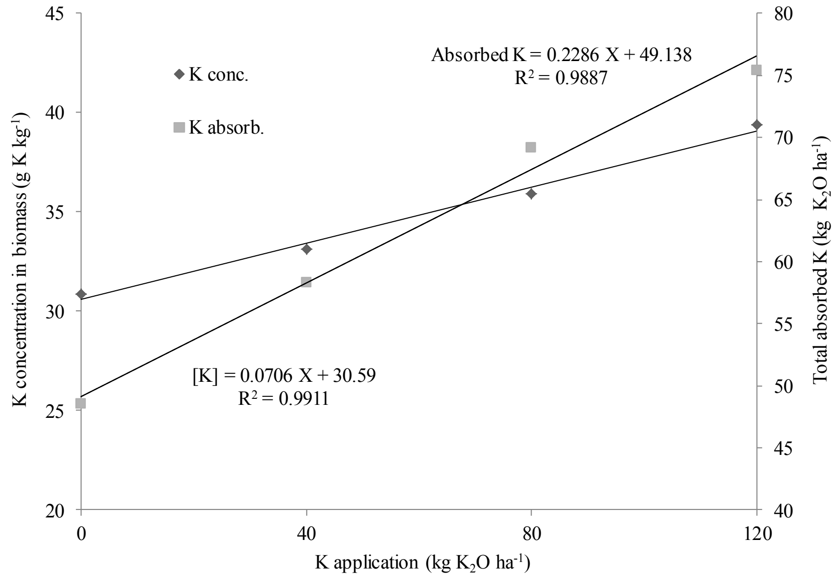


**Fig. 1.** Relation between K added and the concentration of K in biomass and total K absorbed by cover crops. These results are the average concentration of K in biomass for all six cover crops. Each value on the graph represents the average for 24 experimental parcels (6 crops x 4 replicates).

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**Table 4.** Average contents of K in the soil at three depths, for all treatments, before desiccation of the cover crops.

| Cover crops | K in the soil (cm; mg $kg^{-1}$) | | | |
|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 0-40 |
| Brachiaria *(Braquiaria brizantha)* cv. Marandu | 43.3 a | 23.19 ab | 15.5 a | 24 ab |
| Brachiaria *(Braquiaria ruzizienses)* | 32.19 a | 21.63 ab | 13.44 a | 22 ab |
| Finger millet *(Eleusine coracana)* | 39.81 a | 27.0 a | 14.56 a | 27 a |
| Pearl millet *(Pennisetum glaucum)* cv. ADR 500 | 22.2 a | 16.88 b | 12.31 a | 17 b |
| Niger seed (*Guizotia abyssinica)* | 40.0 a | 26.25 ab | 15.56 a | 27 a |
| Lucerne *(Stylosanthes guianenses)* cv. Campo Grande | 34.19 a | 25.69 ab | 14.96 a | 25 ab |
| CV % | 47.28 | 38.09 | 22.12 | 30.71 |
| F-test | ns | * | ns | ** |

*Notes:* CV – coefficient of variation; the values, matched with the same minor letters do not differ statistically, according to the statistical test; *significant at the level of 5%; **significant at the level of 1%; ns – not significant.

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**The paper "Experiments on Fertilization of No-Till Systems in the Brazilian Cerrado. Part I. Potash Fertilization of Cover Crops and its Potential for the Following Soybean Crop" appears also at:**

Regional Activities/Latin America

Residues of cover crop (*Brachiaria brizantha)* in soybean crop. Photo by V. Benites.

# Research Findings

## Assessment of Potassium Nutrition in Soybean for Higher Sustainable Yield in Medium Black Soils of Central India

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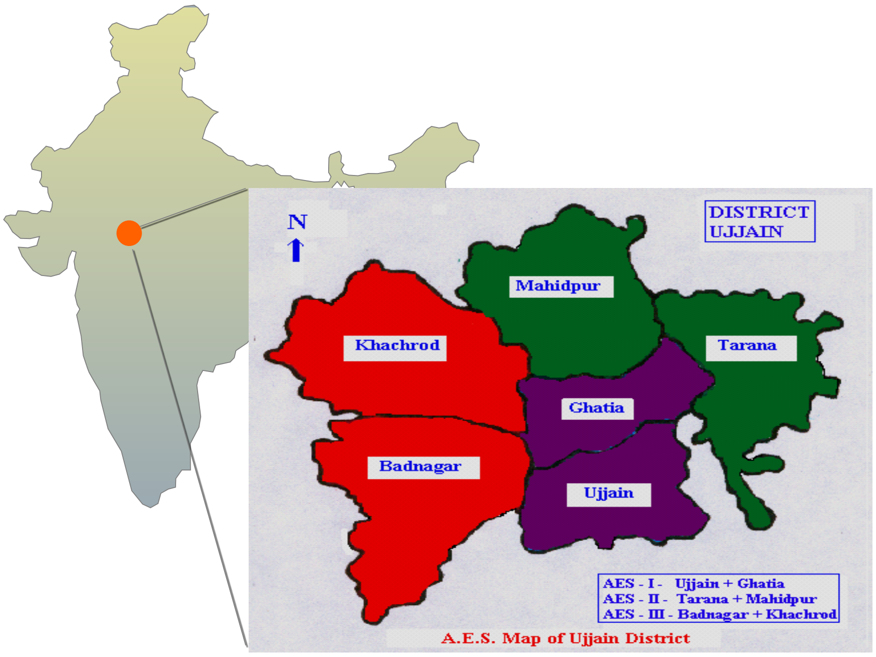


*Agro-ecological situations in the Ujjain district.*
*Source: Directorate of Agriculture, Government of Madhya Pradesh, India.*

### Introduction

Soybean is a major oil and protein crop important in both human and animal nutrition. Rising demand for oil and protein has stimulated soybean production mainly by increasing land use, as very modest growth in productivity has been achieved (Table 1). Soybean covers an area of about 98.8 million hectares (ha) worldwide, of which 90 percent is concentrated in the US, Brazil, Argentina, China and India. The latter contributes 8 percent of the world area (7.8 million ha). India's figures show the lowest productivity (1,064 kg $ha^{-1}$) compared to a world average of 2,249 kg $ha^{-1}$ (FAOSTAT, 2011). In comparison to 2007, these figures demonstrate a slight decline against the world average but reveal an increase in productivity in India.

**Table 1.** All India, Madhya Pradesh state and Ujjain district soybean production figures, 2006-2010.

| Year | All India | | | Madhya Pradesh | | | Ujjain District | | |
|---|---|---|---|---|---|---|---|---|---|
| | Area | Production | Yield | Area | Production | Yield | Area | Production | Yield |
| | *'000 ha* | *'000 mt* | *kg $ha^{-1}$* | *'000 ha* | *'000 mt* | *kg $ha^{-1}$* | *'000 ha* | *'000 mt* | *kg $ha^{-1}$* |
| 2006-07 | 8,320 | 8,850 | 1,063 | 4,705 | 4,789 | 1,019 | 430 | 468 | 1,087 |
| 2007-08 | 8,880 | 9,990 | 1,124 | 5,202 | 5,368 | 1,033 | 432 | 513 | 1,189 |
| 2008-09 | 9,510 | 9,910 | 1,042 | 5,295 | 5,924 | 1,120 | 444 | 628 | 1,416 |
| 2009-10 | 9,607 | 10,050 | 1,046 | 5,349 | 6,406 | 1,199 | 444 | 671 | 1,511 |

Madhya Pradesh (MP) is generally known as the soybean state of India as it is a leading region in soybean production both in terms of area and productivity (70 and 64 percent respectively) covering 4.8 million ha and producing 1,120 kg $ha^{-1}$ (Table 1). Soybean production in Ujjain district accounts for approximately 10 percent of the state area for soybean, with productivity slightly above that of the state average (Table 1). In a Participatory Rural Appraisal (PRA) conducted in 2007 by the Krishi Vigyan Kendra (KVK) in Ujjain district, the following specific factors were assessed as the cause of low yield:

1. Using a very high seed rate (up to 125 kg $ha^{-1}$) in comparison to the recommended seed rate of 70 to 80 kg $ha^{-1}$, depending upon the seed index. This results in overcrowding of plants causing poor growth, high insect pest incidence and hence a problem of non-bearing.

2. The normal row – row spacing for early maturing, non-spreading varieties is 30 cm, and 45 cm for those which are of long duration and spreading type. Irrespective of variety, farmers use a spacing of 25-30 cm.

3. Burning stubble in the field and non-utilization of organic matter / Farm Yard Manure (FYM) at the recommended rate of 5-10 mt $ha^{-1}$ have resulted in soil compaction with reduced fertilizer use efficiency.

4. Greater use of N and P fertilizers without use of K, S and Zn.

5. Broadcasting DAP at 20-25 days after sowing at the time of intercultural operations or mixing DAP with seed at sowing.

6. Heavy weed population due to use of un-decomposed FYM, a lack of integrated weed management measures, and monocropping.

With the improvement of land productivity through the adoption of high-yielding varieties and multiple

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# Research Findings

cropping systems, fertilizer use has become more and more important to increase oil crop yield and quality. The slow pace of growth in soybean productivity is more or less linked to imbalanced and inadequate nutrition being provided for this energy rich crop (Joshi, 2007). Potassium is known as one of the nutrients which is closely involved in metabolic processes and improves yield (Imas and Magen, 2007 and Basseto *et al*., 2007). Long-term experiments conducted in India showed decline in crop yields as a result of potassium deficiency (Rupa *et al.*, 2003). As most of the kharif soybean is grown under rain-fed conditions, soybean experiences water and temperature stresses of varying degrees, particularly at the stage of pod filling. Yield is thus ultimately affected and the relevance of K nutrition in alleviating stress conditions assumes great importance (Tomar and Dwivedi, 2007). The annual consumption of N, P and K fertilizer per ha is in the ratio 8.5:6.9:1 against an ideal of 4:2:1. The potassium fertilizer in the district is applied at a rate of 1.4 kg $ha^{-1}$ in kharif and 6.8 kg $ha^{-1}$ in rabi.

An increased occurrence of K deficiency in soybeans and the potential widespread onset of Asian rust (SBR) (*Phakopsora pachyrhiza*) in the crop have stimulated interest in new management practices that may improve K nutrition and lower disease incidence. Yield loss estimates for this fungal disease range from 10 to 80 percent in areas where rust is established and could result in huge economic losses.

*Monitoring the experiment in the field. Photo by A.K. Dixit.*

*Potassium balance in soybean based cropping systems*

Consideration of K balance in soybean based cropping systems has served as a rationale behind promoting balanced use of K. Based on the findings of long-term fertilizer experiments across the country, the majority of cropping systems being practised result in a negative K balance since K application seldom matches K removal. Under such conditions, there is greater demand on soil K reserves to meet crop K requirement. In soybean-wheat-cowpea on Vertisols, the total uptake of K by the crops far exceeds the amount of K applied. The plots which did not receive K fertilizer (control, N and NP) under continuous cropping with soybean-wheat showed a greater contribution of soil reserve K to crop uptake, thereby indicating a state of continuous stress on the soil system to meet the K requirements of the crops. The Vertisols and vertic type of soils which predominate in the soybean growing area did have high levels of available K but low reserves of K. These soils were thus able to raise crops without fertilizer K but they are being depleted. Shallow Vertisols of Madhya Pradesh are not self -fertilizing and are hence in need of fertilizer K application (Subbarao *et al.*, 2008).

**Methodology**

KVK Ujjain is engaged in the dissemination of technology to the farming community to boost agricultural production by restoring the natural fertility status of soils. The Ujjain district is located at $20^{\circ}$ 43' to $23^{\circ}$ 36' latitude and longitude of $75^{\circ}$ - $76^{\circ}$ 30' at an altitude of 527 meters above mean sea level. It falls within the $X^{th}$ Agro climatic Zone, i.e. Malwa Plateau and Agro-ecological. The study was carried out in Ujjain district of Madhya Pradesh, India during kharif 2008 in Agro-Ecological Situation I (AES-I; see map) on five farmers' plots of the Ujjain and Ghatiya block counties of the district Madhya Pradesh.

In the region of the experiment, the common practice of farmers is to apply 100 kg DAP only to soybean and 125 kg of N:P:K fertilizer in the form of 12:32:16 (Indian Farmers Fertiliser Cooperative Limited, IFFCO grade) in wheat only. Hence in the soybean-wheat cropping system in the region, it is only wheat that receives a modest application of potash (approx. 20 kg $K_2O$ $ha^{-1}$). On the basis of the PRA conducted in 2007, KVK concluded that the most prominent cause of low yield (average 10.40 Q $ha^{-1}$) was the imbalanced use of fertilizers including inadequate use of potash in the soybean-wheat cropping system. Farmers do not, in fact, follow the guidelines provided by the

# Research Findings

Directorate of Soybean Research (DOSR, 2007), in which the recommended rate of N, $P_2O_5$, $K_2O$ and S is 20:80:40+20, respectively, as part of the Integrated Nutrient Management System (INMS) that is advocated.

**Table 2.** Effect of potassium fertilization on growth and yield of soybean (2008).

| Treatment | K level | Plant height | Branches / plant | Nodules / plant | Nodule dry Wt./ plant | Pods / plant | Test Wt.(1) | Grain yield | Straw yield | H.I. |
|---|---|---|---|---|---|---|---|---|---|---|
| | *kg ha⁻¹* | *cm* | *No.* | *No.* | *mg* | *No.* | *g* | ----*q ha⁻¹*---- | | *%* |
| T1 (FP) | 0 | 40.68 | 3.05 | 21.45 | 67.4 | 28 | 11.1 | 12.2 | 25.7 | 47.4 |
| T2 | 20 | 41.38 | 3.45 | 26.93 | 87.29 | 30.9 | 11.78 | 13.2 | 27.5 | 48.12 |
| T3 | 40 | 51.26 | 3.96 | 30.27 | 114.84 | 37 | 12.8 | 15.5 | 29.5 | 52.6 |
| SEm± | | 1.61 | 0.16 | 0.99 | 1.83 | 1.31 | 0.20 | 0.35 | 1.28 | 1.52 |
| t value at error DF (0.05) | | 2.31 | 2.31 | 2.31 | 2.31 | 2.31 | 2.31 | 2.31 | 2.31 | 2.31 |
| CD (P=0.05) | | 3.70 | 0.36 | 2.29 | 4.21 | 3.03 | 0.47 | 0.81 | 2.94 | 3.50 |

(1)weight of 100 seeds.

The aim of the work was to assess potash application to soybean crop and compare farmers practice (K=0), the DOSR rate (20) and a higher dose of K (40 kg $K_2O$ $ha^{-1}$). The average soil test values for available N, P and K in the soil were 186, 9.4 and 289 kg $ha^{-1}$ respectively.

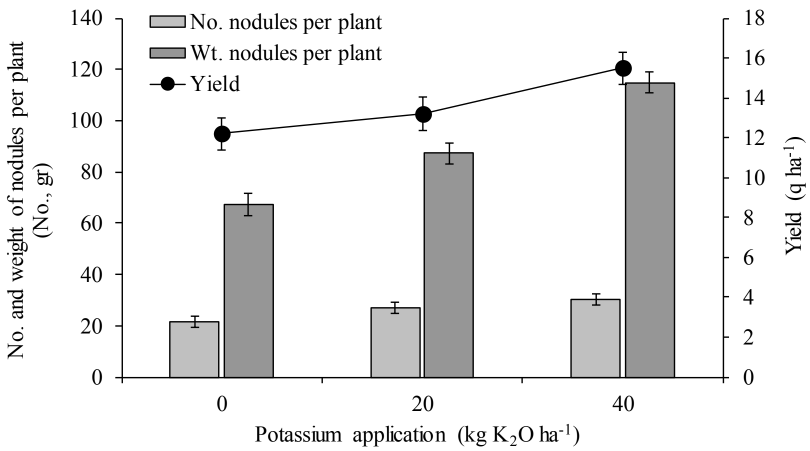


**Fig. 1.** Effect of potash application on the number and weight of plant's nodules. Error bars represent CD at P=0.05.

### Result and Discussion

The data in Table 2 reveal that all the growth parameters, i.e. plant height, branches per plant, number of nodules per plant, nodule dry weight, pods per plant, test weight (weight of 100 seeds), grain and straw yield and the harvest index were significantly affected by the application of 40 kg $K_2O$ $ha^{-1}$, in comparison to the farmers' practice where there was no application of $K_2O$. The most noticeable impact is evident in the increase in the number of nodules per plant and dry weight (Fig. 1), increasing by approx. 50 percent over K=0. This effect on nodules may allow for more biological nitrogen fixation and hence better yield (Fig. 1). The yield levels attained in the experiment (Table 2, Fig. 1) are higher than the average productivity of M.P. (Table 1).

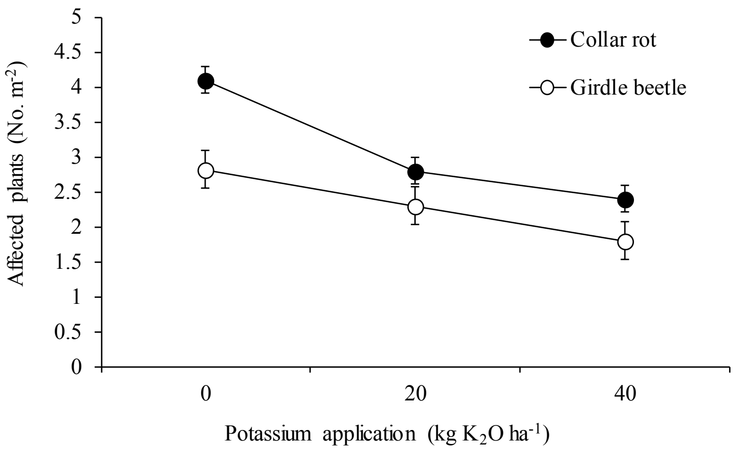


**Fig. 2.** Effect of potash application on the number of plants affected by collar rot disease and girdle beetle. Error bars represent SEM.

Potassium plays a significant role in several physiological and biochemical processes in the plant: it activates more than 60 enzymes; it is essential for photosynthesis and the carbohydrates generated provide the energy needed by nodule bacteria to fix atmospheric N; it also enhances the translocation of carbohydrates to roots and is itself transported to roots where it stimulates new root hair formation as well as nodule development (Mengel and Kirkby, 1980).

The positive effect of K application on resistance of soybeans to pests and disease was already reported for the region (*e-ifc* No. 11, 3/2007). Data

# Research Findings

presented in Fig. 2 from this experiment indicate that the two major biotic stresses encountered at the earlier stages of crop growth are collar rot (*Sclerotium rolfsii*) and girdle beetle attack. The incidence of both is increasing enormously due to imbalanced nutrition and monocropping but can be controlled by the application of K. Our findings show that the number of plants per $m^2$ infected by disease and insect attack decreased in the recommended practice (RP) from 4.6 to 2.4, and 3.03 to 1.8, respectively, a drastic reduction in the incidence of these biotic stresses, which was also accompanied by yield increase.

The profitability of potash application was calculated through the agronomic efficiency of potash application and the changes in income and costs (Table 3). In our experiment, K use efficiency increased with K application, which suggests that higher application of potash should be tested. At 8.25 kg grain for each kg $K_2O$ applied, application of 40 kg $K_2O$ $ha^{-1}$ brings an additional net income of Rs. 5,970 per ha, or an Incremental Cost Benefit Ratio (ICBR) of 15.06, which should be very lucrative for farmers.

**Table 3.** Agronomic efficiency and profitability of potassium application in soybean.

| Treatment | K level | Efficiency and profitability | | |
|---|---|---|---|---|
| | | Agronomic efficiency ($AE_K$) | Net return | ICBR |
| | *kg ha⁻¹* | *kg grain / kg $K_2O$* | *Rs. ha⁻¹* | |
| T1 (FP) | 0 | 0 | 13,680 | 0 |
| T2 | 20 | 5.10 | 15,632 | 9.53 |
| T3 | 40 | 8.25 | 19,650 | 15.06 |

ICBR: Incremental Cost Benefit Ratio (Rs.). The ratio between the increment in yield's income and the cost of used potash. The cost of kg $K_2O$ is Rs. 7.71.

### Dissemination and spread of technology – a huge potential for increased income to farmers

Based on the trial under a real farm situation, the data in Table 4 indicate that by using the recommended doses of potash, together with the other two major nutrients, farmers can increase productivity 8 to 27 percent above the present levels merely by incorporating potash-based fertilizers, which cost Rs.772 per quintal of $K_2O$, i.e. Rs 154 to 308 per ha when using doses as described in treatments T2 and T3, respectively. Overall the region could expect additional revenue as shown in the last column of Table 3. It is a feasible target owing to the very negligible increase in the cost of cultivation.

*Horizontal Spread*

Looking into the benefits of the technology farmers in the coming years could adopt this technology and scientific recommendation. The data in Table 4 reveal the calculated direct impact of the technology in terms of the additional production, total increase in income, and the contribution of the technology in terms of total revenue generated. This reflects the economic sustainability of the technology if adopted by farmers.

*Applicability*

As Soybean is now the most economic crop of the Malwa Plateau zone during kharif season the economic scenario for farmers has consequently changed over the last two decades. However, previous gains are not sustainable today, because of increasing costs of production and yield stagnation, although the genetic potential of varieties under cultivation is more than 2.5 mt $ha^{-1}$. Keeping this in view, and the suitable technology available for yield enhancement, farmers are realizing the importance of K nutrition in soybean in achieving excellent yield increases, as well as better economic crop returns.

*Sustainability*

Almost the entire area under soybean cultivation is sown with improved varieties of high production potential. However, as a consequence of the soybean-wheat cropping sequence and injudicious use of fertilizer, soil health has deteriorated. On the basis of soil testing data, the area has been categorized with a net negative balance for the major nutrients, as well as secondary and micro-nutrients, such as S and Zn. From on farm trials, farmers have been fully satisfied and in agreement with the importance of applying K to soybean. Hence this technology is more sustainable owing to its better performance in terms of yield, high return and low cost.

*Equitability*

The result of K application to soybean at 40 kg $K_2O$ $ha^{-1}$ assessed in different locations in similar agro-ecological situations has showed that yield increments were almost the same in all plots with a variation of 2.55 percent between minimum and maximum yield. Hence, the result has the characteristics of equitability.

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**Table 4.** Horizontal spread of technology and the annual revenue generation in the district of Ujjain.

| Treatment | K level | Net sown area | Productivity | Total production | Additional yield | Additional expenses | Additional profit |
|---|---|---|---|---|---|---|---|
| | *kg ha⁻¹* | *ha* | *q ha⁻¹* | *q* | --------------*Rs.Crore* | ------------- | |
| T1 (base line) | 0 | 450,000 | 12.20 | 5,490,000 | 0 | 0 | 0 |
| T2 | 20 | 450,000 | 13.24 | 5,958,000 | 468,000 | 9.65 | 58.5 |
| T3 | 40 | 450,000 | 15.50 | 6,975,000 | 1,485,000 | 20.00 | 165.63 |

# Research Findings

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**The paper "Assessment of Potassium Nutrition in Soybean for Higher Sustainable Yield in Medium Black Soils of Central India" appears also at:**

Regional Activities/India

*Farmers' day in the experiment's region. Photo by A.K. Dixit.*

# Research Findings

## Impact of Alluvial Deposits on Soil Fertility During the Floods of 2010 in Punjab, Pakistan

*Ahmad, Z.*[(1)].

### Abstract

Flooding of the Indus River in Pakistan during July-August 2010 was the most intense in the area during the last 75 years. Flooding affected an area around 160,000 km$^2$, covering around 0.75 million hectares of cultivated land in Punjab province. On average, a layer of fine mud and silt, about 15 cm thick, was deposited on the soil surface, which is expected to have affected the soil fertility status of the affected areas.

In a bid to assess the impact of flooding on the soil fertility status, samples were taken from 146 selected sites across districts declared "flood affected" by the Government of the Punjab. Depth of deposited material was noted at each site as the soil samples were collected. These samples were then analyzed using the routine methods of the Engro Soil Testing Laboratory, Multan, and the Soil and Water Testing Laboratory, Lahore. The data obtained were subjected to descriptive statistical analysis to interpret the results.

It was noted that the depth of transported mud ranged from 2.5 cm to 30 cm, with higher values recorded for areas along the Indus River in comparison to areas affected by other rivers. It was observed that the combined effect of transported material and flooding resulted in a reduction in the risk of soil salinity and alkalinity in affected areas. The uppermost soil layer deposited after flooding was found to contain relatively lower values of organic matter and soil test P, while values of soil test K and saturation percentage were higher in comparison to the results obtained for the native soil lying beneath.

For early rehabilitation of such soils, it is recommended that they should be deep plowed and manured to improve their physical condition. In relation to fertilizer application, rationalization of resources in favor of N and P application at the cost of K addition is also recommended, at least in the short-term. A site specific approach should be adopted in assessing K requirements of high K demanding crops, such as sugarcane and orchard fruits, prevalent in these areas.

[(1)]*Engro Fertilizers Limited, Karachi, Pakistan.* smdonorth@engro.com.


*The IRS in Pakistan, flooding areas and sampling sites.*

### Introduction

Soils of the Indus Basin, which constitute about 70 percent of the total cultivated area (~27 million ha) of Pakistan, have developed predominantly over the centuries by the deposition of alluvial material transported through water carried by the River Indus and its tributaries. The "Indus Rivers System" (IRS) is the collective name given to the River Indus and its five tributaries in Punjab i.e. Jhelum, Chenab, Ravi, Sutlej and Beas, and Kabul in Khyber Pakhtunkhawah province (NDMA-UNDP, 2010 (see map above). This system originates from vast areas of the Himalayan, as well as the Karakoram and the Hindu Kush, mountain systems, where water flows at high speed until these streams enter the plains (Rehman and Kamal, 2005). The water flowing in these streams originates from a variable mix of sources, including subsurface fountains, melting ice, and rainfall in catchment areas etc.

There are two basic reasons which make the water flowing in these streams a source of enriching plant nutrients for the cultivable lands of the Indus Basin: i) The geologically active and structurally unstable nature of the Himalayas gives rise to large quantities of loose material that is transportable as suspensions in flowing water, and ii) The transport of these waters across the vast spread of plains at negligible gravitational levels which allows the suspensions to settle.

In addition to normal water flow in the

# Research Findings

IRS, and its controlled distribution on cultivable lands of the Indus basin, floods are a frequent seasonal phenomenon that provides occasional impetus to the process of soil formation described above. Floods occur mostly during summer, when the combined effect of monsoon rainfall in catchment areas and increased snowmelt due to elevated temperatures result in increased water flows, which are far beyond the capacity of these streams. The consequence of this is water overflow from streams, which spreads to adjacent areas. Here it is finally leached, or evaporated over time, leading to an impact on the productivity of these soils by the deposition of suspended material. In the short-term, floods are generally destructive in nature for standing crops, water distribution and other agricultural infrastructure, as well as for livestock and humans dwelling in affected areas. In the long-term, however, floods are considered as an important factor in the process of soil formation and a source of enhancing soil productivity due to deposition of fresh alluvium, which is free of excessive soluble salts and rich in minerals, especially potassium (K).

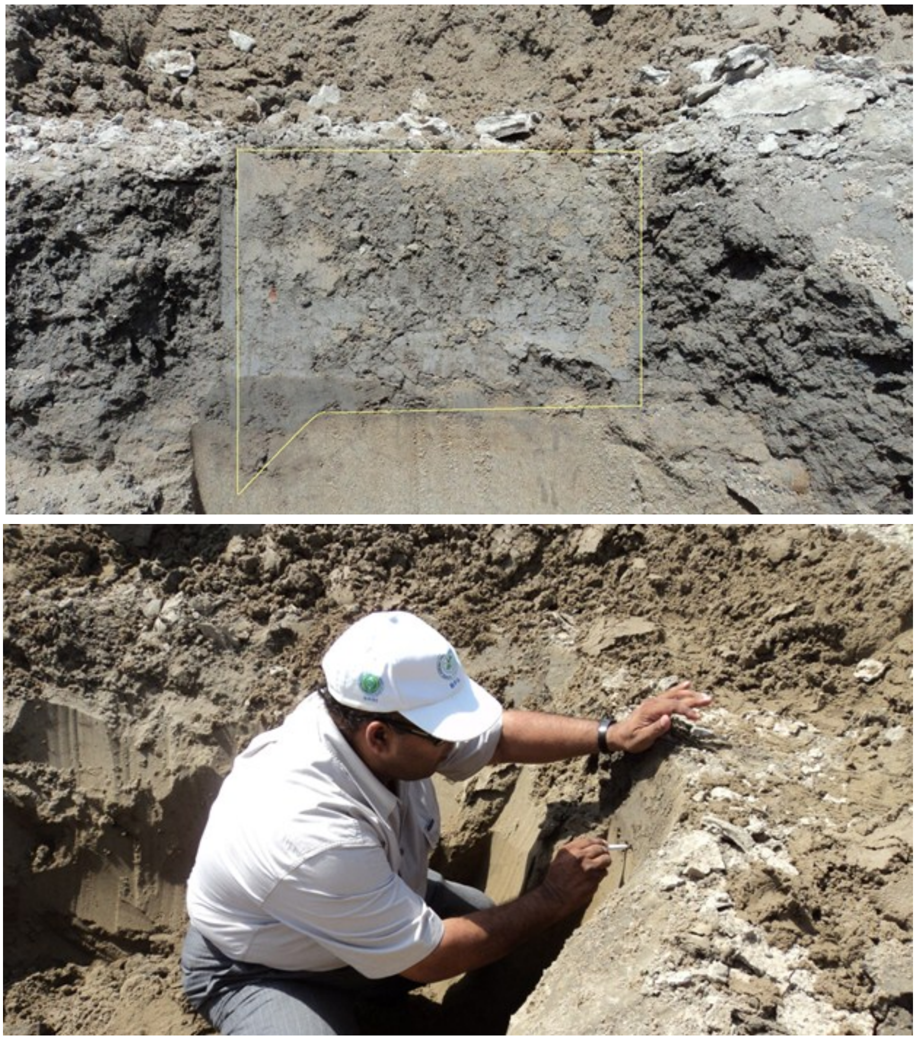

***Photo 1.*** *Distinction and measurement of deposited material in Muzaffargarh area (top) and in Dera Ghazi Khan area (bottom). Photo by Z. Ahmad.*

A historical review of floods in Pakistan reveals that traditionally floods mostly occurred due to high monsoon in catchment areas of IRS tributaries rather than the Indus River itself, which is mostly considered to contain water originating from snowmelt and which remains largely unaffected by monsoon flashes. During 2010, however, the tributaries were mostly docile while the Indus itself became vibrant due to high rainfall in its direct catchment areas during the second fortnight of July. It may be noted that more than half of the total monsoon rainfall in the Indus and Kabul catchment areas occurred in just one week (the 28th July to the 4th of August 2010) while the total monsoon span is generally three months. It was impossible for the Indus River to cope with this amount of water in such a short period, which was about eight to ten times higher than the normal amount expected at this time of year. The result was also unprecedented. The area flooded is estimated to be the most extensive in the known history of floods in the IRS during the last 75 years: A total area of 160,000 km$^2$ is estimated to have been affected by these floods, in comparison to about 90,000 km$^2$ during 1976, which is considered to be the highest area of flooding prior to the 2010 flood.

The objective of this report is to assess the impact of the 2010 floods on soil quality in affected areas in the Punjab, in terms of changes in nutrient status and other relevant soil properties such as pH, electrical conductivity (EC) and soil texture. With knowledge of this information, it is suggested that farmers in affected areas may be provided with a suitable soil management strategy for use in crop cultivation for future seasons.

### Methodology

The objective of this study was to undertake a rapid assessment of the impact of flood deposited material, and the heavy flooding itself, on selected soil properties relevant to crop production. A limited number of soil samples were therefore collected from representative sites of selected districts out of the 25 districts declared as "flood affected" by the Government of the Punjab during the 2010 flood. Only

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those districts which were affected by riverine flood were selected for sampling, ignoring those affected by heavy monsoon only. From each selected site, two samples were drawn: i) the deposited mass of mud and silt and ii) underlying soil up to 15 cm.

Samples were taken during the third and fourth week of September, 2010. Prior to this, local Market Development Officers of Engro Fertilizers in areas to be sampled were trained by the Senior Market Development Officer (North) as to selection of sites, collection of soil samples, and color/visual observation to distinguish thickness of deposited material (Photo 1). By that time, the flood water had either receded or leached/evaporated from around 90 percent of the affected area and land was at an appropriate moisture level that sampling was possible from these areas. A geographical/area grid was not used for selecting sites. However, the distance between any two sites was kept at a minimum of 5 km. In any given Union Council (UC, a demographic unit consisting of a population of 10,000 people used for the purpose of civil administration), more than one sample was drawn if it was expected to be different in terms of thickness of deposited material and/or length of time for which water was reported to have stayed there.

The samples were then analyzed in the laboratory for pH, texture, organic matter, sodium bi-carbonate extractable phosphorus (P) ($NaHCO_3$-P) and ammonium acetate extractable potassium (K) ($NH_4OAc$-K) according to methods mentioned by US Salinity Laboratory Staff, 1954. The work was carried out at Engro Soil Testing Laboratory, Multan and the Soil and Water Testing Laboratory, Lahore. For determining EC, soil suspensions were prepared in distilled water in a soil to water ratio of 1:1. A detail of the sites sampled is provided in Table 1.

The historical data published by the Soil Fertility Research Institute, Punjab had been averaged over Tehsil (district levels), hence it cannot be used as a reference for comparison between soil analysis before and after the flood. The analysis of actual soil beneath the deposited layer was, therefore, used as a benchmark for assessing changes in soil properties caused by the compound effect of mud/silt deposition on soils of the affected areas and the leaching effect as a result of the heavy flooding. Descriptive statistical parameters such as range (between minimum and maximum values), mean and standard deviation were used to interpret the data.

**Table 1.** Detail of soil samples collected from flood affected areas.

| District | No. of UCs* affected | Total affected area (ha) | No. of sites sampled |
|---|---|---|---|
| Attock | 10 | 2,866 | 5 |
| Bahawalpur | 16 | 21,261 | 0 |
| Bhakkar | 64 | 99,060 | 0 |
| Chiniot | 60 | 7,056 | 0 |
| DG Khan | 237 | 148,146 | 17 |
| Faisalabad | 23 | 7,014 | 0 |
| Gujrat | 13 | 659 | 0 |
| Gujranwala | 18 | 4,925 | 0 |
| Jhang | 322 | 179,062 | 10 |
| Jhelum | 73 | 2,826 | 0 |
| Kasur | 20 | 2,482 | 0 |
| Khanewal | 4 | 24,000 | 0 |
| Khushab | 125 | 59,104 | 5 |
| Layyah | 70 | 143,500 | 15 |
| Mandi Bahauddin | 26 | 20,300 | 0 |
| Mianwali | 154 | 31,945 | 10 |
| Multan | 97 | 75,718 | 10 |
| Muzaffargarh | 493 | 400,260 | 22 |
| Narowal | 26 | 1,113 | 0 |
| Nankana Sahib | 50 | 6,376 | 0 |
| Rahi Yar Khan | 145 | 136,046 | 10 |
| Rajanpur | 370 | 355,984 | 22 |
| Sargodha | 152 | 109,191 | 20 |
| Sialkot | 32 | 6,339 | 0 |
| TT Singh | 12 | 4,430 | 0 |
| Total | 2,612 | 1,853,875 | 146 |

*UC: Union Council.

*Possible interferences of the post-flood soil analysis*

1. The samples were collected after water had leached/evaporated from the affected areas. This essentially means leaching of a significant volume of water through the soil profile, which must have resulted in the leaching of salts. This is expected to yield such estimates of the presence of soluble salts in these soils, which may not be truly representative of these soils in pre-flood conditions. In the absence of any other suitable benchmark for comparison in pre- and post-flood scenario, however, the status of soluble salts in the lower layer determined from these samples is used as a reference.

2. Leaching of potassium and organic matter to some extent is also expected from both layers due to heavy flooding.

**Results and discussion**

The soil samples were analyzed for soil fertility parameters used by the Soil Fertility Research Institute, Punjab viz. EC, pH, organic matter (%), soil test level of $NaHCO_3$-P and $NH_4OAc$-K expressed as parts per million (ppm) and Saturation Percentage (SAT). SAT is defined as the moisture content of a soil sample that has been brought to saturation by adding water while stirring, and is an indicator of textural class and water holding capacity. A statistical overview of the data is provided in the Appendix, while

# Research Findings

individual parameters are presented in figures and discussed in the following sub-sections.

*Depth of deposited material*

The depth of deposited material was measured and noted at each site, through color distinction and visual observation by the sample collector. The layer of dark colored structureless muddy mass was considered as “deposited material” (Photos 1). Overall, the depth ranged from a minimum value of 2.5 cm to around 30 cm. A thickness was considered representative of a site only if it was widely present there. Greater thickness of deposited material observed in smaller isolated depressions were ignored. Overall, the mean thickness of deposited material was around 15 cm, with a standard deviation of around three. It was observed that thickness of deposited material was higher in areas along the Indus River (Layyah, DG Khan and Muzaffargarh) than areas influenced by flooding from other rivers. This was mainly because of the extent and degree of flooding, which was higher in the Indus River during 2010 than in other rivers.

The depth to which soil is normally tilled is around 15-20 cm. This means that in areas where thickness of deposited material is higher than 15 cm, the tillage operations undertaken for the initial cropping seasons will remain confined to soil at this depth, and that crop growth may be affected by its properties, such as lower organic matter, soil test P levels, and the massiveness of its structure indicated by higher values of Saturation Percentage (discussed in the following sections). Farmers in these areas should be recommended to undertake deep plowing as soon as possible and adopt a manuring program for such soils to improve soil physical condition such as massiveness, which seriously hampers crop production due to restricted drainage, water movement and root growth. Manuring will also improve microbial activity in these soils and will help in the early improvement of organic matter status of these soils towards the sufficiency range.

***Photo 2.*** *A ruined cotton field due to flooding in Rajanpur Area. Photo by Z. Ahmad.*

*Electrical conductivity and soil reaction (pH)*

It was observed that, overall, EC and pH values were lower in the deposited material compared to the actual soil below (Fig. 1A and 1B, respectively). This may be partly because of the relatively inert nature of deposited material and partly because of the leaching effect over the period of heavy flooding on these soils (Eulenstein *et al.,* 1998). Similarly, one can expect that values of EC and pH observed for soil beneath the deposited material may not give a true picture of its salt status in pre-flood conditions because of the effect of flooding. It is clear from the data that upper soil surface of these areas have largely become clear of any risk of soil salinity or alkalinity, and hence may be considered more productive for crop production with respect to these parameters.

*Soil test levels of organic matter, P and K*

Floods are expected to alter nutrient availability of soils, due to leaching of water soluble nutrients and due to the chemical composition of transported material deposited in the plow layer of the soil (http://www.gov.mb.ca/agriculture/crops/cropproduction/faa18s00.html). Data given in the Appendix and expressed graphically in Fig. 1C, 1D and 1E show that deposited material contained lower amounts of organic matter and P, while it was richer in soil test K compared to the soil below.

An interesting observation in these data is the wide ranges and higher values of Standard Deviations in these parameters in the deposited material (see Appendix) which was unanticipated because of expected homogeneity of transported material, at least in adjacent areas. Lack of homogeneity in observed values of these parameters in the deposited layer can be explained by assuming that this layer may not consist completely of transported material. It may rather be a layer predominantly consisting of transported material mixed homogeneously with some portion of the uppermost soil layer. This mixing would have resulted in a distinguishable color imparted by transported material,

# Research Findings

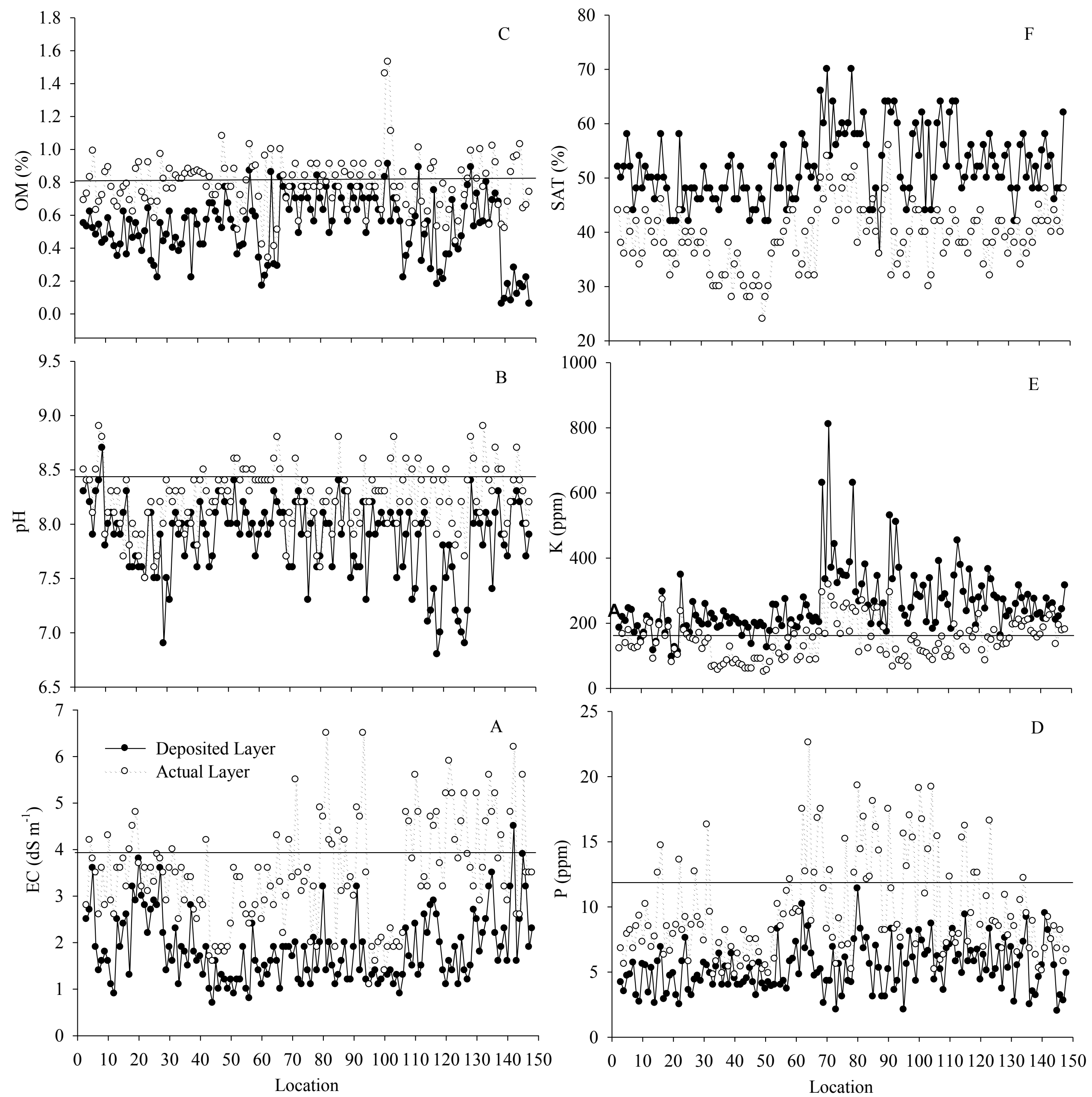


**Fig 1.** Comparison of EC (A), pH (B), OM (C), P (D), K (E) and SAT (F) values obtained from deposited material and actual soil mass across all 146 sites. Lines in Fig. A, B, C, D and E represent the sufficiency range as per benchmarking used by the Soil Fertility Research Institute, Punjab.

while the original soil mass mixed in this layer would have imparted its characteristics vis-à-vis these soil parameters, hence yielding a wider variation of values.

The data clearly indicate that organic matter and soil test P in the upper deposited layer was invariably in the deficient range, while soil test K was in the sufficiency range as per benchmarking used by the Soil Fertility Research Institute, Punjab and indicated as separating lines in Fig. 1C, 1D and 1E. For crop production, therefore, farmers in these areas should be recommended to increase nitrogen (N) and phosphorus (P) usage in their fertilizer practice, while use of potassium (K) can be avoided for a few seasons. Farmers should manage their resources by saving from their expenditure on K to spend more on N and P. However, for high K requiring crops, which are prevalent in these areas, such as sugarcane and orchard fruits, site specific recommendations should be followed. Early and frequent green manuring is also recommended for early rehabilitation of these soils with respect to organic matter and soil

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structure and texture.

*Soil Texture indexed by saturation percentage*

Data provided in the Appendix and expressed graphically in Fig. 1F suggest that the layer containing deposited material had a relatively higher saturation percentage indicative of heavier soil texture and massive soil structure. This is to be expected because of the fine nature of suspended material, which is transported by water and settles when flooded water leaches or evaporates in situ.

This massiveness of structure and heaviness of soil texture is detrimental to crop production because it restricts drainage and air movement, prevents root growth and inhibits microbial activity. Farmers in these areas should be recommended to incorporate green manure and farmyard manure for early rehabilitation of their fields. The sooner the physical conditions of their flood affected soils are improved, the better position they will be in to exploit positive changes in their soils brought about by floods, such as reduced risk of soil salinity and alkalinity and improved K status.

**Conclusion**

Vast areas of crops were devastated by the 2010 flood in Pakistan. Soils were affected both by the transport of large quantities of suspended silt and mud, which were deposited on cultivable lands, and the leaching effect caused by the heavy flooding.

The upper massive layer of mud/silt does not consist of 100 percent transported material. It seems to be a homogenized mixture of original surface layer soil and transported material.

Generally, flooding caused a reduction in soil salinity and alkalinity parameters, while the soil layer containing deposited material was invariably deficient in organic matter and soil test P, but was higher in soil test K, and in fine particles causing heaviness in soil texture.

The foremost recommendation to farmers of these areas should be to improve physical condition of the soil through deep plowing and manuring/green manuring.

Rationalization of resources for nutrient application is also recommended in favor of N and P at the cost of K during the initial cultivation phase. Potassium requirement of high K requiring crops prevalent in these areas, such as sugarcane and orchard fruits, should be provided with site specific recommendations.

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United State Salinity Laboratory Staff. 1954. Diagnosis and Improvement of Saline and Alkaline Soils USDA. Handbook 60 Washington D.C.

**Useful links**

Impact of Flooding on Soil Fertility in the Red River Valley of Manitoba. http://www.gov.mb.ca/agriculture/crops/cropproduction/faa18s00.htm.

The formation of Himalayas. http://library.thinkquest.org/10131/geology.html. ■

# IPI Events

**October 2011**

**International Symposium on "Role of Potassium in Sustaining the Yield and its Quality", Kandy, Sri Lanka, 27-29 October 2011.** Jointly organized by the International Potash Institute, University of Sri Jayewardenepura, Sri Lanka and Department of Agriculture, Sri Lanka. For more details see IPI website or contact Dr. Baladzhoti Tirugnanasotkhi, IPI Coordinator East India, Bangladesh and Sri Lanka. ■

**Spring 2012**

**International Symposium on "Management of Potassium in Plant and Soil Systems in China".** The symposium is jointly organized with the International Potash Institute, Soil Science Institute, Nanjing, Chinese Academy of Sciences and the China Agriculture University. For more details see IPI website or contact Mr. Eldad Sokolowski, IPI Coordinator China. ■

# Other Events

**The 9th New Ag International Conference & Exhibition** will be held in Athens, Greece, during 28-30 June 2011.

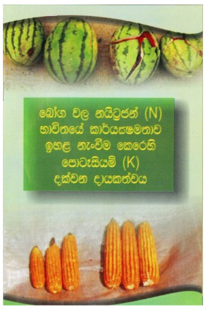
For more details see conference website. ■

# Research Findings

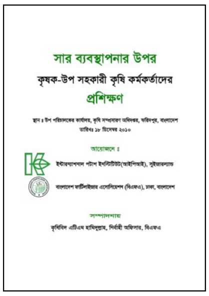
**APPENDIX to Research Findings "Impact of Alluvial Deposits on Soil Fertility during the Floods of 2010 in Punjab, Pakistan":** Statistical overview of EC, pH, organic matter and soil test P and K measured at 146 selected sites in areas affected by the 2010 floods.

| District | n | Depth | Thickness of deposited layer (cm) | | | EC ($dS\ m^{-1}$) | | | pH | | | Organic Matter (%) | | | Extractable P ($mg\ kg^{-1}$) | | | Extractable K ($mg\ kg^{-1}$) | | | SAT (percent) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD | Range | Mean | SD |
| Attock | 5 | 1 | 7.6-20.3 | 13.7 | 6.12 | 1.4-3.6 | 2.4 | 0.83 | 7.9-8.4 | 8.2 | 0.19 | 0.5-0.6 | 0.5 | 0.05 | 3.5-5.7 | 4.6 | 0.81 | 185-245 | 219 | 24.7 | 50-58 | 52.8 | 3.03 |
| | | 2 | | | | 2.6-4.2 | 3.4 | 0.67 | 8.1-8.5 | 8.4 | 0.16 | 0.6-1.0 | 0.8 | 0.14 | 5.6-8.2 | 7.1 | 1.03 | 122-178 | 146 | 24.82 | 36-44 | 40.4 | 3.58 |
| Sargodha | 20 | 1 | 2.5-15.2 | 7.4 | 3.2 | 0.9-3.8 | 2.4 | 0.81 | 7.5-8.7 | 7.9 | 0.33 | 0.2-0.64 | 0.5 | 0.11 | 2.5-7.6 | 4.4 | 1.51 | 96-348 | 186.5 | 62.05 | 42-58 | 48.2 | 4.85 |
| | | 2 | | | | 2.6-4.8 | 3.6 | 0.56 | 7.5-8.9 | 8.0 | 0.37 | 0.6-0.92 | 0.7 | 0.10 | 5.8-14.7 | 9.1 | 2.48 | 80-272 | 159.1 | 48.19 | 32-46 | 38.8 | 3.75 |
| Khushab | 5 | 1 | 5.1-5.1 | 5.1 | 0 | 1.4-2.3 | 1.9 | 0.38 | 6.9-8.0 | 7.5 | 0.45 | 0.4-0.6 | 0.5 | 0.09 | 4.3-3.7 | 5.0 | 0.58 | 195-258 | 215.0 | 26.45 | 46-52 | 48.0 | 2.45 |
| | | 2 | | | | 2.9-4.0 | 3.5 | 0.39 | 8.0-8.4 | 8.2 | 0.15 | 0.8-1.0 | 0.8 | 0.09 | 7.4-16.3 | 10.22 | 3.50 | 120-169 | 145.2 | 17.94 | 36-40 | 37.6 | 1.67 |
| Mianwali | 10 | 1 | 5.1-5.1 | 5.1 | 0 | 1.1-2.8 | 1.7 | 0.46 | 7.7-8.2 | 7.9 | 0.19 | 0.2-0.6 | 0.5 | 0.12 | 4.0-6.4 | 4.8 | 1.01 | 185-235 | 209.0 | 16.18 | 44-54 | 47.8 | 3.05 |
| | | 2 | | | | 2.5-4.2 | 3.1 | 0.55 | 7.8-8.5 | 8.2 | 0.24 | 0.8-0.9 | 0.9 | 0.02 | 4.8-8.2 | 6.0 | 1.16 | 56-127 | 77.5 | 19.62 | 28-38 | 32.2 | 3.05 |
| Jhang | 10 | 1 | 5.1-10.2 | 7.6 | 2.7 | 0.7-1.6 | 1.1 | 0.25 | 7.6-8.4 | 8.1 | 0.26 | 0.5-0.8 | 0.6 | 0.08 | 3.2-5.7 | 4.3 | 0.73 | 125-200 | 175.8 | 27.18 | 42-52 | 45.6 | 3.37 |
| | | 2 | | | | 1.6-3.6 | 2.2 | 0.72 | 8.1-8.6 | 8.3 | 0.14 | 0.7-1.1 | 0.8 | 0.11 | 4.9-8.2 | 6.5 | 1.25 | 50-90 | 70.5 | 15.71 | 24-32 | 29.2 | 2.35 |
| Layyah | 15 | 1 | 10.2-22.9 | 15.5 | 3.7 | 0.8-2.4 | 1.5 | 0.43 | 7.7-8.3 | 8.0 | 0.15 | 0.2-0.9 | 0.5 | 0.23 | 3.7-10.2 | 6.0 | 1.93 | 125-278 | 218.7 | 39.95 | 44-58 | 50.7 | 4.12 |
| | | 2 | | | | 2.2-4.3 | 3.0 | 0.56 | 8.3-8.8 | 8.5 | 0.12 | 0.3-1.0 | 0.7 | 0.24 | 6.0-22.6 | 11.8 | 4.24 | 85-195 | 127.5 | 39.18 | 32-44 | 37.9 | 4.17 |
| Rajanpur | 22 | 1 | 15.2-30.5 | 23.9 | 5.9 | 1.1-3.2 | 1.6 | 0.49 | 7.3-8.4 | 8.0 | 0.30 | 0.5-0.8 | 0.7 | 0.1. | 2.1-11.4 | 5.3 | 2.25 | 195-810 | 361.0 | 151.73 | 36-70 | 56.5 | 8.39 |
| | | 2 | | | | 1.9-6.5 | 3.7 | 1.12 | 7.6-8.8 | 8.1 | 0.29 | 0.6-0.9 | 0.8 | 0.09 | 5.2-19.3 | 11.8 | 4.31 | 110-318 | 213.6 | 59.61 | 36-54 | 45.3 | 4.64 |
| DG Khan | 17 | 1 | 10.2-30.5 | 18.0 | 5.5 | 0.9-3.2 | 1.4 | 0.53 | 7.3-8.2 | 7.9 | 0.28 | 0.5-0.9 | 0.7 | 0.11 | 2.1-8.7 | 6.0 | 1.86 | 173-530 | 292.2 | 105.64 | 44-64 | 55.1 | 7.65 |
| | | 2 | | | | 1.1-6.5 | 2.6 | 1.45 | 7.9-8.8 | 8.2 | 0.25 | 0.6-1.5 | 0.9 | 0.26 | 5.2-19.2 | 13.1 | 4.46 | 66-294 | 116.5 | 52.44 | 30-56 | 39.6 | 5.21 |
| Muzaffar garh | 22 | 1 | 10.2-30.5 | 18.8 | 5.0 | 1.1-2.9 | 1.8 | 0.57 | 6.8-8.1 | 7.5 | 0.40 | 0.2-0.9 | 0.5 | 0.20 | 3.6-9.4 | 6.1 | 1.49 | 162-453 | 293.2 | 71.01 | 48-64 | 54.8 | 5.11 |
| | | 2 | | | | 3.2-5.9 | 4.4 | 0.81 | 7.7-8.6 | 8.2 | 0.27 | 0.4-1.0 | 0.7 | 0.15 | 5.6-16.6 | 9.8 | 3.23 | 85-227 | 145.2 | 34.68 | 32-44 | 39.5 | 3.26 |
| Multan | 10 | 1 | 7.6-20.3 | 14.5 | 4.2 | 1.6-3.5 | 2.4 | 0.60 | 7.4-8.4 | 8.0 | 0.27 | 0.5-0.9 | 0.7 | 0.12 | 2.5-9.2 | 5.2 | 2.23 | 195-315 | 250.7 | 37.45 | 42-58 | 51.4 | 4.99 |
| | | 2 | | | | 2.9-5.6 | 4.3 | 0.92 | 8.1-8.9 | 8.5 | 0.26 | 0.5-1.0 | 0.8 | 0.17 | 6.3-12.2 | 8.6 | 1.87 | 136-210 | 183.3 | 25.39 | 34-42 | 38.1 | 2.33 |
| RY Khan | 10 | 1 | 5.1-15.2 | 9.7 | 3.6 | 1.6-4.5 | 2.7 | 0.98 | 7.7-8.3 | 8.0 | 0.22 | 0.1-0.3 | 0.1 | 0.07 | 2.0-9.5 | 5.4 | 2.43 | 210-315 | 244.2 | 32.62 | 46-62 | 52.3 | 5.08 |
| | | 2 | | | | 2.6-6.2 | 3.8 | 1.26 | 7.9-8.7 | 8.3 | 0.25 | 0.5-1.0 | 0.7 | 0.19 | 5.1-9.2 | 7.0 | 1.37 | 135-243 | 186.8 | 32.49 | 40-48 | 43.3 | 2.91 |
| Total | 146 | 1 | 2.5-30.5 | 14.2 | 7.5 | 0.7-4.5 | 1.9 | 0.73 | 6.8-8.7 | 7.9 | 0.26 | 0.1-0.9 | 0.5 | 0.20 | 2.0-11.4 | 5.3 | 1.82 | 96-810 | 255.7 | 98.82 | 36-70 | 51.9 | 6.49 |
| | | 2 | 7.6-20.3 | 13.7 | 6.12 | 1.1-6.5 | 3.5 | 1.10 | 7.5-8.9 | 8.2 | 0.28 | 0.3-1.5 | 0.8 | 0.17 | 4.8-22.6 | 9.7 | 3.85 | 50-318 | 148.0 | 58.25 | 24-56 | 39.1 | 5.74 |

# Publications

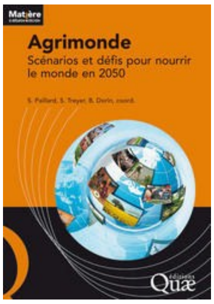


**Contribution of Potassium in Enhancing Nitrogen Use Efficiency in Crops.** 2011. 8 p. Sinhala. For copies contact IPI Coordinator East India, Bangladesh and Sri Lanka. Dr. Baladzhoti Tirugnanasotkhi. ■



**Handbook on Fertilizer Management for Farmers and Sub-Assistant Agriculture Officers.** Jute Research Institute's Regional Station, Faridpur, Bangladesh. 2010. Bangla. Published by IPI and Bangladesh Fertilizer Association (BFA). Download from IPI website. ■

# Other Publications




**Future of Food Could be Bright. 2011.** Paillard, S., S. Treyer, and B. Dorin. (coord.). Agrimonde: Scenarios and Challenges for Feeding the World in 2050. Editions Quae. 2011. ISBN: 978-2-7592-0890-6.

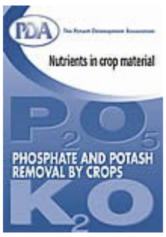
The world will be able to feed the predicted 2050 population of nine billion people, according to two French agricultural research organizations. In a joint report published recently, they lay out findings gleaned from 2006 to 2008 that could overturn some current assumptions about the state of global farming. The report, titled Agrimonde, is published by the French National Institute for Agricultural Research (INRA) and the Centre for International Cooperation in Agronomic Research for Development (CIRAD), both headquartered in Paris. It contains some surprise findings on Africa and other regions - the latest results from an ongoing study by the two research agencies. ■

# Publications by the PDA

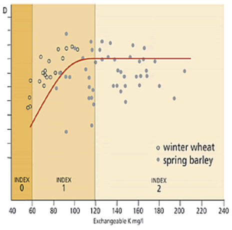
The Potash Development Association (PDA) is an independent organisation formed in 1984 to provide technical information and advice in the UK on soil fertility, plant nutrition and fertilizer use with particular emphasis on potash. See also www.pda.org.uk/.

*Note:* Hardcopies of PDA's publications are available only in the UK and Ireland.


**Potash for Cereals.** January 2011. Full details of the functions, responses, uptake, removal and deficiency symptoms of potash in cereal crops. Recommended amounts and timing for different situations. See PDA website. ■




**Nutrients in Crop Material.** Phosphate and Potash Removal by Crops. August 2010. See PDA website. ■




**Updated Cereals Recommendations and Correction of K Deficiency.** January 2011. See PDA website. ■

## Read on:

- **The Economist:** A special report on feeding the world. February 2011.
- **Nature News:** Climate-smart agriculture is needed. Changes in use of nitrogen fertilizer are key to reducing greenhouse gases. March 2011.
- **IPNI:** Considering Chloride for Wheat. Fall 2010.
- **The Economist:** Climate Change and Crop Yields; One degree over. Data from crop trials underline the threat climate change poses to farmers. March 2011.
- **Science:** Can Biotech and Organic Farmers Get Along? April 2011, 332(6026):166-169.

All the items that appear in our "Read on" section also appear on our Twitter. Follow us on twitter ■

# in the Literature

**Exploring Remotely Sensed Technologies for Monitoring Wheat Potassium and Phosphorus Using Field Spectroscopy.** Pimstein, A., A. Karnieli, S.K. Bansal, and D.J. Bonfil. Elsevier, Field Crops Research 121(2011)125-135.

**Abstract:**

Given the importance of potassium (K) and phosphorus (P) contents to wheat yield and grain quality, and the very little experience that has been gained on nutritional monitoring of other than nitrogen using remotely sensed technologies, as study was undertaken to explore the possibility of identifying these mineral stresses using spectral data. Canopy spectra and biophysical data were collected from commercial and experimental fields in India and Israel. Traditional and newly developed vegetation indices, together with Partial Leas Squares (PLS) regression models, were calculated in order to predict potassium and phosphorus contents from the wheat canopy spectral data. Results show that the application of PLS and specific narrow bands vegetation indices reached significant levels of accuracy in the retrieval of K and P levels, in comparison to traditional broad band indices. Additionally, it was observed that a significant improvement is obtained when the mineral total content is considered instead of the relative content. Therefore it was suggested that the biomass should also be retrieved from the spectral data. Finally, as very different crop conditions were included in this study, it was possible to confirm that the level of accuracy in the retrieval of K and P levels is related to the quality and variability of the data used for calibrating the models.

**Improving Water Productivity by Potassium Application in Various Rice Genotypes.** Quampah, A., R.M. Wang, I. Haider Shamsi, G. Jilani, Q. Zhang, S. Hua, and H. Xu. International Journal of Agriculture & Biology. 10-251/MFA/2011/13-1-9-17.

**Abstract:**

This field experiment evaluated the performance of different rice genotypes under lowland and upland irrigation systems with and without potassium fertilization. The most popular six rice genotypes grown in China; two *Indica* hybrids viz. Liangyoupei 9 and Xieyou 9308, and four *Japonica* rice varieties viz. Bing 0001, Bing 0004, Bing 9904 and Huayu # 1 were used in this study. Impacts of two potassium (K) levels (0 & 180 kg $ha^{-1}$) and two irrigation systems (lowland & upland) were investigated for yield attributes, grain yield and K uptake of these genotypes. Potassium fertilizer increased the yield of rice, but the response of different genotypes was variable. Effect of upland system on rice yield was diverse with K levels and rice genotypes, whereas K uptake by rice grains was significantly lower than in lowland. Genotypes showed statistical variation for production in both irrigation systems and response to K fertilization. Two genotypes (Liangyoupei 9 & Huayu # 1) performed equally well in both lowland and upland system, as well as with and without K fertilizer. With respect to growth, and yield of rice, generally the lowland system proved superior to upland, and K fertilization helped enhance the crop performance in upland irrigation system. However, upland rice cropping practiced with K fertilization improved water use efficiency of the most genotypes.

**Analytical Studies of the $CO_2$ Soil Test for P and K Fertilization.** Stünzi, H. Recherche Agronomique Suisse 2(1):4-11, 2011. French.

**Abstract:**

Extraction of soils with $CO_2$-saturated water is one of the Swiss reference methods for phosphorus and potassium fertilizer recommendations. Laboratory experiments show that a significant role is played by interactions between $CO_2$, calcium, phosphate, the only slightly soluble calcium phosphates and lime. Since soil air exhibits increased $CO_2$ content, these solution equilibria also influence the immediate plant-availability of P in the field. If a soil sample is extracted repeatedly with $CO_2$ water, the extract will always contain similar P concentrations. This reflects the conditions in the field: a soil can supply plants with P over a fairly long period, even if it periodically dries out or becomes waterlogged. The homeostasis of soils as shown in the $CO_2$ method explains why it takes years of over- or underfertilization for the P supply of the plants to be affected. $CO_2$-K also decreases only gradually during sequential extractions. Consequently, the $CO_2$ method yields a good approximation of the readily plant-available P and K. Although reproducible, the results of the sequential extractions with ammonium-acetate and EDTA (<<AAE10>>) are so different from soil to soil that no direct connection with plant availability can be deduced from a chemical perspective.

**Soil Fertility and Crop Productivity: Medium-Term Effect of Organic Inputs and Simplified Cultivation Techniques.** Maltas, A., R. Charles, and S. Sinaj. Recherche Agronomique Suisse 2(3):120-127, 2011. French.

**Abstract:**

The combined effects of the nature of fertilizers (NPK, manure + NPK and liquid manure + NPK), fractionation of the manure inputs (every year or every three years) and tillage (plowing and reduced-tillage) associated with two nitrogen rates (100 or 60% of the optimal dose) on soil fertility and dry matter production of different crops have been studied from 1997 to 2009 in Changins. After twelve years of trial, different soil analyses show that nitrogen fertilization had no effect on soil fertility, only the soil organic matter

# K in the Literature

and total nitrogen contents differed significantly between treatments. In terms of non-limiting nitrogen fertilization, crops treated with manure produced significantly more dry matter than those treated with only inorganic fertilizer. A sub-fertilization with only 60% of the nitrogen fertilizers needs causes a decrease in production of 7-13% according to the treatments. In the absence of the manure input, reducing tillage keeps the stock of soil organic matter, but should be accompanied by a strengthening of nitrogen fertilization. Split manure in annually low inputs doesn't increase the manure efficiency.

**Agroforestry in Switzerland.** Kaeser, A., F. Sereke, D. Dux, and F. Herzog. Recherche Agronomique Suisse 2(3):128-133. 2011. French.

**Abstract:**

Trees in agricultural landscapes provide important benefits for the environment. Nevertheless, they are disappearing from cultivated land due to economic and operational reasons. In modern agroforestry systems, trees are planted in rows on agricultural land in order to facilitate mechanical operations. The economic and ecological potential of modern agroforestry systems in Switzerland was examined. Productivity per hectare, profitability and environmental benefits were estimated using computer-aided models. The results show an up to 30% higher productivity (per unit area) of agroforestry systems compared to monocultures. In the long term, agroforestry systems can become profitable. On fertile arable land, they may reduce soil erosion by 78% and nitrate leaching by 46% as well as sequester up to 133 tons of carbon in 60 years. In interviews, farmers were questioned about their perception of benefits and disadvantages of agroforestry. Farmers rate agroforestry systems as non-productive and unprofitable. However, they admit a benefit for biodiversity and cultural landscape. Farmers need to be made aware of the many agroforestry designs and their economic potential, based on the experience of pioneer farmers.

See the IPI website for more "K in the Literature".

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# Clipboard

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