Optimizing Crop Nutrition

INTERNATIONAL POTASH INSTITUTE

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

Editorial

Dear Readers,

Agronomy. This issue of *e-ifc* covers Indian research projects on papaya and soybean. In both projects, the effect of potash on latex quality (of papaya) and reduced susceptibility to pests and disease (in soybean) demonstrates that potassium has an effect on internal qualities of the plant and product, in addition to the effect on yield. An interesting observation from many of our on-farm trials and demonstrations is the effect of potash application on the ability of the plant to resist the damage born by disease, pests and insects. This phenomena is not new, yet the physiological mechanism is still not known. We anticipate this is a topic we will return to in future editions of *e-ifc*, to expand on the results included in this issue.

Events. IPI held few large scale events during the last few months, and while most of the presentations are on our website, we would like to bring to your attention a collection of abstracts from the joint IPI-EMBRAPA (Brazilian Agricultural Research Corporation) satellite symposium titled "Potash in Agricultural Systems of Tropical Savannas of South America: Adequate Fertilizing Practices in Areas with Poor Soils". The event was organized under the auspice of FERTBIO, and was attended by some 100 researchers.

During November 2006, IPI and the Punjab Agriculture University (PAU) jointly organized an international symposium on "Balanced Fertilization for Sustaining Crop Productivity" (22-25 November 2006, Ludhiana). More details on this and other events are covered later in this issue**.**

Energy vs. food? As we move into 2007 it seems clearer that the world is changing. Global warming no longer appears to be merely scientific speculation, with many countries in the Northern hemisphere experiencing some of the warmest winters on record, while Australia endures it's worst drought in 100 years. The continuing increase in demand for biofuels is a challenge for food production systems. Will crops be used for human and animal food, or car food? Can we maintain the required increase in food production and at the at the same time meet the rapidly increasing demand for carbon neutral fuels? Nutrient management will probably continue to play a major role in all of these agricultural developments.

Extension. Research and extension remain a vital component for increasing agricultural productivity. In this context, the fertilizer industry gathered in Brussels at the beginning of March (7-9 March 2007) to discuss 'Fertilizer Best Practices Management' in developed and developing countries. We take a brief look at some of the Extension issues raised at this conference in this edition's 'K for Thought' section. We will be reporting on the conference in more detail in the next edition of the *e-ifc* due at the end of June 2007.

I wish you all an enjoyable read.

Hillel Magen
Director

A modern variety of cashew growing in Sri Lanka. Picture by V. Nosov.

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I Effect of potassium nutrition on growth, yield and quality of papaya

This report is based on the IPI - Tamil Nadu Agricultural University, Horticultural College & Research Institute project conducted in Coimbatore, Periyakulam, Tamil Nadu, India.

Potassium Nutrition of Papaya

The effect of potash fertilizer on the growth, yield and quality of papaya fruits (cultivars Co-2 and Co-7) and latex (cultivar Co-2) has been investigated by Kumar *et al.* The study was carried out during 2004-05 in India in Tamil Nadu using four locations in farmers' fields. Four treatments with increasing levels of potash were applied: 300:300:0; 300:300:150; 300:300:300 and 300:300:450 g N:P_2O_5:K_2O/plant/year.

General effects on growth

Tree growth parameters were assessed at the first flowering phase, a critical one influencing the yield of papaya. Stem girth was not affected significantly by K nutrition at three of the four locations, but at the other, K exerted a significant detrimental influence such that the greater the K supply, the lesser was the stem girth. This negative effect of K might possibly have been associated with the high availability of N in the soil as excess 'N' is known to decrease trunk diameter and also plant height at the flowering phase.

The continuous production of vegetative growth, flowering and fruiting is a characteristic of Papaya so that for papaya plants a high number of leaves as well as a high leaf surface area are important criteria in assessment of plant vigour. In this investigation, leaf number was significantly increased by K nutrition at two locations while the same was true for leaf area only at one site. A high number of leaves and leaves with a high surface area enhance the production of photosynthates and the synthesis of large quantities of metabolites during growth and development.

Fruit growth and quality

Fruit weight of Papaya, which is a very important economic character as far as marketing is concerned, was significantly influenced by K nutrition at all four locations. In general, an increase in K supply was accompanied by an increase in fruit weight up to K_{300} (Fig. 1). However, with the variety Co-7, maximum fruit weight was observed with 450 g K_2O/plant/year, this variation in response to K being attributed to varietal difference. With an increase in K rates up to $K_{150-300}$, there was also a corresponding increase in the number of fruits per plant at three of the locations, although the effect was non-significant.

Latex tapping in Tamil Nadu. Photo by V. Nosov.

Fruit yield per plant as well as fruit yield per hectare was significantly influenced by K nutrition as revealed in the findings from three sites. The general trend was that fruit yield rose with the increased rate of K application up to K_{300} and then declined (Fig. 1). The exception, the Co-7 variety responded to K fertilization up to highest rate of application. These findings have been interpreted that fertilization with K not only resulted in a higher uptake of K but also increased the availability of other nutrients in the soil, leading to optimum vegetative growth, enhanced uptake of nutrients, with the promotion of photoassimilation and translocation of assimilates from source to sink, the result of which was reflected by increased fruit yields.

K nutrition significantly affected pulp thickness of papaya fruits in all the locations (the maximum being with K_{300} in three sites and with K_{450} in one location). This increase in pulp thickness may be related to the role of K in influencing the developing fruit which acts as a stronger sink for K than for other nutrients. It may also relate, as discussed

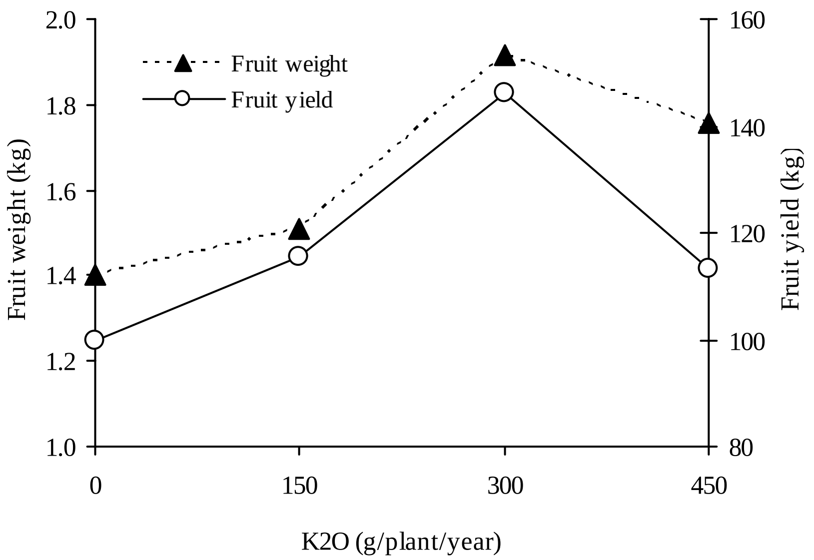

Fig. 1. Effect of K application on fruit weight and fruit yield per plant in papaya (average for four locations).

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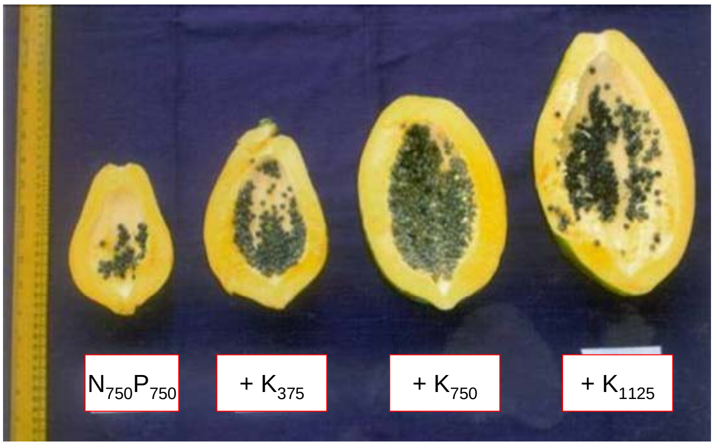
earlier, to the greater number of leaves with a higher surface area that are produced at higher levels of K nutrition, which enable efficient transfer of K from source to sink, in the development of fruit with thicker flesh.

The sweetness of papaya, mainly assessed by TSS (total soluble solids) content, was found to be significantly influenced by K. At all the locations, an increase in the level of K application resulted in a substantial increase in TSS content. Potassium is known to promote sugar translocation in plants, thus its application increased the sugar content as well as TSS in the papaya fruit. Acidity is another important fruit quality trait and should be at its minimum value during ripening. At three locations, the acidity content significantly decreased with increase in K supply.



Potassium effect on size of fruit and yield of papaya. IPI-TNAU project in Vadipatti, Theni district, Tamil Nadu, India. The pictures and more are also available on IPI's K Gallery (http://www.ipipotash.org/k-center/detail.php?i=11). Photo by V. Nosov.

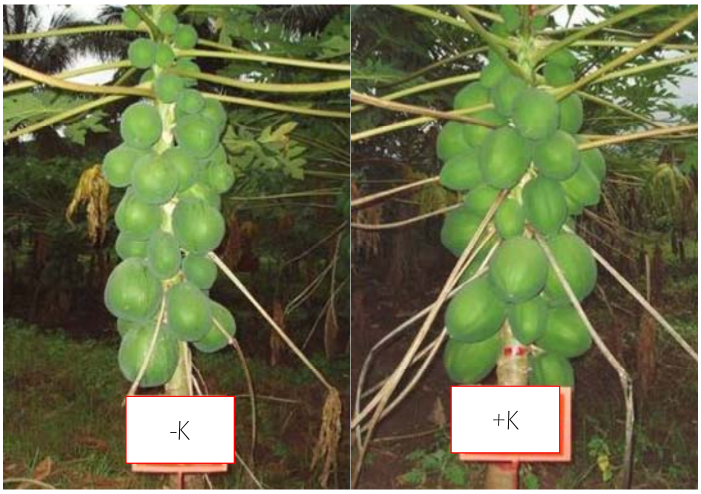
Latex yield and quality

No definite trend was observed on the effect of K application on latex yield, as recorded at the two sites investigated (Table 1). This lack of response may possibly have been due to the inherent problems at field level in tapping the latex at fixed intervals. On the other hand, however, the quality of latex assessed in terms of increased quantity of TSS was raised by increased potash fertilization as revealed in both locations. This finding is of particular interest since TSS content is an important quality criterion by which the latex procuring industries make payments to growers. Additionally this work appears to be the first recorded evidence of a positive effect of K on the quality of papaya latex.

K_2O, g/plant/year	Total latex yield (kg/plot*)		TSS of the latex (°Brix)	
	A	B	A	B
0	181.23	32.00	16.70 ± 0.07	15.84 ± 0.11
150	181.00	36.60	16.83 ± 0.04	15.76 ± 0.10
300	155.22	35.00	16.91 ± 0.08	16.62 ± 0.10
450	137.40	34.10	17.00 ± 0.06	16.80 ± 0.10

* 1,000 sq.m; A - Chandrapuram, B - Thondamuthur.

Table 1. Effect of potassium application on the latex yield and its quality in papaya.



N-P2O5-K2O = 750-750-0 N-P2O5-K2O = 750-750-750

Effect of potassium on number of and size of papaya fruit. Photo by V. Nosov.

Reference

Kumar, N., Meenakshi, N., Suresh, J. and Nosov, V., 2006. Effect of potassium nutrition on growth, yield and quality of papaya (*Carica papaya* L.). Indian Journal of Fertilizers, 2 (4): 43-47. Go to IPI web site.

Edited by E. A. Kirkby.

Research findings

II IPI-EMBRAPA Solos Symposium on "Potash in Agricultural Systems of Tropical Savannas of South America: Adequate Fertilizing Practices in Areas with Poor Soils", Bonito MS, Brazil 19-21 September 2006.

A. Naumov, IPI Coordinator for Latin America.

Country	Local Name of Region/Landscape	States/Provinces/Departments	% of Land Area
Argentina	Región Norte	Santa Fé, Santiago del Estero, Chaco, Formoza, Córdoba* (Chaco forests); Corrientes (Campos)	
Bolivia	Llanos	Beni, Santa Cruz, Chuquisaca, Tarija	50
Brazil	Campos, Campos cerrados (cerrados), Campos limpos	Mato Grosso, Mato Grosso do Sul, Goiás, Tocantins, D.F., Bahia*, Maranhão(1), Piauí*, Minas Gerais*, São Paulo(1), Roraima*	24
Colombia	Llanos Orientales	Meta, Arauca, Casanare, Vichada	29
Paraguay		Amambay, Concepción, San Pedro, Canindeyú, Alto Paraná, Caaguazú, Cordillera, Guairá, Caazapá	25
Venezuela	Llanos de Orinoco	Apure, Barinas, Portuguesa, Cojedes, Guárico, Anzoátegui, Monagas, Delta-Amacuro*	33

Table 1. Savannas in South America (*Source:* A. Naumov).

* Only part of state/province under savanna vegetation.

The symposium, organized by Latin America Coordination of International Potash Institute (IPI) and National Soils Research Center of the Brazilian Corporation for Agricultural Research (EMBRAPA), was a satellite event of FERTBIO – Congress of Soil Fertility and Plant Nutrition, the major biannual event on these topics in Brazil. The 2nd half-day sessions of the symposium which included 9 presentations were attended by more than 200 participants of FERTBIO who took part in discussions. The symposium was opened by welcoming speeches from Mr. Hillel Magen, IPI Director, and Dr. Aluisio Andrade, R&D Chief of the National Soils Research Center of EMBRAPA.

Participants of IPI-EMBRAPA Solos symposium, 19-21 September 2006.

Dr. Alexey Naumov, Coordinator of the Latin American program of IPI and Associate Professor of Moscow State University, Russia, spoke about the geography and agricultural development of tropical savannas regions in South America. Savanna landscapes occupy a large area at this continent, belonging to Brazil, Colombia, Venezuela, Bolivia, and Paraguay (Table 1). Areas with similar climatic characteristics are also found in subtropical parts of the Northern Argentine. Most of the savannas are suitable for agriculture because of the hot and wet climate, plain relief, and good physical conditions of the soils. But the savannas soils are acid, contaminated with Al and Fe oxides, and poor in nutrients, which limits their agricultural development. Colonization of the huge land reserves, available in the savanna areas, is thus dependent on soil correction and fertilization. Dr. Naumov reviewed the current situation in agriculture and prospects for its further development in savanna areas of Colombia (Llanos Orientales), Venezuela (Llanos de Orinoco), Bolivia (Oriente), Paraguay, Brazil (Cerrado) and of the northern provinces of Argentina. In conclusion, he spoke about joint research activities of IPI and EMBRAPA with special focus on field experiments, carried out since 2001 in different parts of Brazilian Cerrado. See presentation titled "Tropical Savannas Regions in South America: Geography and Agricultural Development" (in English) at http://www.ipipotash.org/speech/.

Dr. Rachel Bardy Prado (EMBRAPA National Soil Research Center, or EMBRAPA Soils) presented provisional results of research, which aimed to map potash balance in Brazilian soils (Fig. 1). The balance between data on potash application on the one hand and export with the main commercial crops on the other was already mapped on a national scale 2 years ago. The next step had been to compare these balances with data on potash availability from 2600 soil profiles collected by EMBRAPA Soils. For major geographical coverage, soil profile data were extrapolated to landscape contours. These extrapolations allowed the design of maps of potash availability in areas of Latossolos (Ferralsols, or Oxisols, according to FAO and U.S. classifications, respectively). Currently, the research is focused on detailed (large-scale) mapping of the Southeast of Goias state. During the AGRISHOW agricultural fair at Rio Verde, Goias in April 2006, many local farmers registered as volunteers to provide data for mapping. Soil analysis data of COMIGO cooperative land properties were also included. Collected information was stored in a data bank. In

Research findings

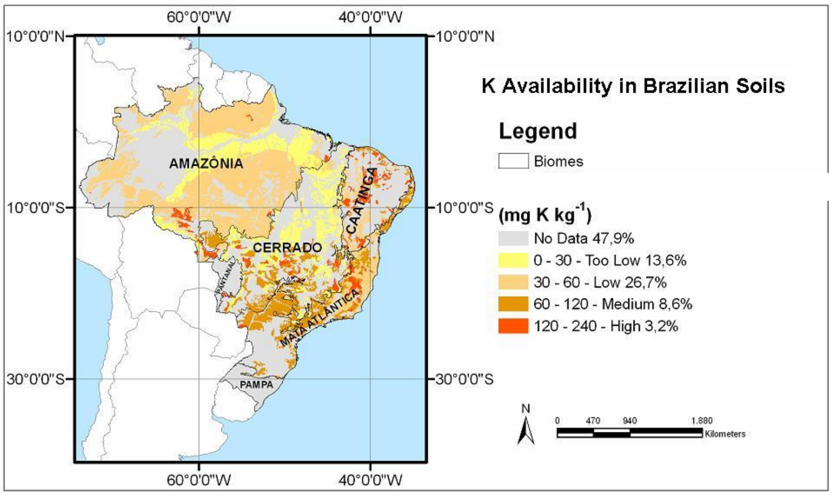


Fig. 1. Mapping of K availability in soil, based on soil profile data (Latossolos and Argissolos; landscape type as mapping unit) (*Source:* R. Prado).

addition, soil samples were gathered for validation. Relief and soil maps, satellite images are also being used for the design of a 1:250,000 map of potash balance in Goias state.

See presentation titled "Proposal for Mapping of Potash Availability in Soil for Southwest of Goias State" (in Portuguese) at http://www.ipipotash.org/speech/.

Dr. Joao Kluthouski (EMBRAPA Rice and Beans Center) focused on integration between crop planting and cattle grazing as a decisive measure for sustainability of Brazilian agriculture. Since 1980, costs for agricultural machinery and fertilizers, in relation to market price of soybeans, rice and other cereals in Brazil had grown very significantly. I.e., in 2005, the cost of 1 t of fertilizer (NPK) was equal to 41 sacks of soybean or 65 sacks of rice (sack = 60 kg), whereas in 1980 these figures were 15 and 13 sacks respectively. Production costs were growing along with colonization of the Brazilian Cerrado, where originally poor soils were being converted from pasturing to agriculture crop production. *Dr. Kluthouski* stressed that more than 40 million ha of pastures in Brazil are degraded. As a measure for improving land use, he proposed different ways of combining planting and grazing. Planting combined with pasturing reduces costs of production because of organic fertilizer application, intensification and diversification of land use (forage and commercial crops grown in rotation). For grazing, benefits are the recuperation of degraded pastures, forage production between main harvests, and possibilities for genetic improvement of husbandry. One of the integrated systems, designed and recommended for the Cerrado by EMBRAPA, is the so-called "Santa Fe" (maize, sorghum, rice, sunflower, combined with tropical forage grasses) (Fig. 2). This system is highly demanding for K and other nutrients. Experimental data provide proof of such advantages of integrated systems, which includes rapid decomposition of harvest residues and mineralization of organic matter (5 times faster than conventional systems) and faster recycling of nutrients.

Dr. Pedro Machado (EMBRAPA Rice and Beans Center) devoted his presentation to precision agriculture techniques with special focus on potash fertilizing in a high productivity soybean planting specialized no-till system. His presentation was based on results of research carried out in Carambei, Parana state (Brazil) where a no-till system has been in practice since 1983. Experimental sites are relatively small – 13 ha of soybeans, planted in rotation with wheat, maize and black oat. The soil is the *Latossolo Vermelho* (tropical red soil). Digital mapping of the field was based on a 40 x 40 m network. Soil analysis showed the following average of exchangeable K expressed as mg dm^{-3} decreasing at depth from 160 at 0-5 cm, to 87 from 5-10 cm to 66 from 10-20 cm. Fertilizing recommendations, depending of K availability, oscillate between 80 to 120 kg K_2O/ha. The results of the experiment did not show a significant response in yield to K application; productivity of soybean was more influenced by physical characteristics of the soil.

See presentation titled "Integration of Planting and Cattle Grazing in No-Till: Decisive Solution for Sustainability of Brazilian Agriculture" (in Portuguese) at http://www.ipipotash.org/speech/.

Roger Taboada Paniagua (CIAT –

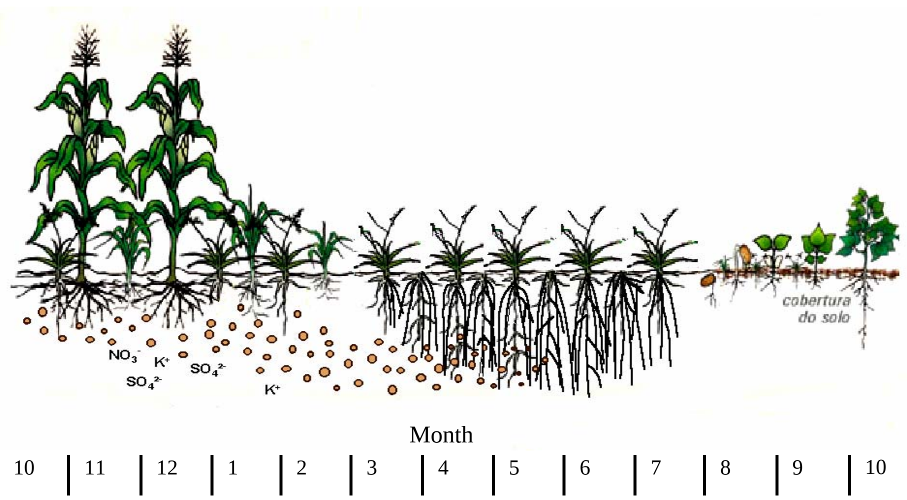


Fig. 2. Dynamic of nutrients in "Santa-Fe" system of integrated planting of grains (months and forage grasses (*Source:* J. Kluthouski).

Research findings

International Center for Tropical Agriculture, Santa Cruz de la Sierra, Bolivia), spoke about the main crops and fertilizing practices in tropical savannas of Bolivia. Two thirds of Bolivian territories are lowlands, at altitudes below 1,500 m in height. One third of this territory is part of the Amazon basin, and a quarter is tropical savanna. 250,000 ha of savannas are included in the department of Santa Cruz, and 130,000 ha in the department of Beni. The principal commercial crops are soybean, maize, rice and sugarcane in summer, and soybean, sunflower, sorghum and wheat in winter. Fertilizing is mostly carried out with "triple 15" (NPK 15:15:15). For rice and wheat, planted in rotation with soybean, farmers apply N as urea (50-150 kg/ha); sugarcane plantations also receive high applications of N.

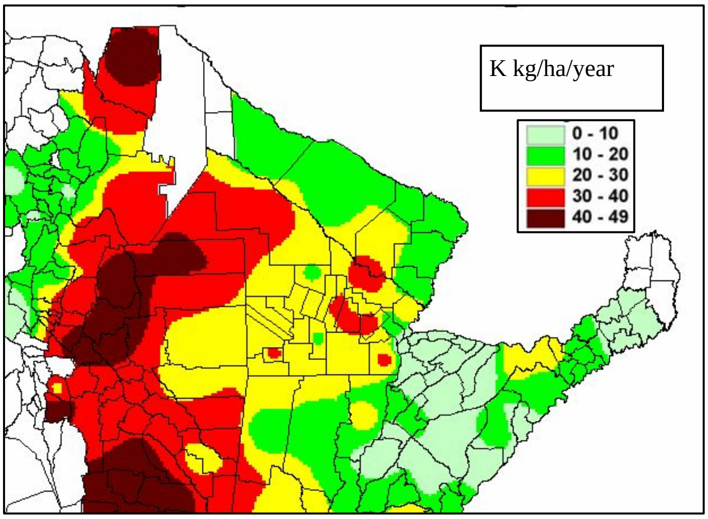


Fig. 3. Export of potash (K/ha) in North Argentina (*Source:* R. Melgar).

Monitoring the soil during a 3 year period of continuous planting showed a decrease of nutrients (15% organic matter, 19% P, 12% K), which could be partially made up for after 1 year of pasturing on the same area. After 3 years of pasturing, nutrient contents increased significantly.

See presentation titled "Main Crops and Fertilization Practices in the Tropical Savannas of Bolivia**"** (in Spanish) at http://www.ipipotash.org/speech/.

Dr. Ricardo Melgar (INTA – Instituto Nacional de Technologia Agropecuaria, Argentina), spoke about Potash in agricultural systems of northern Argentina, a region of recent expansion of agriculture. Historically, these lands were used for pasturing. Fertilizers (mostly P) were used for cotton, rice and soybean planting, with application rates which were equal in amount to the export of this nutrient with the crop. Crops receive only low applications of potash; lack of K is also a limiting factor for cattle productivity. The K concentration in 34% of samples of forage, taken in the Northern provinces, was found to be lower, than that required by cattle during lactation. Total potash consumption in two parts of northern Argentina – Northeast and Northwest — amounts to 21,000 t K_2O, mostly for tobacco, citrus, grains and vegetables. This is less than potash export with a yield estimated as 53,200 t per year. The soils of 6 million ha in an area to the West of the Parana River are potash deficient (Fig. 3). In the Northeast, 75% of soils contain <150 ppm, available K; in 30% the figure is <100 ppm. In this region, soybean shows good economical response to K fertilization, especially when combined with P.

Cotton shows a linear response to K. Recommended rates of potash, in K_2O kg per ha, are: for rice – 50, yerba mate and tea – 70. In the Western provinces of the North, or *Chaco* region, soils are originally more fertile and contain more potash. But in sugarcane plantations, high yields (>90 t/ha) may be obtained only if 100 kg/ha of N and 100 kg/ha of K are applied (Potassium nitrate). In the *Salta* province, which has a 5% annual growth rate of increase in area for soybean production, the limiting factor for the application of fertilizers is their high cost (350 US$ per t of KCl). According to Dr. Melgar, insufficient fertilization will be a negative factor for productivity of Argentinean soils in the mid-term future.

Dr. Aluisio Andrade, R&D Chief of the National Soils Research Center of EMBRAPA (left), Mr. Hillel Magen, Director IPI (middle) and Dr. Alexey Naumov, Coordinator Latin America, IPI (right) signing the continuation of the joint research programs between EMBRAPA and IPI for the period 2006-2009.

See presentation titled "Potash in Agricultural Systems of the Argentinean North" (in Spanish) at http://www.ipipotash.org/speech/.

Dr. June Faria Scherrer Menezes (Department of Agronomy, Federal University of Rio Verde, Goias state, Brazil) devoted her presentation to potash fertilization of soybeans in a no-till system in the Southwest of Goias state. This region is one of major producers of soybeans (0.5 million t per year) and maize (400,000 t). Soil is mostly *Latossolo*, with high Al, originally poor in potash. Potash fertilizers are used for soil correction and for soybeans and maize production. *Dr. Menezes* discussed information from associates of the COMIGO ag-coop, and the GAPES associate group of research, taken from findings from 83 fields in 2001/2002, and 359 fields in 2005/2006. Only 24% of soils had enough exchangeable K, and 23% were rich in K. In this region, farmers usually apply 350 to 400 kg/ha of NPK 02-20-18. It is considered that it is necessary to apply 50-100 kg/ha K_2O for corrective fertilization, and 80-100 kg/ha for row application at planting. Members of the GAPES group historically applied 150 kg KCl/ha as a pre-plant (basal) dressing. These fertiliser rates were sometimes higher, than required, which

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caused disequilibrium of nutrients, waste of K, and economic loses.

See presentation titled "Potash Fertilization of Soybean in No-Till System in the Southwest of Goias" (in Portuguese) at http://www.ipipotash.org/speech/.

Dr. Alberto C. de Campos Bernardi (EMBRAPA Southeast Cattle) spoke about potash fertilization in intensive systems of pasture management. Brazilian cattle ranching is characterized by low intensity (204 million animals grazed on 220 million ha; or 0.6 animal units of 450 kg per ha). The country has about 100 million ha of cultivated pastures, a half of which are in the Cerrado. Of these Cerrado pastures 85% are planted with Brachiaria, and 11% with *Panicum maximum*. 70% of cultivated pastures are degraded, and one of the main factors of degradation is the absence of fertilizer use. Fertilizing pastures helps to improve productivity and quality of forage crops, and allows rotation of pastures. Compared with the conventional system, "rotation" pasturing capacity increases up to 10 animal units per ha (on irrigated pastures), meat production grows up to 600 kg/ha (conventional pasturing – 50 kg), and milk to 20,000 kg/ha. In Brazil, fertilizers are scarcely applied to pastures (average 6 kg/ha per year) because of a lack of knowledge and technical assistance to the producers. Fertilizers are important for seeded pastures at planting (mostly P), and for maintenance (N and K). *Brachiaria brizantha* and *Panicum maximum* grasses are very demanding for K, and alfalfa has a particularly high demand (28 kg K_2O per t of dry matter); to produce 10 t of dry matter 340 kg/ha of K_2O are needed. Dr. Bernardi spoke about criteria for determining rates of potash fertilization, which are exchangeable K in soil, and the K/(Ca+Mg) ratio. For seeded pastures in the *Cerrado*, 20-60 kg K_2O/ha is needed for planting, and 50 kg/ha for maintenance (when K<30 mg/dm^3). Experiments, established at EMBRAPA Southeast Cattle, showed the necessity for applying 150 kg/ha K_2O for alfalfa, which resulted in a linear response of productivity of dry matter (8 t/ha). According to Dr. Bernardi, intensification of pasturing requires: an increase in base saturation to 70% (Ca – 55-60%; Mg – 15-20% CTC), an increase in P from an initial 10 to 30 mg dm^{-3} (10 kg/ha P_2O_5 = 1 mg dm^{-3}), an increase in K from an initial 4% to 6% CTC (100 kg/ha K_2O = 1 $mmol_c$ dm^{-3}), and the application of S. To avoid losses by lixiviation, application of K together with N is recommended as a cover dressing.

Fertbio 2006 attracted hundreds of researchers to the beautiful city of Bonito. This event is an excellent opportunity to meet current research in Brazil.

See presentation titled "Potash Fertilization in Intensive Pastures Management Systems " (in Portuguese) at http://www.ipipotash.org/speech/.

Dr. Jose Carlos Polidoro (EMBRAPA National Soil Research Center) presented joint experiments of EMBRAPA and IPI on potash fertilizing of cover crops before soybean planting in a no-till system. Potash fertilizer (KCl) makes up 7% of the total production cost of soybean and farmers are willing to optimize fertilization and reduce costs. According to common practice, in Southeast Goias, farmers use a formula of NPK blend added in the row at planting. K_2O application rates for millet as a cover crop are 100-300 kg/ha. Experiments have been established at the Technological Center of COMIGO ag-coop. with different cover crops (millet, *Brachiaria bryzantha*, *Brachiaria ruzizenses*, *Stylosanthes*, Niger grass) in which a maximum of 120 kg K_2O/ha is applied at planting, and 40 kg/ha as a cover dressing. Cover crops, it was anticipated, would utilize the K applied efficiently and make it available for the next crop. However, the problem with cover crops is that on one hand, the biomass also absorbs the K from sub soil to be used by the main crop, and on the other that K leaching can be very fast and then it is even lost by the cover crop. Another experiment has been established on sandy soils (available K 60 mg dm^{-3}) with an optimal application rate of 80 kg K_2O/ha. A suggested recommendation is also to synchronize potash application with the precipitation regime.

Sugarcane field in Brazil. Brazil is now a world leader in harvesting energy through biofuel production from sugarcane.

See presentation titled "Potash Fertilization of Cover Crops Anticipating Soybean Planting in No-Till System" (in Portuguese) at http://www.ipipotash.org/speech/.

Edited by E. A. Kirkby.

More presentations that were made during the IPI-EMBRAPA Solos symposium are available on our website at http://www.ipipotash.org/speech/.

Lateral move system installed with sprayers irrigate large scale plots in many Brazilian farms. Photo by H. Magen.

Research findings

III Potassium nutrition in balanced fertilization of a Soybean-Wheat cropping system in Madhya Pradesh, India.

Based on a report submitted to IPI by the National Research Centre for Soybean (NRCS), Indore, Madhya Pradesh, India.

Background to the work

Soybean, the second most important oilseed crop of India has only been cultivated commercially over the past three decades but is providing resilience to the country's oilseed production. During this period the productivity of the crop has shown a gradual increase, but yields over the past few years have more or less reached a plateau of about 1 t/ha. This is because of a deficit and erratic distribution of rainfall and uncertainty in the onset of the Monsoon. Being rain-fed, the productivity of oilseeds in general and soybean in particular has been far below the potential achievable yield. Constraint analyses have indicated however, that imbalanced nutrition is also one of the important reasons for stagnation in productivity.

It is a general practice among farmers of major soybean growing regions in this area to apply some N and/or P mostly as di-ammonium phosphate or single super phosphate (SSP) although at sub-optimal levels. Similarly low rates of applications are also, to a large extent, the case for K based on the misconception that K is a high status nutrient in the soil and in vertisols in particular. In fact, even recommended levels of K application can be insufficient to meet the requirement of the soybean crop as well as that of a soybean based cropping system.

An average soybean crop uptake is about 101-120 kg K/ha and there has been a discrepancy between recommendations for K application and crop requirements.

Effect of 50 kg K_2O/ha applied to soybean crop. IPI-NCSR project in Indore, MP. Photo by P. Imas.

In investigations of net depletion of K (sum total of available and non-exchangeable K) from the soil profile following repeated cropping cycles of soybean-wheat - a frequently practiced rotation in this region - losses of K from the soil were quantitatively much higher than expected. There has thus been an important need to investigate the K nutrition of a soybean-wheat cropping system so as to optimize the crop. An experimental field trial at the Research Farm of the National Research Centre for Soybean, in a randomised block design (plot size 3.6m x 6.0m), compared nine K fertilizer treatments which were applied to both crops. Recommended dressings of N and P were made from soil analyses taken at the onset of the experiment, the basal dressing for soybean being 20 kg N and 60 kg P_2O_5/ha and for the subsequent wheat crop 120 kg N and 60 kg P_2O_5/ha. For both crops P, in the form of SSP, was applied at sowing. For soybean N, as urea, was applied at sowing while for wheat the application was divided equally between sowing and first irrigation. The cultivars used were: Soybean (cv. JS 93-05) and wheat (cv. Sujata). A second set of experiments was carried out simultaneously under farm conditions in three villages but with fewer K treatments. The soybean and wheat varieties grown were JS 335 and Sujata, respectively. Soil properties of the experimental plots are shown in Table 1.

Characteristics	NRCS farm	Village Umrikheda	Village Gokanya	Village Simrol
pH	7.8	7.8	7.7	7.9
EC (dS/m)	0.2	0.2	0.13	0.28
Organic Carbon (%)	0.48	0.60	0.87	0.74
Available N (kg/ha)	180	195	264	249
Available P (kg/ha)	8.41	8.56	11.42	9.30
Available K (kg/ha)	302	326	378	295

Table 1. Soil characteristics of NRCS farm and villages participating in the experiment (Kharif 2004).

productivity from the system by way of making a balanced fertilization by which yields of soybean are improved without depressing those of wheat. Besides its effect on yield and crop quality, K is known to play an important physiological role including building up resistance to insect pests and crop diseases. This aspect has also been considered.

The Experiments

Two types of experiment were conducted during 2004-05 on Vertisols and associated soils in which soybean was cultivated during the rainy (Kharif) season to be then followed by a wheat

Response to Potassium

The experimental field trial

Agronomic and economic benefits

In the 2004-2005 experiment, K application significantly improved the grain yields of both soybean and the subsequent wheat crop (Table 2) indicating that the limitation to the much needed improvement in yields was K deficiency. For both soybean and wheat the split application of potassium gave a slightly higher response than the basal application. The least effective treatment for both crops, in terms of yield, was the two spray foliar application. By doubling the spraying, the treatment was more effective in increasing grain yield so that in soybean it was significantly greater

Research findings

Level of K_2O (kg/ha)		Soybean grain yield	Wheat grain yield	AE_K[(1)] Soybean	AE_K[(1)] Wheat	Additional returns[(2)]	Additional costs[(2)]	GRF[(2,3)]
Soil application		*kg/ha*	*kg/ha*	*Kg grain/kg K*		*Rs/ha*	*Rs/ha*	*Rs/ha*
0		1,510	3,579	-		-	-	-
25	basal	1,807	4,872	11.88	51.72	15,792	488	15,304
50	basal	1,983	4,984	9.46	28.10	19,264	798	18,466
75	basal	1,994	4,984	6.45	18.47	19,236	1,106	18,130
25	50% basal + 50% at flowering	1,870	4,964	14.40	55.40	17,500	668	16,832
50	50% basal + 50% at flowering	2,259	5,499	14.98	38.40	27,762	978	26,784
75	50% basal + 50% at flowering	2,062	4,980	7.36	18.68	20,328	1,286	19,042
Foliar application								
2 spray @ 0.5 % KCl at flowering and 1 week after flowering		1,736	3,955	45.20	75.20	6,552	483	6,130
4 spray @ 0.5% KCl at flowering and 1 week after flowering		1,902	4,135	39.20	55.60	10,486	725	10,002
CD (P=0.05)		279.17	543		-	-	-	-

(1) AE_K = Agronomic efficiency of K (kg grain increase / kg K applied)
(2) Additional returns, costs and calculated GRF were on the basis of the whole cropping system (Kharif soybean and Rabi wheat)
(3) GRF = gross return above fertilizer costs

Table 2. Effect of soil and foliar application of potassium on productivity of soybean and wheat and economics of potash application to the wheat-soybean cropping system.

than the control. The highest grain yield for soybean of 2,259 kg/ha was obtained from the split 50 kg K_2O/ha treatment which also produced the highest wheat grain yield of 5,499 kg/ha. The highest additional yields over the respective controls were thus 749 kg/ha for soybean and 1,920 kg/ha for wheat.

The response to K as expressed by the agronomic efficiency of K (AE_K), the ratio of the kg grain increase to the kg K applied, for soybean ranged from 6.45 (75 kg K_2O basal treatment) to 45.20 (2 sprays of 0.5% KCl). For wheat the range was between the same two treatments but the values were higher from 18.47 to 75.20. The foliar application treatments, although having high agronomic efficiency, were low in grain yields because of the associated low rates of K application. The GRF (Gross return above fertilizer costs) represents the additional returns from the yield increase less the additional costs and is calculated here on the basis of the whole cropping system (Kharif soybean and Rabi wheat). The GRF values as ranging from 6,130 to 26,784 Rs/ha (USD 1 = ~Rs 47), from the 2 spray foliar application to the split basal and flowering application of 50kg K_2O/ ha, show the enormous benefit of potassium fertilization in this soybean-wheat crop sequence. Repeating the experiment for soybean in 2005, the results confirmed the findings reported here.

Resistance to Insects and Crop Disease

The benefits of potassium nutrition in providing resistance to both insect infestations and plant disease on soybean are shown very clearly in Table 3 and Fig 1. .Highest insect infestation and plant disease was found in the untreated crop plants. Applying K markedly depressed insect infestation in the case of blue beetle (*Cneorane spp)* and the defoliators expressed by the number of insects per meter row length (mrl). This was also the case for the percentage disease incidence of stem fly *Melanagromyza sojae* (Zehnt) and the Girdle beetle (*Oberia brevis*). Similarly increased K application depressed the percentage

Level of K_2O (kg/ha)		Insect infestation by				Disease incidence by	
		Blue beetle	Stem fly; Stem tunnelling	Defoliators	Girdle beetle	Collar rot	Myrothecium leaf spot
Soil application		*mrl* [(1)]	*%*	*mrl*	*%*	*% mortality*	*PDI*[(2)]
0		5.9	13.91	1.3	8.35	9.17	38.57
25	basal	2.0	3.87	1.0	2.17	6.07	28.45
50	basal	1.8	2.87	0.8	2.06	4.61	22.58
75	basal	1.3	0.00	0.7	1.91	2.22	25.41
25	50% basal + 50% at flowering	1.8	5.25	0.7	4.70	5.60	22.88
50	50% basal + 50% at flowering	1.8	3.36	0.7	3.29	4.17	26.69
75	50% basal + 50% at flowering	1.6	3.01	0.7	2.47	2.29	27.57
Foliar application							
2 spray @ 0.5 % KCl at flowering and 1 week after flowering		5.1	4.66	0.7	4.37	2.09	29.33
4 spray @ 0.5% KCl at flowering and 1 week after flowering		5.1	4.17	0.6	4.12	2.63	32.12

Table 3. Effect of soil and foliar application of potassium on insect infestation and disease incidence in soybean during Kharif 2004.

Research findings

mortality by collar rot, caused by the fungus *Sclerotium rolfsii* and leaf spot and petiole rot resulting from the pathogen *Myrothecium roridum*.

The reason for the higher incidence of damage by insects and plant pathogens in plants poorly supplied with K is still a matter of discussion. It may in part relate to the function of K in the development of thicker outer walls in the epidermal cells, thus providing protection against plant and animal attack. Additionally, K deficiency is known to impair the synthesis of high molecular weight compounds in the cell (proteins, starch and cellulose) which gives rise to the accumulation of low molecular weight compounds, such as sugars and amino acids, which can provide a ready source of nutrition to animals and plant pathogens.

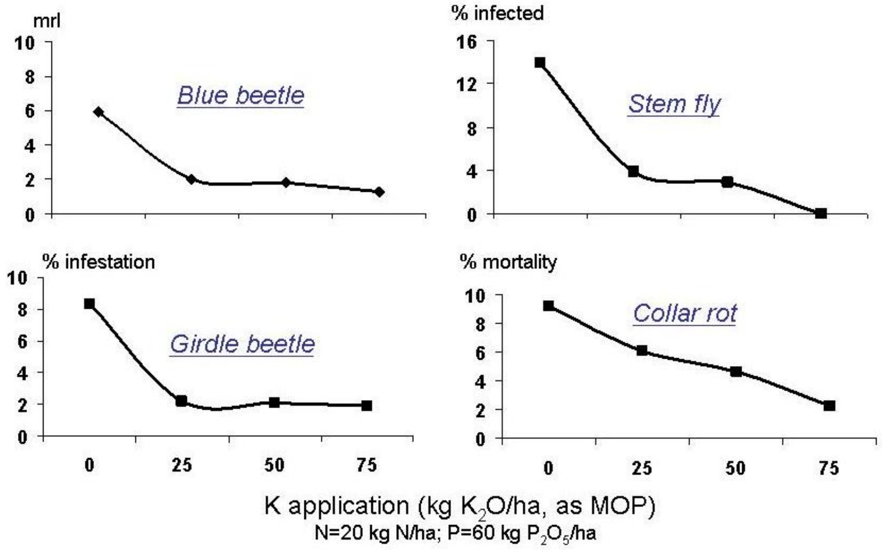


Fig. 1. Effect of K on infection of soybean from various insects and disease. Source: H. Magen; Balanced crop nutrition: Fertilizing for crop and food quality. Presented at the IFA Agriculture Conference, Kunming, 27 Feb.—2 March 2006.

Farmers' Field Trials

Agronomic and economic benefits

The benefits of potash application on the soybean/wheat crop sequence found in the research station field trial was confirmed under practical agricultural practice in the farmers' field trials. These trials demonstrated a marked response to K in terms of soybean equivalent yield (SEY) in kg/ha (Table 4). At all three locations the highest yield was obtained in the $50K_2O$ kg/ha split application treatment as also recorded at the NRCS research station. For the mean values obtained from the three fields, increasing rates of application of K_2O kg/ha from zero in the control to 25 basal, 50 basal, and 25 basal and 25 at flowering, raised the SEY by 13.3%, 31.1% and 33.1% respectively.

The agronomic use efficiency of K (AE_K) rose with increasing K application from 16.44 and was highest at 20.48 with the split 50 K_2O kg/ha treatment. The GRF (gross return above fertilizer costs in Rs/ha) – the most important figure and "bottom line" for the farmer – calculated by the additional returns less the additional costs in potash application, increased from 5,266 to 12,670 to 13,358 for the three potash treatments respectively. This remarkable return demonstrates at first hand to the farmer the benefits which can accrue by applying potash to these soils and to the soybean/wheat cropping system in particular.

India has almost tripled its soybean production over the last 15 years to almost 6.5 million tonnes per year. Nevertheless productivity has remained the same at around 1 tonne/ha so that all the increase in production has been achieved by increasing the area of land used for cultivation. Being an important component in the soybean-wheat cropping system, the need to improve productivity of soybean is crucial.

Edited by E. A. Kirkby.

Name of farmer	Village	Soybean equivalent yield (kg/ha) K_2O level: 0	25 (basal)	50 (basal)	25 (basal) + 25 (at flowering)
Shri Narayan	Umrikheda	2,921	3,086	3,679	3,984
Shri Radheshyam Patel	Gokanya	2,762	3,260	3,866	3,781
Shri Shivnarayan	Simrol	3,589	4,161	4,616	4,580
Mean		3,091	3,502	4,053	4,115
AE_K		-	16.44	19.24	20.48
Additional Returns (Rs/ha)		-	5,754	13,468	14,336
Additional cost (Rs/ha)		-	488	798	978
GRF (Rs/ha)		-	5,266	12,670	13,358

Table 4. Effect of potassium nutrition on productivity and economics of soybean-wheat cropping system under real farm situations during 2004-05.

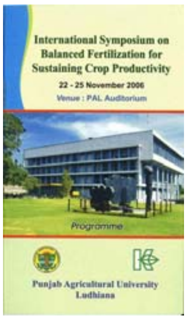
Events

International symposium on "Balanced Fertilization for Sustaining Crop Productivity", 22-25 November 2006, Punjab Agriculture University, Ludhiana,

Inauguration ceremony of the IPI-PAU International Symposium, India, November 2006.

India.

IPI Coordinator for India, Dr. P. Imas, hosted an International Symposium at the Punjab Agriculture University (PAU) in Ludhiana, Punjab. Some 400 participants joined the three day symposium which started with a professional tour for the more than 10 international speakers. The symposium was inaugurated by Dr. J.S. Samra, Deputy Director General (DDG) of the Indian Council of Agri Research (ICAR) and Dr. G.S. Kalkat, Chairman of the Punjab State Farmers Commission. The event was widely covered by the state press, and appeared in about 20 Indian papers in various languages. It is important to note that the joint IPI-PAU symposium was jointly organized by IPI coordinators in the region, namely Dr. P. Imas and Dr. V. Nosov. The symposium was co-sponsored by the Indian Council of Agricultural Research (ICAR), the Fertiliser Association of India (FAI), the Bangladesh Fertilizer Association (BFA) and the National Fertilizer Secretariat (NFS). The large number of participants from Pakistan complemented the significant presence of the regional researchers, officials and industry representatives. The presentations and proceedings will be available on our website shortly.



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International Symposium on "Soil Potassium and K Fertilizer Management", 13-14 November 2006, Zhuhai city, Guangdong, China.

IPI and the Institute of Soil Science Chinese Academy of Sciences in Nanjing (ISSAS) has a long history of conducting workshops and symposia. The 9th joint symposium was organized by IPI Coordinator for China, Dr. S. Ivanova in the city of Zuhai, South China. More then 150 participants from China, Germany, Brazil, Egypt, Turkey, Russia, Belarus and Switzerland attended the workshop. The participants included scientists, students, extensionists, fertilizer company's staff, and local officials. The workshop consisted of 33 presentations made during 4 sessions: Soil potassium and its dynamics, Factors influencing K availability, Progress on K research and prospect of K fertilizer demand, Effect of K application on crops and K management. The presentations made at the symposium are available on the web.

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1st joint IPI-AFA-IMPHOS workshop on "Balanced Fertilization for Optimizing Crop Nutrition", 6-8 February 2007, Sharm El-Sheikh, Egypt.

The first joint IPI-AFA-IMPHOS workshop was held as a satellite event to the 13th Annual meeting of the Arab Fertilizer Association (AFA). 9 papers from scientists and policy makers were presented covering issues related to food security, fertilizer application and nutrient management. The papers presented are available on our website.

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Potassium, Magnesium and Sodium: Recent 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 first part of the symposium will host a group of high level scientists to present the latest plant physiology research in the field of potassium, magnesium and sodium nutrition of plants. The second part of the meeting will focus on the same theme, but with reference to the applied aspects of potash, magnesium and sodium fertilization.

Please follow the news on this event on our web at http://www.ipipotash.org/events/IPI+IFS+Sabanci.

Africa dangerously lags far behind with appropriate fertilizer use: While industrial countries consume on average 206 kg of nutrient per hectare, Sub-Saharan African countries consume only 9 kg/ha, just 4.4% of the industrial countries level of consumption.

Source: Africa Renewal, V 20 No. 2, July 2006.

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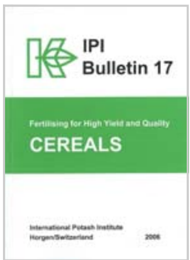
Participants of IX IPI-ISSCAS International Workshop on Soil Potassium and K Fertilizer Management

New publications



IPI – Bulletin No. 17 "Fertilizing for High Yield and Quality Cereals". 177 p. 2006. ISBN 978-3-9523243-0-1. Authored by Prof. E.J. Wibberley, UK. Small-grain cereals include wheat, barley, oats, rye, triticale, some millets and rice. All cereals make up a high proportion of most human diets (typically half daily intake and, in developing countries, even higher) and thus have a strategic place in many farming systems internationally. The bulletin has eight chapters covering 1) the global importance of small-grain cereals; 2) botany and physiology of small-grain cereals; 3) the role of plant nutrients in cereal physiology; 4) nutrient requirements of small-grain cereals; 5) small-grain cereal nutrient management and agro-ecology; 6) effects of fertiliser use on yield and quality of small-grain cereals; 7) small-grain cereals in rotation—integrated nutrition and protection and 8) fertiliser and nutrient management practice for small-grain cereals.

The bulletin also deals with questions of policy and sustainability, management of crops at farm level, extension and farmers' study groups. The IPI Bulletin No. 17 is an important reference for students, advisors in nutrient management and for farmers.

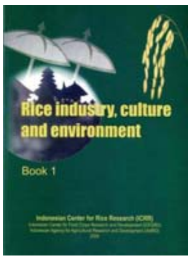
To order this publication please go to http://www.ipipotash.org/publications/.

IPI – Research Topics No. 15 "New edition" (in Hungarian), 75 p. 2006. The first edition of this publication was published in 1993. The new edition is a full color booklet about the formation of potash deposits, the importance of potassium for plant physiology, potassium in the soil, nutrient removal of various crops and detailed information about the importance of potassium for crop production. Potash fertilization recommendations are given for cereal, sugar beet, sunflower, oilseed rape, legumes, tobacco, fodder plants, fruits and vegetables. The authors of IPI Research Topic 15 are experienced scientists working in the field of plant nutrition and crop husbandry.

To order a hard copy of this publication, please contact Dr. T. Popp (Thomas.Popp@kali-gmbh.com). To download the electronic version as PDF please go to http://www.ipipotash.org/publications/.

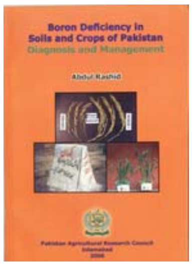
IPI — Research Topics No. 23 Fertigation: Fertilization through irrigation (in Arabic), 77 p. inc. 9 p. with color plates. 2006. Authored by J. Hagin, M. Sneh and A. Lowengart-Aycicegi, translated by M. Rusan. English edition published in 2002, and Arabic version published in 2006. Irrigation is an important input required to increase crop production to feed a still growing global population. However, increasing scarcity of water requires improvements in the efficient use of water in agriculture. In contrast to the traditional surface irrigation, pressurized micro-irrigation systems fulfill this need. As much of the arid and semi-arid agriculture is in Arab speaking countries, the IPI and the Arab Fertilizer Association (AFA), Cairo, Egypt initiated this translation and jointly printed it. This publication should meet the requirements of scientists and extension workers dealing with fertigation in Arabic speaking countries.

To order a hardcopy of this publication, please go to http://www.ipipotash.org/publications/218.



Rice Industry, Culture and Environment Book 1 (in English) 318 p. 2006. ISBN 979-540-028-2. Edited by Sumarno, Suparyono, A. M. Fagi and M. O. Adnyana. Proceedings of the International Rice Conference 2005, September 12-14, Tabanan, Bali, Indonesia. Published by the Indonesian Center for Rice Research (ICRR), Indonesian Center for Food Crops Research and Development (ICFORD) and the Indonesian Agency for Agricultural Research and Development (IAARD).

Inaugurated by Dr. A. Suryana, director general of IAARD, the congress had more than 35 papers, among them two dealing specifically with Site Specific Nutrient Management (SSNM): Dr. R. Buresh, senior soil scientist at IRRI together with co– authors published a paper titled *'**Improving Nutrient Management for Irrigated Rice with Particular Consideration to Indonesia**'*. Dr. C. Witt, director of IPI-IPNI program in SE Asia, together with co-authors, published a paper titled *'**A Nutrient Decision Support System Software for Irrigated Rice**'*.



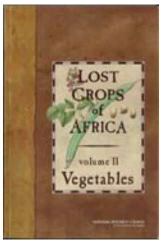
Boron deficiency in soils & crops of Pakistan: Diagnosis and management. 34 p. including 5 p. with color plates. 2006. ISBN 969-409-184-5. Authored by A. Rashid, Pakistan Agricultural Research Council, Islamabad. The booklet describes the requirements and availability of boron in many soils and crops of Pakistan. Many of the crops grown in the country suffer from boron deficiency, and the author describes the soil and plant diagnosis of boron, fertilization with boron and crop response in yield and quality. For copies please contact Dr. A. Rashid, National Agricultural Research Center Islamabad-45500, Pakistan (http://www.parc.gov.pk).

Ripple. Bi-monthly report of the Irrigated Rice Research Consortium (IRRC), International Rice Research Institute (IRRI), Manila, Philippines. The IRRC strives to ensure

New publications

that Asian rice farmers benefit from technologies arising through research. The consortium aims to 1) strengthen national agricultural research and extension systems (NARES)-extension partnerships for technology development, validation, and promotion; 2) strengthen capacity of NARES partners; 3) develop improved approaches and technologies for more productive and sustainable production and 4) disseminate promising production principles and technologies. The 'Productivity and Sustainability' workgroup within the IRRC is supported with funds from the Swiss Agency for Development and Cooperation (SDC), the International Fertilizer Association (IFA), International Potash Institute (IPI) and the International Plant Nutrition Institute (IPNI).

To view the report go to http://www.irri.org/irrc/.



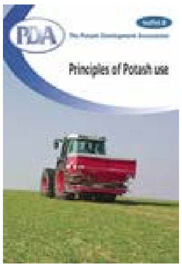
Lost Crops of Africa; Volume II: Vegetables. 2006. 349 p. ISBN 10-309-10333-9. National Research Council. The National Academic Press, Washington, D.C. Amaranth, Bambara Bean, Baobab, Celosia, Cowpea, Dika, Eggplant, Egusi, Enset, Lablab, Locust Bean, Long Bean, Marama, Moringa, Native Potatoes, Okra, Shea and Yambean each of these species is described for its habitat, nutritional value, growth conditions and future prospects. The region below the Sahara is home to hundreds of plant varieties which contribute to the food supply, with meagre scientific support, official promotion or inclusion in development schemes. This book is intended to provide support for increasing food security in the continent.

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.



#8. Principles of Potash use

Normal plant growth requires large quantities of potassium (K, often referred to as potash, K_2O). In fact, throughout growth most crops contain more potassium than any other nutrient including nitrogen (N). Small quantities of potassium are needed to support many of the crucial enzyme processes within the plant but very much larger amounts are used to control the water relationships in the plant. Potassium also plays a vital role in the transport of sugars and other products of photosynthesis from leaves to storage organs. Adequate quantities of potassium are thus essential for a crop to achieve its full yield potential and also for many aspects of product quality such as grain size and appearance, tuber size, oil content, dry matter and starch content, percentage sugar and fruit ripening and quality. See PDA website.

K in the literature

Potassium Fixatin in San Joaquin Valley Soils Derived from Granitic and Nongranitic Alluvium. Murashkina, M. A., Southard, R. J. and G. S. Pettygrove. 2007. Soil Sci. Soc. Amer. J. 71 (1) p. 125-132. http://soil.scijournals.org/.

Abstract: Potassium fixation influences the effectiveness of fertilization in soil–plant systems. A rapid method for measuring K fixation could help clarify relationships with other soil properties, especially mineralogy. Our objectives were to compare some existing measurement techniques for soil K fixation and availability, develop an alternative K fixation test, and evaluate the utility of soil texture and parent material for predicting K fixation in soils derived from granitic Sierra Nevada (SN) and nongranitic Coast Range (CR) alluvium. Potassium pools were estimated by 1 mol L^{-1} NH_4OAc and sodium tetraphenylboron (TPB) extractions. Our 1-h fixation method correlated well (R^2 = 0.95, P = 0.001) with a 7-d procedure, so the 1-h method was used for subsequent work. The SN soils fixed up to 740 mg K kg^{-1}; CR soils fixed up to 263 mg K kg^{-1}. There was no significant relationship between K fixation and soil clay or silt content for either parent material. The TPB test had a stronger correlation with NH_4OAc-extractable K in SN soils (R^2 = 0.77, P = 0.001) than in CR (R^2 = 0.49, P = 0.001). Plant-available nonexchangeable K (PANK = TPB minus NH_4OAc) did not correlate with K fixation potential for pooled data from all pedons (R^2 < 0.11), and had negative correlation (R^2 from 0.97 to 0.99, P = 0.01) for individual pedons. The PANK probably represents K that has already been fixed and satisfies some of the K fixation capacity. The 1-h test is a reliable, rapid method for predicting K fixation potential. Together, the TPB and NH_4OAc tests could be useful for identifying K already fixed by soils, thereby reducing K fixation potential.

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Effect of alternative anions (Cl^- *vs.* SO_4^{2-}) on concentrations of free amino acids in young tea plants. Ruan, J., Gerendás, J., Haerdter, R. and B. Sattelmacher. 2007. J. of Plant Nut. And Soil Sci. 170 (1) p. 49-58. Link: http://www3.interscience.wiley.com/.

Abstract: The quality of green tea is highly dependent on the concentration of free amino acids, whose profile is domi-

K in the literature

nated by the unique amino acid theanine (N^5-ethyl-glutamine). A high quality is associated with a high amino acid-to-catechin ratio, but previous results indicated that excessive chloride (Cl^-) supply is detrimental for amino acid accumulation. Several experiments were conducted to investigate the effect of chloride on growth and concentrations of free amino acids in young tea plants. Soil-grown tea plants supplied with different levels of potassium (K) as K_2SO_4 or KCl exhibited increased concentrations of free amino acid in young shoots only when supplied with K_2SO_4, and the negative effect of KCl supply was mainly due to a reduced concentration of theanine. Concentrations of other nutrients in plant tissues were not influenced. The uptake of Cl^- and its interaction with nitrogen (N) uptake were further investigated in a second experiment, in which soil-cultivated tea plants were supplied with varying amounts of Cl^-. Chloride application reduced yield of young shoots, and severity of leaf damage was related to the concentration of Cl^- in leaves. Nitrogen uptake was reduced by Cl^- addition. To verify whether the decrease of free amino acids was simply a result of inhibited NO assimilation, a third experiment was conducted, in which tea plants were NH-fed in the absence or presence (equivalent to the NH concentration) of Cl^-. Again, concentrations of theanine and total free amino acids in young shoots were reduced by Cl^- supply, but changes of the free-amino acid pool did not contribute to the maintenance of charge balance. However, concentration of theanine in roots, where it is synthesized, was not influenced by Cl^-. Total N concentrations of roots and mature leaves, uptake rate of NH, and activity of glutamine synthetase in fibrous roots and young leaves were all unaffected by Cl^- as well. It is suggested that translocation of theanine from root to shoot and its catabolism in young shoots might be influenced by Cl^-.

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Some cesium and potassium salts increase the water permeability of astomatous isolated plant cuticles. S. Elshatshat, L. Schreiber and J. Schönherr. 2007. J. of Plant Nut. and Soil Sci. V 170(1) p. 59-64. Link: http://www3.interscience.wiley.

Abstract: Salts were applied as aqueous solution to the outer surfaces of astomatous isolated cuticles, and the water was allowed to evaporate. Effects of salt residues on the surfaces of cuticles on water permeability of cuticles were measured at 25°C. A surface dose of 0.2 mol m^{-2} Cs_2CO_3 and K_2CO_3 increased the water permeability of pear leaf cuticles by factors of 9.9 and 3.9, respectively. Na_2CO_3 was barely effective, and Li_2CO_3 as well as $(NH_4)_2CO_3$ had no influence on water permeability. Potassium applied as sulfate, nitrate, or chloride had no effect on the water permeability of pear leaf cuticles, while K^+ salts of weak acids (0.2 mol m^{-2}) were effective, as they increased water permeability by factors of 5.4 (K^+-acetate), 3.9 (K_2CO_3), and 2.0 (K_2HPO_4), respectively. Sensitivity of *Idesia polycarpa* leaf cuticles to treatment with K_2CO_3 at 0.2 mol m^{-2} was greatest as water permeability was increased 35-fold, while the water permeability of cuticles from other species tested (astomatous leaf cuticles from *Hedera helix*, *Citrus aurantium*, *Prunus laurocerasus*, *Pyrus communis*, and *Populus canescens*; fruit cuticles from *Capsicum annuum* and *Lycopersicon esculentum*) increased only by factors ranging from 1.7 to 3.9. Data are discussed in relation to swelling and ion-exchange properties of cuticles.

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Current and Potential U.S. Corn Stover Supplies. R. L. Graham, R. Nelson, J. Sheehan, R. D. Perlack and L. L. Wright. 2007. Agron J. 99:1-11. Link: http://agron.scijournals.org/cgi/.

Abstract: Received for publication July 28, 2005. Agricultural residues such as corn (*Zea mays* L.) stover are a potential feedstock for bioenergy and bio-based products that could reduce U.S. dependence on foreign oil. Collection of such residues must take into account concerns that residue removal could increase erosion, reduce crop productivity, and deplete soil carbon and nutrients. This article estimates where and how much corn stover can be collected sustainably in the USA using existing commercial equipment and estimates costs of that collection. Erosion constraints to collection were considered explicitly, and crop productivity and soil nutrient constraints were considered implicitly, by recognizing the value of residues for maintaining soil moisture and including the cost of fertilizer to replace nutrients removed. Possible soil carbon loss was not considered in the analysis. With an annual production of 196 million Mg of corn grain (~9.2 billion bushels), the USA produces 196 million Mg of stover. Under current rotation and tillage practices, ~30% of this stover could be collected for less than \$33 Mg^{-1}, taking into consideration erosion and soil moisture concerns and nutrient replacement costs. Wind erosion is a major constraint to stover collection. Analysis suggests three regions of the country (central Illinois, northern Iowa/southern Minnesota, and along the Platte River in Nebraska) produce sufficient stover to support large biorefineries with one million Mg per year feedstock demands and that if farmers converted to universal no-till production of corn, then over 100 million Mg of stover could be collected annually without causing erosion to exceed the tolerable soil loss.

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Environmental impact and economic benefits of site-specific nutrient management (SSNM) in irrigated rice systems. M. F. Pampolino, I. J. Manguiat, S. Ramanathan, H. C. Gines, P. S. Tan, T. T. N. Chi, R. Rajendran and R. J. Buresh. 2007. Agricultural Systems, 93 (1-3), p. 1-24. Link: http://www.sciencedirect.com/science.

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About agriculture and global warming

In AD 1085, William the Conqueror ordered a survey of his new domain, England. This survey of England's land and resources showed that, surprisingly, 85% of the countryside was already deforested and used for agriculture. The 1.5 million people living in England at that time required 9 ha per capita to live from. This clearly demonstrates that the increase of CO_2 in the atmosphere and the consequent global warming is a process that started with the beginning of 'agriculture'. Later, at the 'Industrial' era, with the use of fossil fuels, this process accelerated.

(Source: Plows, Plagues & Petroleum, by W. F. Ruddiman, 2005, Princeton Univ. Press).

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for thought—Extension

Does extension receive sufficient attention when we attempt to disseminate agricultural information?

The economic benefit of extension work was highlighted in 1995 by the International Food Policy Research Institute (IFPRI, Rosegrant and Evenson, 1995). The authors show that public research, extension expenditures, irrigation and foreign private research each have a statistically significant, positive impact on the Total Factor Productivity (TFP) in India between 1956 until 1987.

Source: Rosegrant, M. and R.E. Evenson. Total factor productivity and sources of long–term growth in Indian agriculture. 1995. EPTD discussion paper No. 7. International Food Policy Research Institute (IFPRI), Washington, USA.

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Preliminary synthesis of farmers' attitude and preferences towards nutrient application in China and India

Magen, H., Imas, P. and S. Bansal. 2007. A paper presented at the IFA meeting on Fertilizer Best Management Practices (FBMP), Brussels, 7-9 March 2007.

Abstract: IPI has initiated the distribution of a questionnaire to several hundred farmers in villages and locations across India and in two locations in East China, and to approximately a hundred fertilizer dealers in India. The results were compiled and compared between the two countries, and in some cases, between villages of the same country. The results show that Chinese farmers rarely avoid the annual application of N, P, K and OM, when compared with farmers in India. About 40% of farmers asked in India add potassium 'sometimes' or 'never', while 10% only apply 'sometimes' in China. The use of a soil test was highly varied between the various locations in India, but was very low in the two locations surveyed in China. Dependence on precipitation and the socio economic level of farmers strongly affects the use of nutrients and consumption of services such as soil test.

The full paper will be an IFA published proceeding. But in the meantime, we learned that in each farming community there is a need to carefully identify, through participatory approach, the most adequate and beneficial channel of dissemination of agricultural knowledge. It is indeed the "last-mile delivery" that counts.

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"What considerations lead policymakers to invest in agricultural extension as a key public responsibility, and what factors and agency incentives explain differences in extension system performance? A conceptual framework is used to analyze several extension modalities and their likely and actual effectiveness. The analysis highlights the efficiency gains that can come from locally decentralized delivery systems with incentive structures based on largely private provision, although in most poorer countries extension services will remain publicly funded".

Quoted from: Anderson, J. & G. Fedder. 2004. Agricultural Extension: Good Intentions and Hard Realities. The World Bank Research Observer, vol. 19, no. 1 (2004), pp. 41-60. See also at http://wbro.oxfordjournals.org/.

'Graviola' (family Annonaceae, genus Annona, species Muricata) is one of the many tropical fruits grown in Brazil. Paracuru experimental station, EMBRAPA, near Fortaleza, state of Ceara. Photo by A. Naumov.

Clip board

- Subscribe to receive this *e-ifc* electronically at e-ifc-subscribe@ipipotash.org.
- Mr. M. Marchand has been elected as the regional coordinator for IPI activities in the WANA region. He has replaced the activity done by Dr. M. Rusan in Egypt and Iran, effective 1 January 2007.

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