Optimizing Crop Nutrition

# INTERNATIONAL POTASH INSTITUTE

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

## Editorial

Dear Readers,

The effect of potassium application in rice-wheat cropping system in Bangladesh is the first of three topics in the 'Research findings' section of this *e-ifc* issue. The progress Bangladesh has achieved in improving its food security is impressive, and much of it is related to nutrient management.

And in India, public and private research has a pivotal impact on the productivity of Indian agriculture. But what about extension? The Punjab Agriculture University (PAU), in Ludhiana, took research hypothesis and applied them with the mission to advocate good up-to-date science to the farmers of Punjab. The results of this on-farm IPI-PAU experiment conducted by KVK (farmers' training center) are brought here, in the second item of our 'Research findings'.


*New orange and clementine varieties displayed at the 'Desert Agriculture Exhibition' in South Israel. Photo by H. Magen.*

Poland has a large arable land with fertile soils. Yet, drought during June and July often impairs productivity of summer cereals and sugar beet. Read more about IPI experiments that demonstrate the (well-known) role of potassium in alleviating drought stress.

Meetings are an important component of IPI's activities. In this edition we provide an update of past and future events. Make a note in your diary of our UK meeting from 5-7 December. IPI, together with the International Fertilizer Society (IFS), UK and Prof. I. Cakmak of the Sabanci University, Istanbul, Turkey are organizing a symposium in Cambridge titled "Potassium and Magnesium: Recent Advances in Research and Application". Invited speakers from Australia, USA, Germany and the UK will present the latest findings on potassium and magnesium uptake by plants, the role of potassium in salinity tolerance, resistance to disease, and alleviating biotic and abiotic stresses, amongst other topics. The keynote papers will be subsequently published in an international peer review journal. Read more about this symposium in the 'Events' section of this issue.

In the 'K for thought' section you will find interesting findings on K depletion in the UK. This worrying phenomenon is not confined to poorly educated farmers… rather it reflects the need for constant monitoring, making sure that all the checks and balances are carried out to ensure that agricultural productivity is maintained.

At mid-year, and before the summer holidays, we wish you all an enjoyable read.

Hillel Magen
Director

*Experimental setup in soybean under an IPI-CAU research project, Jilin province, China. Photo by H. Magen.*

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# Research findings

## *I* Efficiency of potash fertilizer application in a rice-wheat cropping system in North-West Bangladesh.

*This report is based on the IPI – Bangladesh Rice Research Institute (BRRI), Soil Science Division project conducted in North-West Bangladesh.*

*Mazid Miah, M.A., Saha, P.K., Islam, A., Nazmul Hasan, M. and Nosov, V., 2006. Efficiency of potash fertilizer application in a rice-rice and a rice-wheat cropping system in Bangladesh. Paper presented at the IPI-PAU International Symposium on "Balanced Fertilization for Sustaining Crop Productivity". Ludhiana, India, 22-25 November 2006.*

### Introduction

The general recommended application rate of potash fertilizer for modern rice varieties in Bangladesh is about 35 kg K/ha, whereas an average crop of rice yielding 4.0 t/ha removes at least 70 kg K/ha from the soil (*note elemental basis is used here*). The present K fertilizer management practice may thus not be adequate to sustain soil K fertility status in the long term. There is therefore a tremendous potential for K fertilizer application both to maintain soil fertility and to increase cereal crop production in Bangladesh. Application of organic matter as crop residues is very limited in Bangladesh because these are largely used as fuel for cooking purposes and also as fodder for livestock.

*T. Aman rice demo plots at Bhog Nagar village, Dinajpur, Rajshahi, Bangladesh (05.10.2003): $K_0$ (left) and $K_{55}$ (right)*

**Table 1.** Initial soil characteristics and grading of the experimental site.

| Soil properties | Unit | ……………Locations…………… Experimental farm (at HDSTU) | Farmers' fields (range among the five villages) |
|---|---|---|---|
| pH | | 4.7 | 3.6 – 4.05 |
| OM | % | 1.13 (L) | 1.17 (L) – 1.52 (L) |
| Total N | % | 0.06 (VL) | 0.06 (VL) – 0.08 (L) |
| Available P (Bray & Kurtz) | ppm | 17.8 (M) | 4.53 (VL) – 28.16 (Opt) |
| Exchangeable K | meq/100 g soil | 0.05 (VL) | 0.03 (VL) – 0.09 (L) |
| Available S | ppm | 4.5 (VL) | 2.2 (VL) – 6.1 (L) |
| Available Zn | ppm | 1.21 (Opt) | 0.4 (L) – 1.4 (Opt) |
| Textural class | | Sandy loam | Sandy loam |

Grading: VL = Very low, L= Low, M= Medium, Opt = Optimum, H = High, VH = Very high

### Materials and methods

A research trial and farmers' field demonstrations with several combinations of potash fertilizer rates were conducted under a wheat-rice (transplanted Aman) cropping pattern in NW regions of Bangladesh during 2003-2006. The research trial was carried out at the Hajee Danesh Science and Technology University (HDSTU) experimental farm, Dinajpur (Old Himalayan Piedmont Plain, medium highland) and the farmers' field demonstrations at Dinajpur, Thakurgaon and Panchagar. The soils of the experimental fields are sandy loam in texture, and strongly to very strongly acidic in nature. They are very low in total nitrogen, and in exchangeable K and S, as well as being very low to optimum in P and low to optimum in Zn content (Table 1).

In the research trial, six K treatments viz. zero K ($K_0$), recycling of crop residues but no K fertilizer ($K_{0+CR}$), 33 kg K/ha ($K_{33}$), 50 kg K/ha ($K_{50}$), 66 kg K/ha ($K_{66}$) and farmers' practice for K ($K_{FP}$) were tested for both rice and wheat using a randomized block design (RBD) with four replications. In the farmers' field demonstrations, three K treatments were compared for both crops, K control ($K_0$), farmer's practice for K ($K_{FP}$) and a soil test based K application ($K_{STB}$). The soil test based recommendations for NPS and Zn were applied to all the plots.

### Rice and Wheat response to K

Application of K fertilizer significantly increased the grain yield of rice and wheat over the control treatment $K_0$ (Table 2). It is evident that farmers' practice for K (25 and 30 kg K/ha in rice and wheat, respectively; $K_{FP}$) was not enough to produce high yields in either of the cereals. Of the treated plots, where K fertilizer was applied, an application of 66 kg K/ha produced the highest grain yield of both rice and wheat in any season. Potash fertilizer application was more efficient in wheat in the dry season as compared with the wet monsoon rice season (Fig. 1). For instance, the highest rate of 66 kg K/ha increased grain yield of rice on the average by 30 per cent but the comparative figure for wheat was 53 per cent (Table 2). In general, the additional grain yield obtained by potash application was between 0.69 to 0.9 t/ha for rice and 0.65 to 1.23 t/ha for wheat (Fig. 1). As compared with the $K_0$ treatment, farmers achieved an additional 0.46-0.60 t/ha when using

# Research findings

their regular practice ($K_{FP}$) or through the application of crop residues ($K_0$+CR; Fig. 1).

Recycling of crop residues significantly increased the grain yield over $K_0$, with grain yields statistically similar to those of $K_{33}$ and $K_{FP}$ for both rice and wheat (Table 2). Crop residue incorporation increased grain yield of the two crops on average by 20-21 per cent, as compared with the $K_0$ treatment. Thus, potash fertilizer application on light textured soils gave higher crop productivity, as compared with crop residue incorporation alone without potash fertilizer. As farmers in Bangladesh generally remove straw from their fields, recommended rates of potash fertilizer need to be applied to optimize crop K nutrition and to preserve the soil from K mining.

Soil test-based K fertilization ($K_{STB}$) significantly increased the grain yield of both crops over $K_0$ and $K_{FP}$ treatments in farmers' field demonstrations (Table 3). Again, the contribution of K fertilizer to grain yield production was found to be more prominent in wheat than that in rice. On average, the use of K fertilizer in recommended rates in farmers' fields produced 25 per cent higher rice grain yield and 86 per cent higher wheat grain yield as compared with the $K_0$ treatment. (*Continued next page.)*

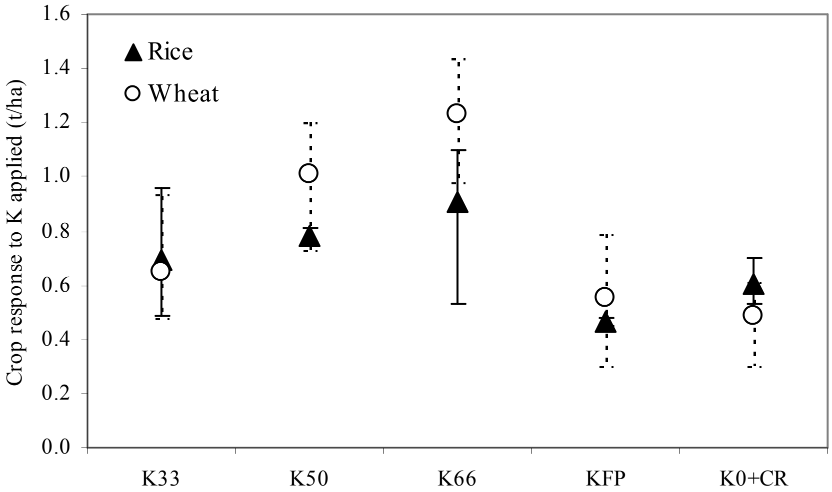



**Fig. 1.** The average yield response for potassium treatments in rice and wheat (based on the results from the HDSTU experimental farm; t/ha).

**Table 3.** Effect of K fertilizer use on the grain yield of rice and wheat on farmers' fields.

| Treatment | Rice 2003 1st crop | Rice 2004 3rd crop | Rice 2005 5th crop | Rice Mean | Rice Yield increase | Wheat 2004 2nd crop | Wheat 2005 4th crop | Wheat 2006 6th crop | Wheat Mean | Wheat Yield increase |
|---|---|---|---|---|---|---|---|---|---|---|
| | t/ha | | | | % | t/ha | | | | % |
| $K_0$ | 3.31 | 3.27 | 3.17 | 3.25 | - | 1.52 | 1.84 | 2.59 | 1.98 | - |
| $K_{FP}$ (1) | 3.68 | 3.81 | 3.60 | 3.70 | 14 | 2.79 | 2.73 | 2.84 | 2.79 | 41 |
| $K_{STB}$ (2) | 3.89 | 4.16 | 4.14 | 4.06 | 25 | 3.72 | 3.60 | 3.71 | 3.68 | 86 |

(1) $K_{FP}$ = Farmers practice only for K, based on the average of 25 local farmers that applied 25 and 30 kg K/ha, in rice and wheat, respectively.

(2) $K_{STB}$ = K application according to Soil Test Basis (STB): $K_{43\text{-}65}$ (av. $K_{58}$) in Rice and $K_{72\text{-}99}$ (av. $K_{87}$) in Wheat season.

*Notes*: The results are the average yields of 5 farmers' fields per season (except in 4 fields during the Rice 2005 season and 3 fields during the Wheat 2005 season); Basic application of N-P-S-Zn according to Soil Test Basis; Rice variety: BRRI dhan31, BRRI dhan39 & BR11; Wheat variety: Shatabdi.

**Table 2.** Effect of K fertilizer use on the grain yield of rice and wheat at the HDSTU experimental farm (t/ha).

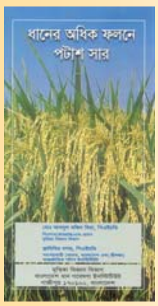
| Treatment | Rice 2003 1st crop | Rice 2004 3rd crop | Rice 2005 5th crop | Rice Mean | Rice Yield increase | Wheat 2004 2nd crop | Wheat 2005 4th crop | Wheat 2006 6th crop | Wheat Mean | Wheat Yield increase |
|---|---|---|---|---|---|---|---|---|---|---|
| | t/ha | | | | % | t/ha | | | | % |
| $K_0$ | 1.97 | 2.32 | 4.64 | 2.98 | - | 2.64 | 1.99 | 2.33 | 2.32 | - |
| $K_{33}$ | 2.46 | 2.96 | 5.60 | 3.67 | 23 | 3.58 | 2.52 | 2.81 | 2.97 | 28 |
| $K_{50}$ | 2.73 | 3.13 | 5.41 | 3.76 | 26 | 3.84 | 3.09 | 3.06 | 3.33 | 44 |
| $K_{66}$ | 3.07 | 3.41 | 5.17 | 3.88 | 30 | 3.92 | 3.43 | 3.31 | 3.55 | 53 |
| $K_{FP}$ (1) | 2.44 | 2.77 | 5.12 | 3.44 | 15 | 3.43 | 2.57 | 2.63 | 2.88 | 24 |
| $K_{0+CR}$ (2) | 2.50 | 2.90 | 5.34 | 3.58 | 20 | 3.20 | 2.60 | 2.63 | 2.81 | 21 |
| $LSD_{0.05}$ | 0.35 | 0.31 | 0.23 | | | 0.47 | 0.22 | 0.36 | | |
| CV, % | 9 | 7 | 3 | | | 9 | 6 | 9 | | |

(1) $K_{FP}$ = Farmers practice only for K, based on the average of 25 local farmers that applied 25 and 30 kg K/ha, in rice and wheat, respectively.

(2) CR = Crop residues.

*Notes*: Basic application of N-P-S-Zn (kg/ha): 100-5.5-14-0.5 for Rice and 133-18-31-0.5 for Wheat; Rice variety: BRRI dhan31; Wheat variety: Shatabdi.

**IPI publication in Bangla language.**



IPI and BRRI co-published a six page leaflet in Bangla language summarizing the effects and recommendations of potash fertilization in Bangladesh.

To download the leaflet log on to http://www.ipipotash.org/publications/detail.php?i=163.

# Research findings

### Economic analysis

Economic analysis was carried out on the mean data of three crop seasons (Tables 4 & 5). The maximum additional incomes in both rice and wheat were obtained from the same treatment in which K fertilizer was applied at 66 kg K/ha. Applied potash was of greater benefit than that of crop residue incorporation in both rice and wheat production. The additional income earned resulting from K-fertilization was much higher in wheat than in rice. In the case of farmers' demonstrations, K applied on the basis of a soil test always contributed to considerably higher additional benefit than that from farmers' fertilization practice, especially in the wheat crop.

In all the treatments, the value cost ratio (VCR) was found to be more than the acceptable limit (VCR=2), but the treatment with crop residue incorporation showed the lowest VCR. The comparably higher VCR for potash fertilizer application was found in the wheat crop.

Edited by E.A. Kirkby

*Wheat demo plots at Madhay Paltapur village, Dinajpur, Rajshahi, Bangladesh (March 2005): $K_0$ (left) and $K_{98}$ (right)*

**Table 4.** Economics of potash fertilizer application to rice (mean of three crops).

| Experiment location | Treatment | Grain yield | Yield increase | Value of extra production | Cost of potash (MOP) | VCR | Net additional income | |
|---|---|---|---|---|---|---|---|---|
| | | t/ha | | Tk/ha[1] | | | Tk/ha | USD/ha |
| HDSTU experimental farm | $K_0$ | 2.98 | - | - | - | - | - | - |
| | $K_{33}$ | 3.67 | 0.69 | 6,900 | 924 | 7.5 | 5,976 | 87 |
| | $K_{50}$ | 3.76 | 0.78 | 7,800 | 1,400 | 5.6 | 6,400 | 93 |
| | $K_{66}$ | 3.88 | 0.90 | 9,000 | 1,848 | 4.9 | 7,152 | 104 |
| | $K_{FP}$[2] | 3.44 | 0.46 | 4,600 | 700 | 6.6 | 3,900 | 57 |
| | $K_{0+CR}$[3] | 3.58 | 0.60 | 6,000 | 2,250[4] | 2.7 | 3,750[4] | 54[4] |
| Farmers' fields | $K_0$ | 3.25 | - | - | - | - | - | - |
| | $K_{FP}$[2] | 3.70 | 0.45 | 4,500 | 672 | 6.7 | 3,828 | 55 |
| | $K_{STB}$[5] | 4.06 | 0.81 | 8,100 | 1,624 | 5.0 | 6,476 | 94 |

(1) Bangladesh Taka (USD 1 = Tk 69).

(2) $K_{FP}$ = Farmers practice only for K, based on the average of 25 local farmers that applied 25 and 30 kg K/ha, in rice and wheat, respectively.

(3) CR = Crop residues.

(4) Input cost and additional income with crop residue.

(5) $K_{STB}$ = Soil Test Basis: $K_{43\text{-}65}$ (av. $K_{58}$) in Rice and $K_{72\text{-}99}$ (av. $K_{87}$) in Wheat season.

### IPI Coordinator in Bangladesh

*Dr. Vladimir Nosov joined IPI in 1998. He has been the Coordinator for India, Bangladesh and Sri Lanka since 2003. Vladimir studied at Lomonosov Moscow State University, where he also completed his PhD in soil science. He has published more than 40 scientific papers. Besides being IPI's coordinator, Vladimir is a technical expert with the International Potash Company (IPC), where he is assigned to various technical and management projects. Between his busy schedule and visits to IPI's projects in India, Sri Lanka and Bangladesh, Vladimir enjoys fishing and gardening.*

**Table 5.** Economics of potash fertilizer application to wheat (mean of three crops).

| Experiment location | Treatment | Grain yield | Yield increase | Value of extra production | Cost of MOP | VCR | Net income | |
|---|---|---|---|---|---|---|---|---|
| | | t/ha | | Tk/ha[1] | | | Tk/ha | USD/ha |
| HDSTU experimental farm | $K_0$ | 2.32 | - | - | - | - | - | - |
| | $K_{33}$ | 2.97 | 0.65 | 7,150 | 924 | 7.7 | 6,226 | 90 |
| | $K_{50}$ | 3.33 | 1.01 | 11,110 | 1,400 | 7.9 | 9,710 | 141 |
| | $K_{66}$ | 3.55 | 1.23 | 13,530 | 1,848 | 7.3 | 11,682 | 169 |
| | $K_{FP}$[2] | 2.88 | 0.56 | 6,160 | 840 | 7.3 | 5,320 | 77 |
| | $K_{0+CR}$[3] | 2.81 | 0.49 | 5,390 | 2,250[4] | 2.4 | 3,140[4] | 46[4] |
| Farmers' fields | $K_0$ | 1.98 | - | - | - | - | - | - |
| | $K_{FP}$[2] | 2.79 | 0.81 | 8,910 | 868 | 10.3 | 8,042 | 117 |
| | $K_{STB}$[5] | 3.68 | 1.70 | 18,700 | 2,436 | 7.7 | 16,264 | 236 |

(1) Bangladesh Taka (USD 1 = Tk 69).

(2) $K_{FP}$ = Farmers practice only for K, based on the average of 25 local farmers that applied 25 and 30 kg K/ha, in rice and wheat, respectively.

(3) CR = Crop residues.

(4) Input cost and additional income with crop residues.

(5) $K_{STB}$ = Soil Test Basis: $K_{43\text{-}65}$ (av. $K_{58}$) in Rice and $K_{72\text{-}99}$ (av. $K_{87}$) in Wheat season.

# Research findings

## *II* Evaluation of the effect of potassium application on the yield and quality of crops under an intensive sunflower-maize-pea cropping system in Punjab, India.

*Dr. M. S. Brar - Principal Investigator, Department of Soils, Punjab Agricultural University, Ludhiana, India. This work was conducted through the cooperation of the Indian Coordinator, Dr. P. Imas.*

### Introduction

Rice-wheat is the major cropping system in the Punjab and it is undoubtedly mostly through this system that India has achieved its goal of food self-sufficiency. For the past decade however, productivity of this important system has reached a plateau or even begun to decline as a consequence of depletion of native nutrient reserves, the emergence of multi-nutrient deficiencies, and an associated fall in factor productivity of applied nutrients.

Crop diversification is essential for enhancing farm income as well as for reducing excessive nutrient mining and other deleterious effects on soil health. For this purpose, the Punjab Government has outlined a plan to encourage farmers to shift from a rice-wheat rotation and introduce more profitable crops to replace traditional cereals. This policy aims to diversify at least one million hectares away from the rice-wheat crop rotation to legumes, pulses, vegetables, and other high value crops.

For successful implementation of the proposed crop diversification plan in the state, there is a requirement to evaluate fertilizer recommendations for the new cropping system. Special attention needs to be addressed to potassium, as the rice-wheat cropping sequence at moderate yield level of 8.8 t/ha, removes from the soil 235, 92 and 336 kg/ha/year of N, $P_2O_5$ and $K_2O$ respectively (IFA World Fertilizer Use Manual, 1992). Evidently, even with the recommended rate of fertilization, a negative nutrient balance is being noticed particularly for K.

In this study, we have evaluated the effect of balanced application of fertilizers on the yield of crops under a sunflower-maize-pea cropping system with the aim of establishing the most appropriate rates of application of potassium for optimum yields.

### Effect of potassium application on the yield and yield parameters of sunflower

Three field trials, two at farmers' fields and one at Krishi Vigyan Kendras (KVK) Bahowal in Hoshiarpur district were conducted during Rabi, 2006. KVK centers were established to train farmers in various occupations related to agriculture in all districts of the Punjab, to help the trainees generate self-employment and to help the farmers follow modern techniques of farming.

The physico-chemical properties of soils are reported in Table 1.

Five treatments viz. 60:0:0; 60:30:0; 60:30:30; 60:30:60 and 60:30:90 kg $N:P_2O_5:K_2O$ per ha were applied. The crop was grown following randomized block design (RBD) with three replications at each location of the experiment. All the di-ammonium phosphate (DAP), muriate of potash and half of urea was applied at sowing and the second half of urea was applied after 30 days (DAS).


*Dr. M. S. Brar delivers a talk to farmers at the KVK center. Photo by P. Imas.*

**Table 1.** Physico-chemical properties of experimental soils of sunflower 2006.

| Soil Characteristics | KVK Bahowal | Sakrooli | Nangal Khurd |
|---|---|---|---|
| pH | 8.6 | 8.1 | 8.2 |
| EC (dS/m) | 0.28 | 0.23 | 0.31 |
| Organic Carbon (%) | 0.35 | 0.71 | 0.57 |
| Available N (kg/ha) | 150.5 | 351.2 | 363.7 |
| Available P (kg/ha) | 21.9 | 49.6 | 32.4 |
| Available K (kg/ha) | 125.4 | 131.6 | 124.3 |
| Clay (%) | 3.2 | 7.2 | 11.2 |
| Sand (%) | 65.0 | 47.5 | 32.5 |
| Silt (%) | 31.8 | 45.3 | 11.2 |
| Texture (USDA) | Sandy Loam | Loam | Silt Loam |

*Heads and stems of sunflower plants: Only N (left), N and P (center) and N, P and K (right). Photo by M. S. Brar.*

The application of both P and K increased the yield of grain and straw of sunflower and an optimum yield of 23.0 q/ha was obtained with combined application of $N_{60}P_{30}K_{90}$ (Table 2). Addition of K at the rates of 30, 60 and 90 kg $K_2O$/ha increased average grain yield by 8.6, 6.2 and 10.0 per cent over application. The agronomic efficiency of potassium application ($AE_K$) was calculated to be 6.0 kg grain per kg $K_2O$ application. Application of potassium at the rates of 30, 60 and 90 kg $K_2O$/ha increased the straw yield by 6.1, 12.1 and 11.9 per cent over NP application with an agronomic efficiency of 8.7 kg straw per kg of $K_2O$ applied.

Growth and yield parameters were enhanced by K application (data not shown). Potassium increased the 1000-

# Research findings

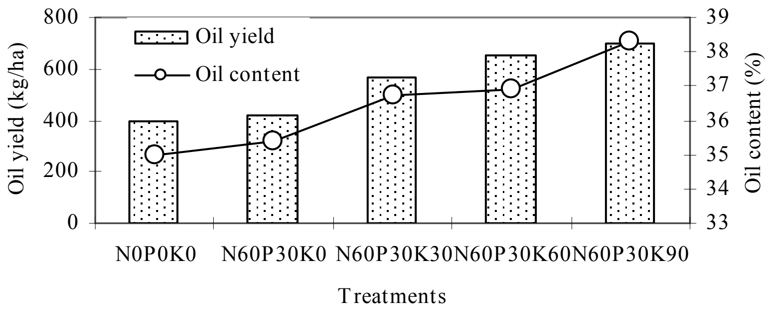
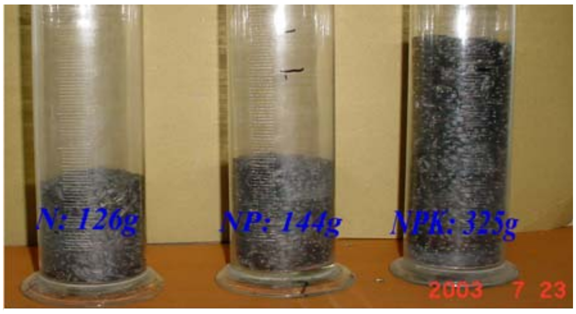



**Fig. 1.** Oil yield and oil content of sunflower as influenced by nutrient treatment.




*1000 grain weight of sunflower: 126 g for N; 144 g for NP and 325 g for NPK treatment. Photo by M. S. Brar.*

**Table 2.** Grain, straw and fresh head yield of sunflower as influenced by nutrient treatments.

| Treatment | Location: KVK Bahowal | Location: Nangal Khurd | Location: Sakrooli | Average yield | $AE_k$[1] |
|---|---|---|---|---|---|
| | | *Grain yield (q/ha)* | | | kg grain/straw per kg $K_2O$ |
| $N_{60}P_0K_0$ | 23.3 | 22.1 | 12.6 | 19.3 | - |
| $N_{60}P_{30}K_0$ | 23.9 | 25.6 | 13.0 | 20.8 | - |
| $N_{60}P_{30}K_{30}$ | 24.4 | 30.8 | 12.6 | 22.6 | 6.0 |
| $N_{60}P_{30}K_{60}$ | 24.0 | 28.9 | 13.4 | 22.1 | 2.2 |
| $N_{60}P_{30}K_{90}$ | 22.5 | 32.1 | 14.6 | 23.0 | 2.4 |
| CD (5%) | 3.9 | 6.6 | NS | | |
| CV | 10.0 | 15.4 | 19.8 | | |
| | | *Straw yield (q/ha)* | | | |
| $N_{60}P_0K_0$ | 69.9 | 18.4 | 23.3 | 37.2 | - |
| $N_{60}P_{30}K_0$ | 68.0 | 34.6 | 25.9 | 42.8 | - |
| $N_{60}P_{30}K_{30}$ | 71.2 | 33.2 | 31.9 | 45.4 | 8.7 |
| $N_{60}P_{30}K_{60}$ | 72.7 | 34.4 | 37.1 | 48.0 | 8.6 |
| $N_{60}P_{30}K_{90}$ | 72.1 | 33.2 | 38.3 | 47.9 | 5.6 |
| CD (5%) | 14.8 | 9.2 | NS | | |
| CV | 12.5 | 19.5 | 32.7 | | |
| | | *Fresh head yield (q/ha)* | | | |
| $N_{60}P_0K_0$ | 130.6 | 172.0 | 180.0 | 160.8 | |
| $N_{60}P_{30}K_0$ | 132.0 | 192.0 | 185.0 | 169.6 | |
| $N_{60}P_{30}K_{30}$ | 150.0 | 259.0 | 231.0 | 213.3 | |
| $N_{60}P_{30}K_{60}$ | 144.0 | 222.0 | 210.5 | 192.1 | |
| $N_{60}P_{30}K_{90}$ | 151.3 | 285.0 | 230.0 | 222.1 | |
| CD (5%) | 27.7 | 33.6 | 33.4 | | |
| CV | 11.7 | 9.6 | 10.4 | | |

[1] $AE_K$: Agronomic efficiency of K

**Table 3.** Physico-chemical properties of experimental soils of maize 2006.

| Soil Characteristics | KVK Bahowal | Sakrooli | Makhangarh | Atwalan |
|---|---|---|---|---|
| pH | 8.58 | 8.35 | 8.31 | 8.50 |
| EC (dS/m) | 0.28 | 029 | 0.21 | 0.29 |
| Organic Carbon (%) | 0.35 | 0.54 | 0.33 | 0.44 |
| Available N (kg/ha) | 150.5 | 376.3 | 301.0 | 313.6 |
| Available P (kg/ha) | 21.90 | 69.44 | 21.90 | 16.17 |
| Available K (kg/ha) | 125.44 | 279.44 | 154.0 | 158.48 |
| Clay (%) | 3.2 | 10.2 | 4.8 | 7.8 |
| Sand (%) | 65.0 | 45.0 | 62.5 | 57.5 |
| Silt (%) | 31.8 | 44.8 | 32.7 | 34.7 |
| Texture (USDA) | Sandy Loam | Loam | Sandy Loam | Sandy Loam |

grain weight, head diameter, plant height, the stem girth of plants and total leaf area. Fresh harvested head yield increased by 25.7, 13.2 and 30.0 per cent with the application of 30, 60 and 90 kg $K_2O$/ha, respectively over NP application. Grain to head ratio, which reflects photosynthate partitioning efficiency of crop plants increased in response to K application. Stems of the plants from the balanced fertilized treatment (NPK) were much thicker than those of the imbalanced fertilized treated plants (NP only).

Total leaf area increased significantly with application of K as compared with NP thereby enabling a greater production of photosynthates in the balanced fertilized crop.

Potassium application increased both oil content and oil yield (Fig. 1). The oil yield of 696 kg/ha was obtained with 90 kg K/ha application as against 392 kg/ha with imbalanced fertilization (NP only).

### Effect of potassium application on the yield and yield parameters of maize

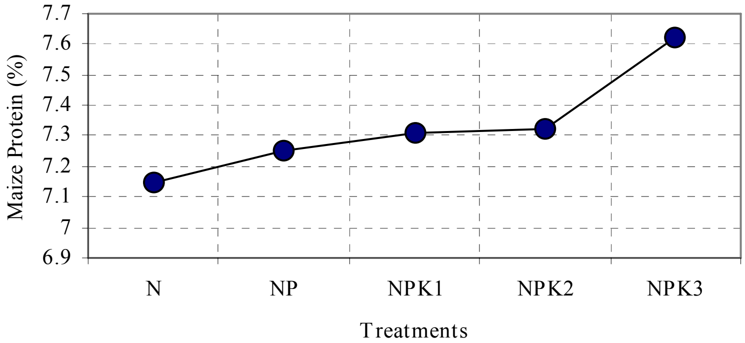
Four field experiments, three at a farmers' field and one at KVK in the Hoshiarpur district were conducted during kharif 2006 to predict the response of maize to K application in soils testing low to medium in available K. Physico-chemical properties of the soils are reported in Table 3.

Five treatments viz. 125:0:0; 125:60:0; 125:60:30; 125:60:60 and 125:60:90 kg

# Research findings

$N:P_2O_5:K_2O$ per ha were applied. The crop was grown following RBD with three replications at each site. Nitrogen and phosphorus were applied uniformly to all the plots at 125 kg N/ha and 60 kg $P_2O_5$/ha as urea and di-ammonium phosphate (DAP). All the phosphorus and one third of the amount of N was applied at sowing, a third of the N when the crop was at knee-high stage and the remaining third at the tasseling stage. Potassium was applied as muriate of potash at sowing. The crop was manually harvested at maturity.

The grain yield of maize increased with increasing levels of K up to 90 kg $K_2O$/ha at all the sites (Table 4).




N=125; P=60; K1=30; K2=60; K3=90 kg/ha

**Fig. 2.** Percentage of protein in maize as influenced by nutrient treatment (average of three locations, 2005).

**Table 4.** Grain yield (q/ha) of maize as influenced by nutrient treatments.

| Treatment | ……Location…… | | | | Average |
|---|---|---|---|---|---|
| | KVK Bahowal | Atwalan | Makhangarh | Sakrooli | yield |
| | Grain yield (q/ha) | | | | |
| $N_{125}P_0K_0$ | 22.0 | 55.7 | 44.0 | 64.6 | 46.6 |
| $N_{125}P_{60}K_0$ | 28.0 | 54.3 | 45.5 | 63.5 | 47.8 |
| $N_{125}P_{60}K_{30}$ | 28.1 | 58.2 | 47.2 | 64.2 | 49.4 |
| $N_{125}P_{60}K_{60}$ | 22.4 | 66.1 | 52.0 | 66.0 | 51.6 |
| $N_{125}P_{60}K_{90}$ | 33.5 | 69.7 | 64.7 | 73.2 | 60.3 |
| CD (5%) | 7.2 | 7.5 | 13.1 | NS | |
| CV | 14.2 | 8.0 | 16.7 | 11.2 | |

Imbalanced application of fertilizer, with addition of only N recorded the average yield (4 sites) of 46.6 q/ha. The addition of phosphorus and potassium increased the yield further. However, optimum yield of 60.3 q/ha was obtained with the combined application of N, P and K at the rates of $N_{125}$, $P_{60}$ and $K_{90}$ kg/ha. Additional doses of K at the rates of 30, 60 and 90 kg $K_2O$/ha along with combined application of N and P increased the average grain yield by 3.3, 11.7 and 26.1 per cent. The much lower yields at KVK Bahowal than elsewhere were the result of comparatively poor stand of the crop due to excessive soil moisture conditions caused by excessive rain. The highest yield of all the sites was at Sakrooli, which may have resulted from the comparatively high fertility status of this soil. Thus the yield of maize in general, was related to the fertility status of the different experimental sites. However, NPK application enhanced yields at all sites irrespective of differences, in fertility status, varietals differences, and crop management practices adopted.


*Effect of potash application on grain filling of corn. Photo by M. S. Brar.*

Application of K resulted in significantly bigger cobs with more length, girth and number of grain lines at most sites, compared to those produced from the NP treatment. Increased cob length, girth and number of grain lines per cob in turn increased grain weight per 100 cobs and 100 grains weight. Growth parameters viz. plant height, plant girth and leaf area index were also positively influenced by potassium application (data not shown).

The protein content of maize was increased with balanced application of fertilizers (Fig. 2). Hence the balanced fertilization not only increased the yield but also improved the quality of maize.

**Effect of potassium application on the yield and yield parameters of peas**

Vegetable (green) pea is an important winter season crop of the Punjab and is mainly grown in the Hoshiarpur, Nawanshehar and Ropar districts. The soils of these districts are low to medium in available potassium. Green peas, being a short duration crop, are likely to respond to the application of potassium.

To study the effect of potassium on the yield of green pea, experiments were conducted at Krishi Vigyan Kendra (KVK), Bahowal, Nangal Khurd, and Sakrooli (District Hoshiarpur). Various physico-chemical properties of soils from various experimental sites are listed in Table 5.

Five treatments viz. $N_{50}P_0K_0$, $N_{50}P_{60}K_0$, $N_{50}P_{60}K_{30}$, $N_{50}P_{60}K_{60}$ and $N_{50}P_{60}K_{90}$ (N, $P_2O_5$ and $K_2O$, kg/ha) were applied at all sites. The crop was grown following RBD with three replications at each location. A recommended dose of 50 kg N/ha as urea and 60 kg $P_2O_5$/ha as di-ammonium phosphate was given at the time of sowing. This was carried out in

# Research findings

**Table 5.** Physico-chemical properties of experimental soils for peas.

| Soil Characteristics | KVK Bahowal | Nangal Khurd | Sakrooli |
|---|---|---|---|
| pH | 8.5 | 7.7 | 7.8 |
| EC (dS/m) | 0.22 | 0.17 | 0.11 |
| Organic Carbon (%) | 0.35 | 0.69 | 0.45 |
| Available N (kg/ha) | 98.6 | 338.6 | 326.1 |
| Available P (kg/ha) | 18.2 | 68.9 | 66.7 |
| Available K (kg/ha) | 118.4 | 101.9 | 100.8 |
| Clay (%) | 2.2 | 3.6 | 4.96 |
| Sand (%) | 63.6 | 42.8 | 52.2 |
| Silt (%) | 34.2 | 53.5 | 42.8 |
| Texture (USDA) | Sandy loam | Silt Loam | Sandy Loam |

mid October 2004 at all the experimental sites using the variety Arkel.

Yield of fresh pods of green peas, which is an important parameter since the crop is sold as green pods for vegetable purposes, was increased over the control by application of K at all the sites (Table 6). At KVK Bahowal, Sakrooli and Nangal Khurd highest pod yield

**Table 6.** Fresh pods and grain yield of peas as influenced by nutrient treatments.

| Treatment | Location | | | | $AE_k$ [(1)] |
|---|---|---|---|---|---|
| | KVK Bahowal | Nangal Khurd | Sakrooli | Average | |
| | | *Pod Yield (q/ha)* | | | kg pod/grain per kg $K_2O$ |
| $N_{50}P_0K_0$ | 16.9 | 13.1 | 22.7 | 17.5 | - |
| $N_{50}P_{60}K_0$ | 21.1 | 20.0 | 32.6 | 24.5 | - |
| $N_{50}P_{60}K_{30}$ | 23.6 | 27.9 | 30.6 | 27.3 | 6.0 |
| $N_{50}P_{60}K_{60}$ | 28.0 | 25.0 | 30.9 | 27.9 | 5.7 |
| $N_{50}P_{60}K_{90}$ | 34.3 | 31.2 | 38.1 | 34.5 | 11.1 |
| CD (5%) | 9.5 | 5.7 | 5.5 | | |
| CV | 22.9 | 12.9 | 9.4 | | |
| | | *Grain Yield (q/ha)* | | | |
| $N_{50}P_0K_0$ | 6.3 | 4.4 | 7.5 | 6.0 | - |
| $N_{50}P_{60}K_0$ | 6.9 | 6.6 | 12.2 | 8.5 | - |
| $N_{50}P_{60}K_{30}$ | 9.6 | 8.7 | 11.4 | 9.9 | 4.7 |
| $N_{50}P_{60}K_{60}$ | 9.7 | 7.7 | 12.4 | 9.9 | 2.3 |
| $N_{50}P_{60}K_{90}$ | 12.3 | 9.9 | 14.7 | 12.3 | 4.2 |
| CD (5%) | 3.9 | 2.1 | NS | | |
| CV | 25.8 | 14.8 | 21.5 | | |

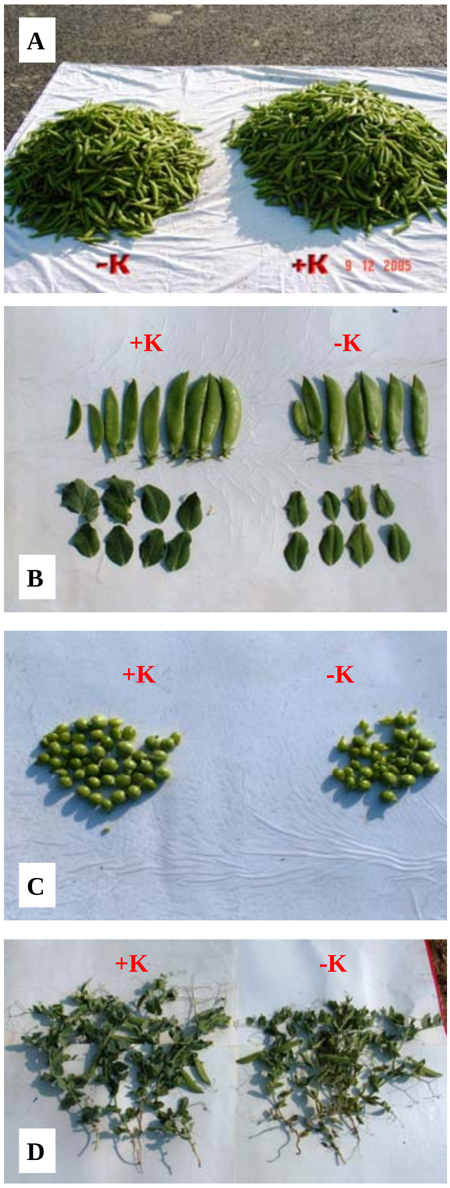
[(1)] $AE_K$: Agronomic efficiency of K

(34.3, 38.1 and 31.2 q/ha) was obtained with the $N_{50}P_{60}K_{90}$ treatment. Average pod yield increased by 11.4, 13.8 and 40.8 per cent over N and P fertilized plots by application of 30, 60 and 90 kg $K_2O$/ha. The highest agronomic efficiency of K ($AE_K$) of 11.1 kg fresh pods with application of 1.0 kg of $K_2O$ was obtained by the application of 90 kg $K_2O$/ha.

Application of K enhanced all the yield parameters. Potassium application increased the number of pods per plant, the 100 pod weight and grain weight from 100 pods (data not shown). The effect of potassium application was to increase all the factors such as number and weight of pods per plant contributing to a higher yield of peas. The yield of fresh grains is an important criterion, particularly in a crop like green pea as it indirectly determines its price in the market. An increase in yield to the extent of 44.7 per cent was observed with application of 90 kg $K_2O$/ha, over N and P treated plots. The highest $AE_K$ of 4.7 kg fresh grain with application of 1 kg $K_2O$/ha was obtained (Table 6).

The results of this study clearly indicated the need for a balanced fertilizer application, especially with potassium in order to obtain the optimum yield of crops. It was also established that the sunflower-maize-peas cropping system is a good alternative to a rice-wheat system, particularly in an area with a scarcity of water. Since this cropping system also includes oilseed, cereal and vegetable (pulse) in the rotation, soil health and crop productivity will be sustained as compared to cereal-cereal system. The system is particularly suitable because of the very fast rate of groundwater depletion in the Punjab.

Edited by E.A. Kirkby




*The effect of potash application on pod (A, B) and pea (C) yields and above ground biomass of three pea plants (D). Photos by P. Imas.*

# Research findings

## *III* The effect of simulated drought and potassium fertilization on yield of triticale and sugar beet.

*Dr. Thomas Popp, Coordinator Central Europe.*

### Introduction

Crop growth and productivity depend upon environmental conditions such as radiation, temperature, water supply and nutrient availability. In many areas of the world the occurrence of drought has become more frequent and research on overcoming drought stress is required.

In Poland, which is on the border of the maritime and continental climate, short-term drought periods are frequent and depress yields especially in the sandy soils, which cover 60 per cent of Poland's agricultural land. One of the many functions of potassium in plants is the regulation of the osmotic potential and turgor in plant cells, i.e. control of water consumption. The following experiments were conducted in order to investigate the role and contribution of potassium in triticale and sugar beet production under two different periods of induced drought.

### Methods and materials

To evaluate the effect of water and K availability on crop yield, two field experiments were established at the Brody Research Station (Agricultural University of Poznań, Poland). The experimental soil was loamy sand with a neutral reaction and a potassium content of 14 mg $K_2O$/100 g (Double Lactate method). Two crops were tested, triticale (1993 – 1995, 3 seasons) and sugar beet (1998 – 2000, 3 seasons). The two-factorial trial consists of two potassium application rates (0, $100_{triticale}$ / $150_{sugar\ beet}$) and four different water management regimes (Table 1).

A static plastic shelter, covering the experimental area of 72 $m^2$ was used to obtain soil moisture stress at particular stages of growth of the two crops. Nitrogen and phosphorus were applied at 100 and 30 kg/ha for triticale and 120 and 50 kg/ha for sugar beet, respectively. P and K-fertilizers were provided as a basal dressing before seeding and planting, and nitrogen supplied twice in an equally split application in two split applications.

### Results and discussion

#### Triticale

The highest yields were achieved, when fields were irrigated and these were closely followed by plants grown under rainfed conditions (Fig. 1). Inducing drought reduced yield considerably; the effect being greater when water shortage occurred during stem elongation (June), as compared with during flowering (July).

Potassium fertilization was beneficial in all treatments, producing 1.33 mt/ha additional grain production and an agronomic efficiency of K of 13.3 kg ($AE_K$, kg grain/kg $K_2O$). The yield increase under full irrigation was only 6 per cent, whereas under rainfed conditions as much as a 22 per cent additional yield was recorded, when 100 kg/ha $K_2O$ were applied (Fig. 1).

Under drought conditions, K application had a tremendous effect on grain yield. When the drought period occurred at stem elongation, the application of K

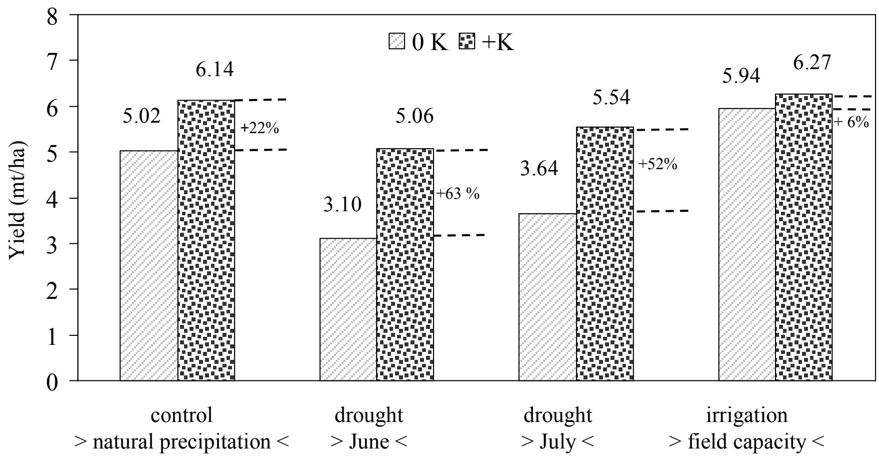



**Fig. 1.** Effect of K application on triticale yield under various water management regimes (average of three years).

**Table 1.** Treatments applied in triticale and sugar beet.

| Treatment | Water management | ..............Triticale....................... | | | ........................Sugar beet.................... | | |
|---|---|---|---|---|---|---|---|
| | | N-$P_2O_5$-$K_2O$ [kg/ha] | Drought months | Drought duration | N-$P_2O_5$-$K_2O$ [kg/ha] | Drought months | Drought duration |
| 1.1 | Rainfed | 100-30-0 | -- | -- | 120-50-0 | -- | -- |
| 1.2 | Rainfed + K | 100-30-100 | -- | -- | 120-50-150 | -- | -- |
| 2.1 | Drought 1 | 100-30-0 | June | 3 weeks | 120-50-0 | July | 4 weeks |
| 2.2 | Drought 1 + K | 100-30-100 | June | 3 weeks | 120-50-150 | July | 4 weeks |
| 3.1 | Drought 2 | 100-30-0 | July | 3 weeks | 120-50-0 | August | 4 weeks |
| 3.2 | Drought 2 + K | 100-30-100 | July | 3 weeks | 120-50-150 | August | 4 weeks |
| 4.1 | Irrigated | 100-30-0 | kept at 70 % field capacity | | 120-50-0 | kept at 70 % field capacity | |
| 4.2 | Irrigated + K | 100-30-100 | kept at 70 % field capacity | | 120-50-150 | kept at 70 % field capacity | |

# Research findings

increased yield by 63 per cent, from 3.1 mt/ha to 5.06 mt/ha (drought June). This effect on yield was slightly lower, when water shortage occurred at flowering (drought July), nevertheless with an additional yield of 1,900 kg/ha it is still impressive. In both drought treatments, $AE_K$ was very high at approximately 19 kg grain per 1 kg of potassium applied. The 3-years field trial with induced drought periods clearly demonstrates that an adequate supply of K could markedly reduce the impact of drought on grain yield of triticale, and can be considered as an 'insurance policy' for erratic rain conditions.

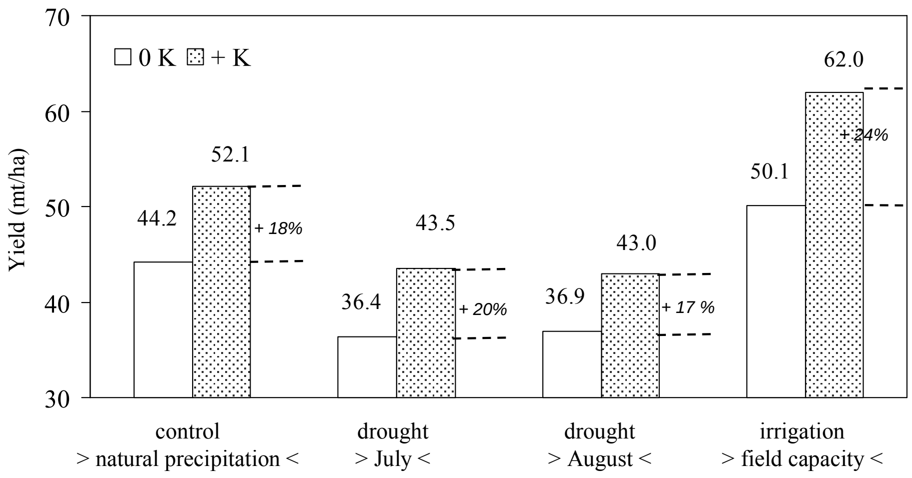



**Fig. 2.** Effect of K application on sugar beet yield under various water management regimes (average of three years).

### Sugar beet

Both experimental factors, water treatments as well as K application, influenced the final average yields of sugar beet roots of the three year trial (Fig. 2). Potassium fertilization resulted in an average yield increase of 8.25 mt/ha, taking into account all four water treatments. The average $AE_K$ was 55 kg of sugar beet per kg of potassium, and was much higher with irrigation, $AE_K$ being increased to 79 kg of sugar beet per kg potassium applied. The highest yield (62.0 mt/ha) was obtained from both K fertilized and irrigated treatment. This treatment also showed the largest effect of K application, which resulted in an additional yield of 24 per cent (Fig. 2). Induced drought had a significant effect on root yield and, compared to the rainfed treatment, the yield of beets at harvest was lower by up to 9 mt/ha. There was not much difference in the yield response, whether the drought period occurred during July or August. Potassium fertilization increased the beet yield by 17 per cent (drought in August) and 20 per cent (drought in July). Both experimental factors had only a small effect on sugar content (approx. 16.7%), α-amino N, K and Na content, and therefore the refined sugar yield followed the same pattern as the root yield.

### Conclusions

The need for an adequate water supply and a balanced K fertilization was demonstrated in trials with triticale and sugar beet in experiments carried out over a period of three years. In both crops, potash application had a pronounced effect in increasing yield, by helping to alleviate the depressive effect of drought. Potash application can be considered as an 'insurance policy' and should be made annually. Potash application also raised yields under natural precipitation, without any obvious periods of water restriction. It is concluded that potash fertilization, at 100 and 150 kg $K_2O$/ha in triticale and sugar beet, respectively, is cost effective when regular precipitation occurs, and has a dramatic effect on yield under drought conditions.

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- Wyrwa P., Grezbisz W. & Diatta J.B. 1998: The effect of simulated drought and potassium fertilization on spring triticale growth and yield. Internal report.
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Edited by E.A. Kirkby

**Potassium and drought resistance in plants.**

"A favorable effect of potassium (K) application on plant water relations during water deficit has been reported for several crops… Increased application of K has also been shown to enhance photosynthetic rate, plant growth, yield, and drought resistance in different crops under water stress conditions… Furthermore, a favorable relationship between K content of leaves and plant water relations under water deficit has been observed… In fact, K is a predominant low molecular weight inorganic ion accumulating during drought stress in case of various crops… It can accumulate in plants in concentrations ranging from 50 to 150 mM in the cytoplasm and vacuoles of the cells without imposing any harmful effect on plant metabolism…"

Adapted from Moinuddin and P. Imas, "Evaluation of Potassium Compared to Other Osmolytes in Relation to Osmotic Adjustment and Drought Tolerance of Chickpea Under Water Deficit Environments". Journal of Plant Nutrition, 30: 517–535, 2007.

# Events

**IPI Open Forum on "Potassium Research in Central Europe", 22 March 2007, Budapest, Hungary.**

*Dr. Tomáš Lošák, Mendel University of Agriculture and Forestry, Brno, Czech Republic, presents the results of the effect of K on quality of poppy crop. Photo by H. Magen.*

IPI Coordinator for Central Europe, Dr. T. Popp, organized a satellite event to the 5th New Ag International Conference and Meeting, 21-23 March 2007. Ten papers covering potassium demand, application and status in soils, and results from the various experiments and research conducted in Bulgaria, Hungary, Poland, Czech and Slovak republics were presented by scientists from these countries. A presentation on the effect of potassium on plant disease was given by Dr. L. Datnoff, IFAS University of Florida, USA.

All the presentations made at the event are available on the IPI website.

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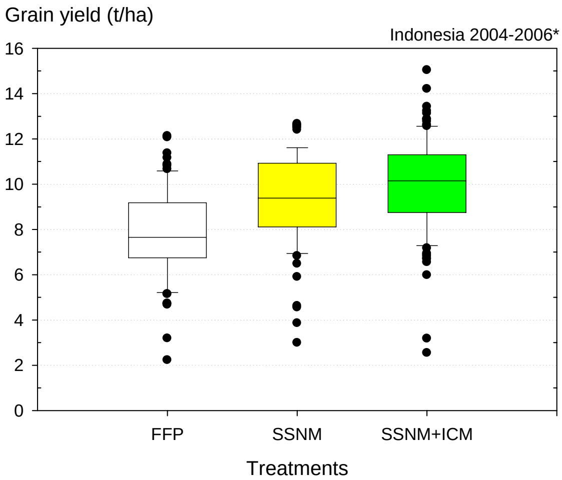
**5th Workshop on "Site specific Nutrient Management for Maize in Indonesia", 31 May 2007, Bandar Lampung, Indonesia.**

Collaborators of the project on *Site-Specific Nutrient Management (SSNM) for Maize in Indonesia* met to review recent research and develop fertilizer recommendations for participatory evaluation at project sites in the provinces of North Sumatra, Lampung, East and Central Java, and South Sulawesi in 2007/08. In recent months, much progress has been made in the development of the new SSNM approach for maize, particularly in the formulation of guidelines to determine meaningful yield targets; calculate fertilizer N, P, and K rates; and manage fertilizer N depending on crop need by growth stages, including the use of the leaf color chart. Data from trials with different planting densities were used to provide decision support on the selection of adequate row-spacing and plant spacing within-rows for favorable and less favorable tropical maize growing environments. Several management practices, including the application of lime or organic matter, have been evaluated at project sites in the last three years depending on suspected constraints to high yield. Average yield advantages with SSNM and improved crop management were about 1-2 t/ha compared to the farmers' practice (see graph above). With SSNM for maize approaching maturity, the team has started the development of an integrated framework geared towards an Ecological Maize Intensification (EMI) based on the selection of suitable crops grown in rotation, optimal planting times, varieties, and best management practices including SSNM.





Maize yield in the farmers' fertilizer practice (FFP) and treatments with Site-Specific Nutrient Management (SSNM) or SSNM plus Improved Crop Management (SSNM+ICM) at project sites in Central Java (2005-2006, one season for Grobogan; one season for Wonogiri, nine farms), Lampung (2006, one season, five farms), North Sumatra (2005-2006, two seasons, 10 farms), East Java (2005-2006, three seasons, 15 farms).

Farmers, extension workers, and researchers attending a field day organized by the Assessment Institute of Agricultural Technologies (AIAT) in Lampung to discuss project findings on improved nutrient and crop management strategies for maize on 30 May 2007 (photo above, by C. Witt). Workshop participants on 1 June 2007 (photo on top) were from various research centers and institutes in Indonesia, IPNI (Canada), FENALCE (Columbia), IRRI (Philippines), IPI (Switzerland), the University of Nebraska (U.S.), and the Southeast Asia Program of IPNI and IPI (Singapore).

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# Events

## Coming events:

**IPI-IFS-Sabanci University joint symposium on "Potassium and Magnesium Sodium: Advances in Research and Application", 5-7 December 2007, Cambridge, UK.**

This symposium is jointly organized by IPI, the International Fertilizer Society (IFS) and Prof. Ismail Cakmak of Sabanci University, Istanbul, Turkey. The Conference will start at midday on Wednesday the 5th December 2007 and finish after lunch on Friday 7th. It will be of interest and value to academics, agronomists and advisors and also to fertilizer company staff. Distinguished speakers have been invited to give a keynote addresses. The speakers and their topics will be announced soon on the websites of the IFS (www.fertiliser-society.org) and IPI (www.ipipotash.org). The Symposium is open to all, and the registration fee will be approximately GBP250. The registration fee includes coffees and lunches, as well as a full set of Proceedings, but does not include accommodation or evening meals, which will be approximately GBP150 per delegate for the full Conference. VAT will be added to these prices for delegates from within the EU.

For more information see http://www.ipipotash.org/events/IPI+IFS+Sabanci.

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**IPI-IFDC-BRRI-BFI International workshop on "Balanced Fertilization for Increasing and Sustaining Crop Productivity", 30 March-1 April 2008, Dhaka, Bangladesh.**

The workshop will be jointly organized by IPI, International Center for Soil Fertility and Agricultural Development (IFDC), Bangaladesh Rice Research Institute (BRRI) and Bangladesh Fertilizer Association (BFA).

A major new challenge in future food production is to meet the demand of the growing Asian population. Malnutrition remains endemic in Bangladesh, an overwhelmingly agrarian country, and without adequate measures the level of vulnerability is likely to increase as a result of severe land degradation, soil erosion and the lack of appropriate technologies in agriculture. Successful diversification in crop production, which is helpful in providing ability to withstand market variability, requires wide dissemination of modern technologies for the cultivation of high value crops like fruits and vegetables. Research-based balanced application of mineral fertilizers will increase agricultural productivity for self-sufficient crop production and for maintaining soil fertility for future generations.

This Workshop will provide an opportunity for delegates to discuss soil fertility issues and concerns resulting from current status of fertilizer application, and to share experiences gained from advanced nutrient management practices.

For more details, see the web or contact Dr. Vladimir Nosov (Vladimir.nosov@ipipotash.org).

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## Other events:

**Dahlia Greidinger Symposium 2007 on "Advanced Technologies for Monitoring Nutrient and Water Availability to Plants", 12-13 March 2007, Technion - Israel Institute of Technology, Haifa.**

The availability of water and nutrients is a major factor regulating world agricultural productivity. Until recently, large scale estimation of such availability has been problematic. However, the development of global positioning system technology (GPS) and computerized approaches to chemical, spectral and biological sensing of nutrients and water has lead to numerous breakthroughs in this cutting edge area of research and development.

Previous symposia have covered on slow release fertilizers, fertigation, fertilization under saline conditions, nutrient and resource management and the environment, amongst other topics. The 9th Dahlia Greidinger Symposium was focused this time on the technical developments in the field of GPS and advanced monitoring systems and approaches, and provided an opportunity for leading scientists to present 18 invited lectures and contributed posters describing on-going research on monitoring methods, technologies for measuring physiological processes in plant systems, VNIR reflectance spectroscopy, spectral data and hyperspectral images used for nitrogen prediction in potatos, irrigation control and stress mapping.

The symposium was followed by a technical tour to the Dead Sea and Negev area where Israel's potash and phosphate resources are mined and processed.

For proceedings of Dahlia Greidinger's meetings since 1993, log on to http://gwri-ic.technion.ac.il/main.php?location=news&action=show_proceed&flag=d.

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# New publications

**Revised edition of successful publication Rice: A Practical Guide to Nutrient Management. T.H. Fairhurst, C. Witt, R.J. Buresh, and A. Dobermann (eds).** 2007. *Rice: A Practical Guide to Nutrient Management (2nd edition).* International Rice Research Institute (IRRI), Philippines, International Plant Nutrition Institute (IPNI) and International Potash Institute (IPI), Singapore. 89p text and 47p Annex with color plates. ISBN 978-981-05-7949-4. 110 mm x 140 mm. First edition 2002. Reprinted 2003, 2005. Second edition 2007.

In the last five years, site-specific nutrient management (SSNM) for rice has become an integral part of initiatives on improving nutrient management in many Asian countries. Nutrient recommendations were tailored to location-specific needs, evaluated together with rice farmers, and promoted through public and private partnerships at wide-scale. The first edition of Rice: A Practical Guide to Nutrient Management published in 2002 quickly became the standard reference for printed materials on SSNM. The guide was high in demand with 2,000 copies distributed and sold to date.

Over the years, SSNM has been continually refined through research and evaluation as part of the Irrigated Rice Research Consortium. Conceptual improvements and simplifications were made particularly in nitrogen management. A standardized 4-panel leaf color chart (LCC) was produced and the promotion of the new LCC continues with more than 250,000 units distributed until the end of 2006. A new SSNM website was developed (www.irri.org/irrc/ssnm) to provide up-to-date information and local recommendations for major rice-growing areas in Asia.

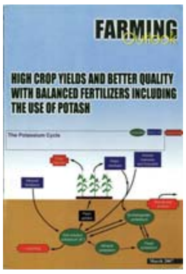
The revised edition of the practical guide provides up to date information consistent with advice provided on the SSNM website and local training materials. We are pleased to announce that this 2nd edition is to be translated into a number of languages including Bangla, Chinese, Hindi, Indonesian, and Vietnamese. This pocket-sized guide introduces the concept of yield gaps and the underlying constraints. The functions of each nutrient are explained in detail, with a description of the deficiency symptoms and recommended strategies for improved nutrient management. The 47-page color annex provides a pictorial guide to the identification of nutrient deficiencies in rice.

To make the 2nd edition of the guide as widely accessible as possible, the publishers are selling the guide through their websites and bookstores, and have also made the guide available in electronic format (pdf) at the websites of IRRI (http://www.irri.org) and the Southeast Asia Program of IPNI and IPI (http://www.ipni.net/seasia) using a Creative Commons "attribution-noncommercial-share alike" license: http://creativecommons.org/licenses/by-nc-sa/3.0.

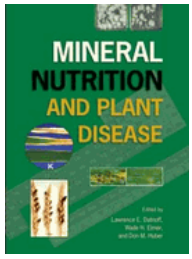
### Language editions:

The following language editions will be available in late 2007: Bahasa Indonesia, Bangla, Chinese, Hindi, and Vietnamese.

IPI coordinators in India, Bangladesh and China are undertaking the relevant translations.



**Farming Outlook, March 2007. *High Crop Yields and Better Quality with Balanced Fertilizers Including the Use of Potash.* 31p. ISSN 1680-5984.** Farming Outlook is a quarterly educational magazine on policy and developments of progressive agriculture, published in Pakistan. The editor, Dr. M. T. Saleem participated at the IPI International Symposium in India 22-25 November 2006. This issue of Farming Outlook provides extensive coverage of the symposium. Farming Outlook has an International Advisory Board and gives the reader an excellent overview of developments in Pakistan's progressive agriculture sector. For more details, please contact Dr. M. T. Saleem at tahir.pak@comsats.net.pk.



**Mineral Nutrition and Plant Disease. Edited by Lawrence E. Datnoff, Wade H. Elmer and Don M. Huber 400p; 40 color and black and white images, ISBN 0-89054-346-1.** This comprehensive book examines how mineral nutrition affects plant disease. Minerals improve the overall quality and health of plants. Knowing how each individual mineral affects a plant is beneficial for efficiency in production and sustaining the ecosystem. From a plant pathology perspective, ***Mineral Nutrition and Plant Disease*** brings the discussion of plant disease diagnosis and management to a new level. Mineral nutrients are important in production agriculture and horticulture because they can often be the first line of defense against plant diseases. It is an area of knowledge that can be misunderstood or overlooked in the study of diseases and their diagnosis. This reference succeeds

# New publications

in organizing what we know and explaining the interactions at work. ***Mineral Nutrition and Plant Disease*** is the first book to successfully combine these two important plant science disciplines, nutrition and pathology, to provide current information on theoretical aspects of nutrition in disease physiology while contributing a wealth of basic practical information for obtaining immediate disease suppression with specific fertilizers.

***Mineral Nutrition and Plant Disease*** was financially supported by IPI and some of its member companies. IPI published ***RT No. 3 on Potassium and Plant Health***, (2nd completely revised edition) in 1990, and it can be ordered at http://www.ipipotash.org/publications/detail.php?i=24.

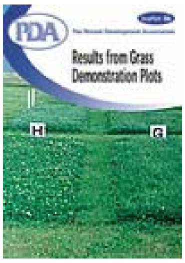
For more information log on to http://www.shopapspress.org/minuandpldi.html.

# Publications by the PDA

What is the PDA (Potash Development Association)?

The Potash Development Association 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 http://www.pda.org.uk/.

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




#5b. Results from Grass Demonstration Plots

Crops of grass were grown on small unreplicated plots in the arable area of the National Agricultural Centre, Stoneleigh. The same treatments were used on the same plots for each of 4 consecutive years. Three cuts were taken each year at silage stage and crops were weighed and analysed. Soil was sampled in the autumn before the first harvest year and in each autumn of the comparison. See PDA website.

# K in the literature

**Long-Term Soil Experiments: Keys to Managing Earth's Rapidly Changing Ecosystems.** Richter, D.deb., Hofmockel, M., Callaham, M.A., Powlson, D.S. and P. Smith. 2007. Soil Sci. Soc. Am. J. 71:266-279. http://soil.scijournals.org/cgi/content/abstract/71/2/266.

**Abstract:**

To meet economic and environmental demands for about 10 billion people by the mid-21st century, humanity will be challenged to double food production from the Earth's soil and diminish adverse effects of soil management on the wider environment. To meet these challenges, an array of scientific approaches is being used to increase understanding of long-term soil trends and soil-environment interactions. One of these approaches, that of long-term soil experiments (LTSEs), provides direct observations of soil change and functioning across time-scales of decades, data critical for biological, biogeochemical, and environmental assessments of sustainability; for predictions of soil productivity and soil-environment interactions; and for developing models at a wide range of scales. Although LTSEs take years to mature, are vulnerable to loss, and have yet to be comprehensively inventoried or networked, LTSEs address a number of contemporary issues and yield data of special significance to soil management. The objective of this study was to evaluate how LTSEs address three questions that fundamentally challenge modern society: how soils can sustain a doubling of food production in the coming decades, how soils interact with the global C cycle, and how soil management can establish greater control over nutrient cycling. Results demonstrate how LTSEs produce significant data and perspectives for all three questions. Results also suggest the need for a review of the state of our long-term soil-research base and the establishment of an efficiently run network of LTSEs aimed at soil-management sustainability and improving management control over C and nutrient cycling.

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**Comparison of Seven Kinetic Equations for K Release and Application of Kinetic Parameters.** LU Xiao-Nan, XU Jian-Ming, MA Wan-Zhu and LU Yun-Ful. 2007. Pedosphere 17(1): 124-129.

**Abstract:**

Corn field experiments with two treatments, NP and NPK, where N in the form of urea, P in the form of calcium

# K in the literature

phosphate, and K in the form of KCl were applied at rates of 187.5, 33.3, and 125 kg/ha, respectively, on soils derived from Quaternary red clay were conducted in the hilly red soil region of Zhejiang Province, China. Plant grains and stalks were collected for determination of K content. Seven equations were used to describe the kinetics of K release from surface soil samples taken before the corn experiments under electric field strengths of 44.4 and 88.8 V/cm by means of electro-ultrafiltration (EUF) and to determine if their parameters had a practical application. The second-order and Elovich equations excellently described K release; the first-order, power function, and parabolic diffusion equations also described K release well; but the zero-order and exponential equations were not so good at reflecting K release. Five reference standards from the field experiments, including relative grain yield (yield of the NP treatment/ yield of the NPK treatment), relative dry matter yield (dry matter of the NP treatment/dry matter of the NPK treatment), quantity of K uptake in the NP treatment (no K application), soil exchangeable K, and soil $HNO_3$ soluble K, were used to test the effectiveness of equation parameters obtained from the slope or intercept of these equations. Correlations of the Ymax (the maximum desorbable quantity of K) in the second-order equation and the constant b in the first-order and Elovich equations to all five reference standards were highly significant (P <0.01). The constant a in the power function equation was highly significant (P <0.01) for four of the five reference standards with the fifth being significant (P <0.05). The constant b in the parabolic equation was also significantly correlated (P <0.05) to the relative grain yield and soil HNO3-soluble K. These suggested that all of these parameters could be used to estimate the soil K supplying capacity and the crop response to K fertilizer.

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**Foliar K applications safe with glyphosate.** Nelson, K., Motavalli, P., Stevens, G., Kendig, A., Nathan, M. and D. Dunn. 2007. Fluid Journal, Issue 56, Vol. 15, No. 2 - Spring 2007, pp 14-16.

**Abstract**:

Soybean injury resulting from foliar applications of up to 19.2 lbs/A of $K_2O$ from several potassium (K) fertilizer sources (i.e., potassium chloride, potassium thiosulfate, and 3-18-18) was generally less than 10 per cent. K fertilizer sources tank-mixed with glyphosate, such as 3-18-18 at 2.4 and 9.6 lbs $K_2O$/A, 5-0-20-13 (KTS + urea-triazone) at 2.4 lbs $K_2O$/A, and 0-0-62 at 9.6 and 19.2 lbs $K_2O$/A, controlled more than 90 per cent of weeds and produced grain yields similar to herbicide applications with diammonium sulfate (DAS), while providing additional K fertilizer to the soybean plant in a single-pass weed management system in northern Missouri. However, two-pass weed management in southern Missouri provided excellent weed control for all additives, and grain yields were greater than or similar to glyphosate plus DAS. The results of the study indicate that foliar K applications can be mixed with glyphosate with minimal crop injury and reduction in weed control, depending on product selection and application rate.

Link:

http://www.fluidfertilizer.com/pastart/potassiu.htm.

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**Yield, Seed Quality, and Sulfur Uptake of Brassica Oilseed Crops in Response to Sulfur Fertilization.** Malhi, S.S., Gan, Y. and J.P. Raney. 2007. Agron. J. 99:570–577.

http://agron.scijournals.org/cgi/content/abstract/agrojnl;99/2/570.

**Abstract**:

Field experiments were conducted in 2003, 2004, and 2005 on a S-deficient Gray Luvisol (Boralf) soil near Star City, in northeastern Saskatchewan, to determine yield, seed quality and S uptake response of different *Brassica* (*B.*) oilseed species/cultivars to S deficiency and S fertilization. A total of 20 treatments were tested in a factorial combination of four oilseed crops (*B. juncea* canola cv. Arid, *B. juncea* canola cv. Amulet, *B. juncea* mustard cv. Cutlass, and *B. napus* cv. InVigor 2663 hybrid canola) and five rates of potassium sulfate fertilizer (0, 10, 20, 30, and 40 kg S/ha). All *B.* species/cultivars responded positively for seed yield and most other parameters to S fertilizer in all 3 yr, but the magnitude of response varied with species/cultivar and year. Seed yield was highest with Cutlass *juncea* mustard in a dry year (2003), but was highest with InVigor 2663 hybrid canola in years with above-average precipitation (2004 and 2005). Seed yield was usually maximized at the rate of 30 kg S/ha for all *B.* species/cultivars. Oil concentration in seed increased with S fertilization for all *B.* species/cultivars. There was a significant (albeit small) increase of protein concentration in seed due to S fertilization. Cutlass *juncea* mustard accumulated considerably high concentrations of glucosinolates in seed, but glucosinolate concentrations were low in other *B.* species/cultivars. Sulfur uptake in seed was highest with Cutlass juncea mustard in all years. The effects of S deficiency and applied S were more pronounced on seed than straw. In conclusion, S fertilizer requirements for optimum seed yield were similar for all the *B.* species/cultivars used in this study on S-deficient soil, but higher yielding types of *B.* would produce greater seed yield by using S more efficiently.

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# K in the literature

**Low Input Approaches for Soil Fertility Management in Semiarid Eastern Uganda.** Kaizzi, K.C., Byalebeka, J., Wortmann, C.S. and M. Mamo. 2007. Agron. J. 99:847–853.

http://agron.scijournals.org/cgi/content/abstract/agrojnl;99/3/847.

**Abstract**:

Grain sorghum [*Sorghum bicolor* (L.) Moench] is an important food crop of semiarid sub-Saharan Africa. Crop yields are generally low, partly due to low soil fertility. Research was conducted with farmers to evaluate soil fertility management practices in sorghum-based cropping systems including: mucuna [*Mucuna pruriens* (L.) DC.] fallow; cowpea [*Vigna unguiculata* (L.) Walp.] rotation with sorghum; animal manure application; N and P fertilizer application; and reduced tillage. Four studies, comprised of 142 on-farm trials, were conducted at three locations over three years in drought-prone parts of eastern Uganda. Mucuna on average produced 7 Mg/ha of aboveground dry matter containing 160 kg N/ha across the three locations. Application of 2.5 Mg/ha of manure and of 30 kg N plus 10 kg P/ha increased grain yield by 1.05 and 1.30 Mg/ha, respectively. A combination of 2.5 Mg/ha manure with 30 kg N/ha increased grain yield by 1.50 Mg/ha above the control (1.1 Mg/ha). The increase in sorghum grain yield in response to 30 kg N/ha alone, to a mucuna fallow, and to a rotation with cowpea was 1.15, 1.55, and 0.82 Mg/ha, respectively. These soil fertility management practices, as well as reduced tillage, were found to be cost effective in increasing sorghum yield in the predominantly smallholder agriculture where inorganic fertilizer was not used much. On-farm profitability and food security for sorghum production systems can be improved by use of inorganic fertilizers, manure, mucuna fallow, sorghum–cowpea rotation, and reduced tillage.

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**Long-term fertilization impacts on corn yields and soil organic matter on a clay-loam soil in Northeast China.** Ping Zhu, Jun Ren, Lichun Wang, Xiaoping Zhang, Xueming Yang and D. MacTavish. J. Plant Nutr. Soil Sci. 2007, 170, 1–5.

http://www3.interscience.wiley.com/cgi-bin/abstract/114211539/ABSTRACT.

**Abstract**:

A long-term fertilization experiment with monoculture corn (*Zea mays* L.) was established in 1980 on a clay-loam soil (Black Soil in Chinese Soil Classification and Typic Halpudoll in USDA Soil Taxonomy) at Gongzhuling, Jilin Province, China. The experiment aimed to study the sustainability of grain-corn production on this soil type with eight different nitrogen (N)-, phosphorus (P)-, and potassium (K)–mineral fertilizer combinations and three levels (0, 30, and 60 Mg ha/y) of farmyard manure (FYM). On average, FYM additions produced higher grain yields (7.78 and 8.03 Mg/ha) compared to the FYM0 (no farmyard application) treatments (5.67 Mg/ha). The application of N fertilizer (solely or in various combinations with P and K) in the FYM0 treatment resulted in substantial grain-yield increases compared to the FYM0 control treatment (3.56 Mg/ha). However, the use of NP or NK did not yield in any significant additional effect on the corn yield compared to the use of N alone. The treatments involving P, K, and PK fertilizers resulted in an average 24 per cent increase in yield over the FYM0 control. Over all FYM treatments, the effect of fertilization on corn yield was NPK > NP = NK = N > PK = P > K = control. Farmyard-manure additions for 25 y increased soil organicmatter (SOM) content by 3.8 g/kg (13.6%) in the FYM1 treatments and by 7.8 g/kg (27.8%) in the FYM2 treatments, compared to a 3.2 g/kg decrease (11.4%) in the FYM0 treatments. Overall, the results suggest that mineral fertilizers can maintain high yields, but a combination of mineral fertilizers plus farmyard manure are needed to enhance soil organic matter levels in this soil type.

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*An IPI field experiment in Turmeric (Curcuma longa) is being conducted in Tamil Nadu, South India. This crop is widely used in Indian cuisine and is believed to have many medicinal properties. Photos by P. Imas.*

For more K literature go to www.ipipotash.org/literature/.

*Note:* All abstracts in this section are published with permission from the original publisher.

## for thought

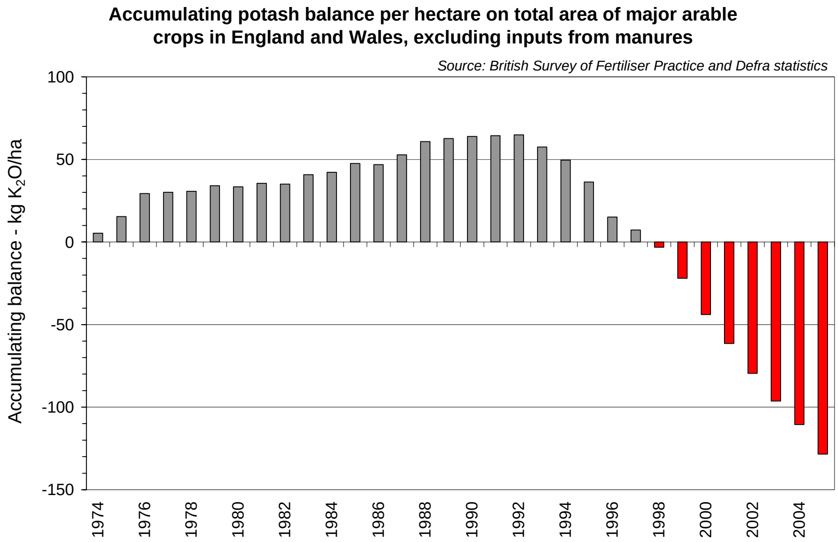
### Balancing outputs with adequate, responsible and sustainable inputs.

Sustainable agriculture implies the long term maintenance of soil fertility. The figure on the right illustrates how this can change in relation to potash by considering the accumulating average potash balance in $K_2O$ per hectare over the past thirty years as calculated by annual differences between inorganic fertilizer inputs and crop offtakes for the major arable crops in Britain: cereals, oilseeds, sugar beet and potatoes. Manures are not taken into account but this has little bearing on the calculation because the supply of K to the soil in this form is relatively low in arable farming.

Over the period between 1973 and 1992 arable farmers in England and Wales applied a little more potash fertilizer each year than was removed in harvested crops, so that by 1992 on average these arable soils had 65 kg $K_2O$ more than they had in 1973. However since then, over the last 15 years, the soil reserves have been mined, drawing from the "soil potassium bank" approximately 200 kg/ha of potash, without "paying back" through fertilization for all that was removed by harvest over that period.

Such balance calculations are very useful in assessing long-term consequences of changing fertilization practices. Farmers should not wait for the inevitable loss of fertility resulting from potash depletion but rather increase potash fertilization to maintain balance.

Adapted from data published by PDA, November 2006.




*Fertilizer broadcasting in Parana, Brazil: key to replenishing nutrients in the soils where the fertility status is fragile. Photo by A. Naumov.*

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