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Optimizing Crop Nutrition

Editorial

Dear readers,

The current discussion over present and future food security is as relevant today as it has been for decades. According to various estimations, farming systems will need to provide 70 to 100 percent more food within the next 40 years. This extra production will be needed to feed a larger population with higher demands in terms of total calorie intake as well as types of food consumed.

In any production process, uniformity of output at a high level brings maximum productivity. As agriculture is highly dependent on weather (temperature, radiation and precipitation), performance is very variable, and we can only compare agricultural productivity between regions where similar agro climatic conditions prevail. Where large yield gaps between similar agro climatic regions exist, however, it is logical to assume that these gaps, being mostly driven by management factors, can be closed through use of best practices informed and supported by science.

It is time, therefore, to concentrate our efforts in low yielding areas, where yields can be brought up to match potential. For example, we know that maize productivity in East Africa can be doubled, just by using good quality seeds and moderate NPK fertilizer application. We also know that large regions in eastern Europe, despite having favorable precipitation are well below their cereal production capacity (see Mueller *et al.*, Nature 490, 2012). Another argument for focusing on the low yielding systems is that increasing productivity under such conditions is very profitable in terms of nutrient use efficiency, ensuring that for every additional grain of nutrient, the highest product returns are obtained.

We believe that a significant proportion of the extra 70 to 100 percent increase in production is waiting to be realized from low yielding areas. This belief is based on our strong conviction that farmers can improve their management skills; this is where we should aim our thoughts and our actions.

I wish you an enjoyable read.

Hillel Magen
Director

Photo cover page: Effect of Potassium on the Rhizome Yield and Nutrient Uptake of Ginger *(Zingiber officinale)*, Spices Research Centre (BARI), Shibgonj, Distt. Bogra, Bangladesh. 2012. Photo by S.K. Bansal.

Research Findings

Castor crop in Andhra Pradesh. Photo by Ch. Srinivasarao.

Impact of Potassium on Crop Productivity, Use Efficiency, Uptake and Economics of some Rainfed Crops in Andhra Pradesh, Southern India: On-Station and On-Farm Experiences

Srinivasarao, Ch.[(1)]

Introduction

India makes up only 2.5 percent of the world's land mass but supports as much as 17 percent of the global population. Since the inception of the Green Revolution about 50 years ago, the population of India has increased three-fold to approximately 1,140 million. Over this period there has been a sustained effort to increase food grain production using irrigation, hybrid seeds and fertilizers. To meet the needs created by further forecasted population increases, it is estimated that by 2020, India will need an annual production of about 294 mt of food grains, compared with the 230 mt produced today. An additional production of 64 mt of food grains has therefore to be achieved from the same or smaller land area, when degradation of cultivated land and the possible detrimental effects of climate change are taken into account. Proper nutrient management, through efficient, judicious and balanced or integrated use of nutrients coupled with other effective measures in soil and agronomic management, is therefore top priority (Subba Rao *et al.*, 2011).

While rainfed agriculture in India represents 58 percent of the total arable land area of 141 M ha, it produces only 40 percent of the food (Venkateswarlu *et al.*, 2012), with the productivity

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levels of rainfed, dryland crops far below those of irrigated crops. This to some extent may be accounted for by the rainfall-scarce environments of the tropical and sub-tropical regions of the country, which are characterized by arid and semi-arid climates with soils inherently low in organic matter. This is a major component determining soil quality and is strongly related to food security (Srinivasarao *et al.*, 2012). Increasing the productivity of rainfed cropping systems is therefore an urgent and challenging task to meet the food demands of an ever increasing population.

Until relatively recently, the general opinion of Indian scientists and policy makers has been that Indian soils are rich in potassium (K); hence, not much attention has been given to K as a crop nutrient (Tandon and Sekhon, 1987). In soil, K is generally considered in relation to the forms (or pools) of K present: i.e. in solution, exchangeable, non-exchangeable or as mineral K, and the mobilization of K between these pools (Syers, 2003). Under intensive cropping, in solution and exchangeable K (together measured as available K), are readily taken up by roots from the soil solution. This uptake of K induces further release of K from less accessible sources, including the non-exchangeable fraction. Under conditions of low K availability, the quantity of non-exchangeable K in the soil, its rate of release into the soil solution and the extent to which the K release from this fraction is able to match the K demand of the crop, are important factors relating to K nutrition of crop plants (Mengel, 1985; Darunsontaya *et al.*, 2012; Srinivasarao and Surekha, 2012). Many rainfed crops can remove 100 to 200 kg K ha^{-1} during a growing season. This is usually far in excess of that released from slowly exchangeable sources in soils low in available K. Likewise, the current rates of K application in mineral fertilizers in India are much lower than those required for crop supply, as is evident from current NPK consumption data (Fig. 1). K consumption was low for all eight crops shown. Only two crops (groundnut and cotton) were supplied within the range of 10 to 15.2 kg K_2O ha^{-1} and the remaining six crops were supplied with even lower amounts, with only sunflower receiving more than 6 kg K_2O ha^{-1}.

Different soil types occur in agro-ecological regions such as alluvial, medium and deep black soils, and red and lateritic soils. The K status of these soils varies depending on soil type, parent material, texture and management practices. Red and lateritic soils with kaolinite as a dominant clay mineral and of light texture are low in exchangeable as well as non-exchangeable K (Subba Rao *et al.*, 2011). This is the case, for example, in the acidic soils of Bangalore, which contain about 94 percent kaolinite, 4 percent mica, 1 percent quartz and 1 percent feldspars. Most red and lateritic as well as alluvial soils of India are low in exchangeable and non-exchangeable K. The amount of mica, as well as biotite mica, in acidic soils is low, as expressed by X-ray diffraction (XRD) peak intensities in several red and lateritic soils of India. Soil reserves of K (non-exchangeable K) are thus very low in acidic red soils.

The present study examines the impact of increasing levels of K fertilization on productivity, K use efficiency, K content and economics in rainfed groundnut, sorghum, maize and castor grown on the red soils of Andhra Pradesh, both at a research station and on-farm.

Materials and methods

All experiments were carried out in the state of Andhra Pradesh. Field experiments were conducted at Gunegal Research Farm, Central Research Institute for Dryland Agriculture, Hyderabad, Andhra Pradesh, India, using four important rainfed crops. Two oil seed crops (groundnut and castor) and two cereals (sorghum and maize) were supplied at three rates of K (Control, 20, 40, 60 kg K ha^{-1}) during 2010-2011. The soil was a light textured sandy loam (Alfisol), acidic pH, non-saline, low in soil organic carbon (3.2 g kg^{-1}), low in available N (122 kg ha^{-1}), medium in Bray P

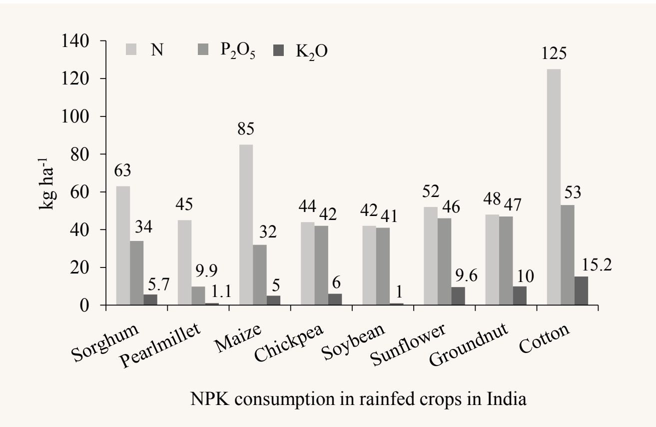

Fig. 1. Typical N, P and K consumption (kg nutrient ha^{-1}) in the main rainfed crops in India. *Source:* FAI, 2011-2012.

Groundnut crop grown in the experiment.
Photo by Ch. Srinivasarao.

(12 mg kg^{-1}) and low in available K (46 mg kg^{-1} ammonium acetate extraction) (Hanway and Heidel, 1952). The soil was also medium in sulphur (14 mg kg^{-1}), low in DTPA extractable zinc (0.45 mg kg^{-1}) and adequate in available iron (Fe), manganese (Mn), copper (Cu) and boron (B) (Jackson, 1973). All other required nutrients were applied as per the soil test data and state recommendations (maize: 100 kg N and 60 kg P_2O_5; sorghum: 80 kg N and 40 kg P_2O_5; groundnut: 20 kg N and 40 kg P_2O_5; and castor: 80 kg N and 40 kg P_2O_5). K was applied in the form of muriate of potash (MOP with 60 percent K) at the three graded levels already described, with three replications per treatment, including the control.

Improved varieties or hybrids were used in the trials viz. groundnut (JL-24), sorghum (SPV 462), maize (Hybrid DHM 177) and castor (DCS-9). Plot size was 5 x 5 meters and the trials were randomized. All appropriate management practices were followed.

Over the same period, 23 on-farm trials were also conducted in nine villages of two rainfed districts of Andhra Pradesh (Khammam and Nalgonda) using three rainfed crops (maize, sorghum and groundnut). In these trials, two treatments only were considered: farmers' practice, and farmers' practice + 30 kg K ha^{-1} as MOP. Farmers' field practice (FFP) of fertilizer application is not based on soil testing. While N is often applied in excess, P application is more or less near to recommended state level. Application of other macro- and micro-nutrients is uncommon. These soils were also predominantly red (Alfisols) with a sandy loam texture, acidic pH, non-saline, low in available N, medium in Bray P, and low to medium in ammonium acetate extractable K (40 to 62 mg K kg^{-1}) (Hanway and Haidel, 1952). DPTA extractable Zn was low (<0.5 mg kg^{-1}) and Fe, Mn and Cu contents were adequate. Soil analysis was replicated three-fold and a mean computed.

Crop yields (grain or pod, plus straw yields) were recorded and plant parts were analyzed for K content. K use efficiency was computed in terms of agronomic efficiency (AE; kg yield increase per kg nutrient applied) and partial factor productivity (PFP; kg harvested product per kg nutrient applied). The economics of K application was computed, based on additional income obtained from K application in relation to the cost of K fertilizer. The K content of different groundnut plant parts (pod, leaf and haulm), and the grain and straw K content of sorghum and maize, was determined (Jackson, 1973). Statistical analysis was carried out as per the methods suggested by Gomez and Gomez (1984).

Results and discussion

On-station studies on K nutrition in rainfed crops

Grain and straw yields

The impact of graded levels of K on grain yields of four different rainfed crops, viz., groundnut, sorghum, maize and castor, is presented in Table 1. In all four crops, K application significantly ($P<0.05$) increased grain yields. Among the four crops, maize showed higher grain yields, followed by sorghum, castor and groundnut at the various K application levels. The groundnut yields increased from 0.54 mt ha^{-1} (control) to 0.75 mt ha^{-1} (60 kg K ha^{-1}), a 38 percent increase over the control. Sorghum grain yields also rose from 2.8 mt ha^{-1} (control) to 3.74 mt ha^{-1} at 60 kg K ha^{-1} (33 percent increase). Maize too responded substantially to K application, by increases of 18, 25 and 33 percent respectively over the control, at 20, 40 and 60 kg K ha^{-1}. Even under rainfed conditions, maize yields obtained with optimum K application were above 5 tons per ha, indicating the potential of balanced fertilization in raising rainfed crop productivity (Srinivasarao *et al.*, 2010a, b). In castor, another important oil seed crop, grain yields increased from 0.74 mt ha^{-1} (without K) to 0.94 mt ha^{-1} with 60 kg K ha^{-1}, showing 27 percent gain over the control.

Similarly, straw yields of groundnut, sorghum, maize and castor were significantly increased ($P<0.05$) by 11, 19, 32 and 36 percent at 60 kg K ha^{-1}. The substantial crop response to K application in rainfed crops in these regions can be attributed to lack of K in these light textured red soils (Alfisols) (Naidu *et al.*, 1996). These soils, inherently low in K, have been under continuous cultivation, supplemented by N and P mainly in the forms of urea and diammonium phosphate (DAP), without any recycling of crop residues or potash fertilizer as a source of available K. Crop K requirements over many years have therefore been derived mainly from soil K reserves, so-called "mining" of soil

Table 1. Impact of graded levels of K in productivity of rainfed crops on Alfisols in Gunegal Research Farm.

Potash application	Groundnut	Sorghum	Maize	Castor
kg ha^{-1}	*mt ha^{-1}*			
	Pod/grain yield			
Control	0.54	2.80	3.90	0.74
20	0.60	3.30	4.60	0.86
40	0.67	3.60	4.90	0.92
60	0.75	3.74	5.12	0.94
LSD (P=0.05)	0.05	0.11	0.13	0.05
	Straw yield			
Control	0.29	7.40	6.00	1.60
20	0.36	8.00	7.20	2.01
40	0.38	8.60	7.60	2.15
60	0.39	8.81	7.94	2.19
LSD (P=0.05)	0.06	0.45	0.31	0.21

K, exacerbated by continuous additions of N and P. That crops readily respond to K addition, as evident from our findings, clearly demonstrates the need for K by these soils.

Table 2. AE_K and PFP_K in rainfed crops on Alfisols in Gunegal Research Farm.

K rate	Groundnut	Sorghum	Maize	Castor
kg ha⁻¹	----------------*Agronomic efficiency of K (AE_K; kg kg⁻¹)*----------------			
20	12	25	35	6
40	3.4	20	25	4.5
60	3.4	15.6	20	3.3
LSD (P=0.05)	1.1	1.3	1.2	0.4
kg ha⁻¹	------------*Partial factor productivity of K (PFP_K; kg kg⁻¹)*------------			
20	30	165	230	43
40	17	90	122	23
60	13	62	85	16
LSD (P=0.05)	1.3	2.1	2.6	2.3

Agronomic Efficiency (AE) and Partial Factor Productivity (PFP) of K application

Nutrient use efficiency is a crucial factor in rainfed agriculture, as low and erratic rainfall often lowers use efficiency of added nutrients. AE of K (AE_K) was seen to be highest for maize, followed by sorghum and groundnut, and was lowest in castor (Table 2). High values of AE_K as obtained in the maize (AE_K of 35 to 20) and sorghum (AE_K of 25 to 15.6) crops should encourage farmers and end their reluctance to apply K, knowing that the additional yield will compensate for the risk that typically exists under rainfed conditions. Such high AE_K also leads to economic profit (see later). PFP_K also varied widely due to soil K deficiency and response to K application (Table 2).

K content and K uptake

Application of graded levels of K significantly increased the K content of various parts of the groundnut (Fig. 2A), as well as the grains of sorghum and maize (Fig. 2B). In groundnut, leaf and shells' K content was higher compared to that of the pod (Fig. 2A).

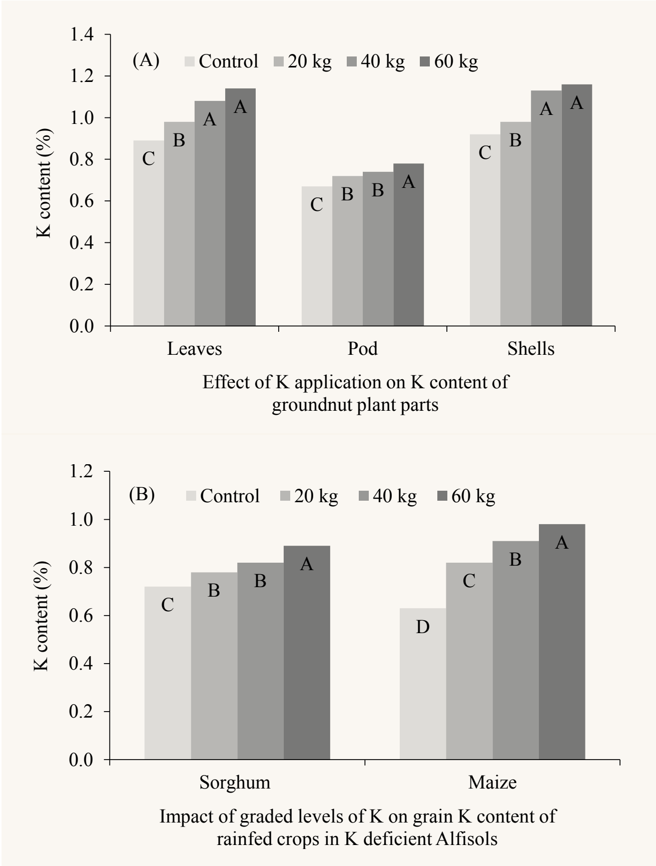

Fig. 2. Variations in K content in groundnut plant parts (A) and in sorghum and maize grain (B) at graded levels of added K.

K offtakes, as computed from pod/grain and straw yields and the K content in respective plant parts - assuming removal of all plant parts from the field - indicated the substantial increases resulting from K application to the three rainfed crops (Fig. 3). Total K offtake was highest in maize, followed by sorghum, with a very much lower offtake by groundnut, in accordance with the much lower yield and K content. The high K uptake levels in sorghum (up to 120 kg K ha⁻¹) and maize (160 kg K ha⁻¹) underline the importance of K management in K deficient Alfisols (Srinivasarao *et al.*, 2010 a, b). Even without K additions (i.e. control plots), total K uptake was about 65 kg K ha⁻¹ in sorghum and maize, providing evidence of large-scale mining of K. These results clearly indicate the need for K application because of the cultivation of K exhaustive crops like maize and sorghum, which has led to depletion of soil K. This is of major importance in the red soil regions of India where K depletion has become an important constraint to crop production.

Economics of K application

Application of graded levels of K on rainfed crops showed substantial economic benefits. Higher economic benefits were obtained in maize, followed by sorghum, castor and groundnut. In the case of groundnut, the additional income obtained was Rs 1,620, 3,510 and 5,670 at 20, 40 and 60 kg K ha⁻¹ respectively. Additional returns in sorghum were Rs 4,900, 7,840 and 8,820 with 20, 40 and 60 kg K ha⁻¹. Benefits were much higher in maize at all the levels of K application, showing an additional income of Rs 12,480 at 60 kg K ha⁻¹. Castor also showed significantly higher additional income with K fertilization. Per rupee invested on K fertilization, the return yielded was: Rs 10 for groundnut, between Rs 16 to 27 for sorghum, Rs 23 to 40 for maize and Rs 14 to 26 for castor.

On-farm experiments with K fertilization and economic benefits to farmers

The application of 30 kg K ha^{-1} to three important rainfed crops grown in 23 farmers' fields of two districts (Khammam and Nalgonda) in Andhra Pradesh increased yields of groundnut, sorghum and maize as compared to FFP treatments (Farmers Fertilizer Practice) i.e. without K (Fig. 4; page 8).

Pod/grain yield responses due to K application varied widely, however, among crops as well as farmers' fields. The additional yields with K varied from 0.07 to 0.21 mt ha^{-1} for groundnut, from 0.15 to 0.35 mt ha^{-1} for sorghum and from 0.34 to 0.76 mt ha^{-1} for maize (Table 3). Interestingly, all farmers (23) were successful in increasing the yields of their crops after K application, even though the level of improvement varied. Differences in crop response to applied K in farmers' fields were due mainly to variations in available K in the soil, which varied between 40 to 62 mg kg^{-1}. Average yield response to 30 kg K ha^{-1} was 0.14, 0.25 and 0.53 mt ha^{-1} for groundnut, sorghum and maize respectively, with corresponding average additional net income of Rs 2,970, Rs 1,590 and Rs 4,702 (Table 3). From the available K soil data, the recommended dose of K for rainfed crops varied between 20-40 kg K ha^{-1} according to the State Agricultural University and the State Government Agriculture Ministry. However, actual field application of K fertilizer to these crops is almost nil and few other commercial crops receive K fertilization at farmers' level.

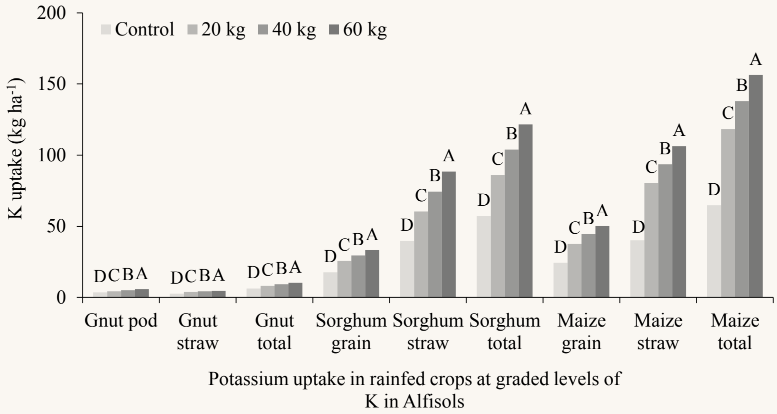

Fig. 3. Offtakes of K in grain, straw and total K in groundnut, sorghum and maize (castor was not analyzed).

Table 3. Response to K and economics of K fertilization in on-farm trials.

Crop	No. farmers	Average yield FFP	Average yield with K application	AE_K	Average response over FFP	Average additional net income
		mt ha^{-1}	*mt ha^{-1}*	*kg kg^{-1}*	*mt ha^{-1}*	*Rs ha^{-1}*
Groundnut	6	0.34	0.46	3-7	0.14	2,970
Sorghum	8	1.01	1.24	5-12	0.25	1,590
Maize	9	4.05	4.58	13-25	0.53	4,702

Conclusions

In most rainfed crops the importance of K fertilization is not given the attention it deserves, despite significant economic benefits that can be obtained. This is because of farmers' lack of knowledge as well as their reluctance to increase inputs, given the uncertainty of crop cultivation in rainfed conditions.

The results of the experiments reported here indicate that rainfed crops - maize, sorghum, groundnut and castor - responded substantially to K application on the K deficient red soils of Andhra Pradesh, Southern India, both in on-station and on-farm conditions. Maize showed the highest yield response (AE_K 13-35) and economic return to K application, followed by sorghum (AE_K 5-25), castor (AE_K 3-6) and groundnut (AE_K 3-12). On-farm trials indicated that additional returns to K application were higher than benefits obtained on-station. These relatively high AE values to K application indicate that in these conditions, K is highly deficient, leading to limited yields, and its application provides a high probability of obtaining additional economic return.

Moreover, as optimal K nutrition is of particular benefit to crops in providing drought tolerance during intermittent dry spells in the rainfed environment, application of K may introduce additional benefits to farmers, beyond remedying the deficient soil K status.

The inclusion of K in nutrient management programs in rainfed crops is hence essential to realize the potential of these crops in K-deficient, red, lateritic, acidic, and light textured soils in rainfed regions of India.

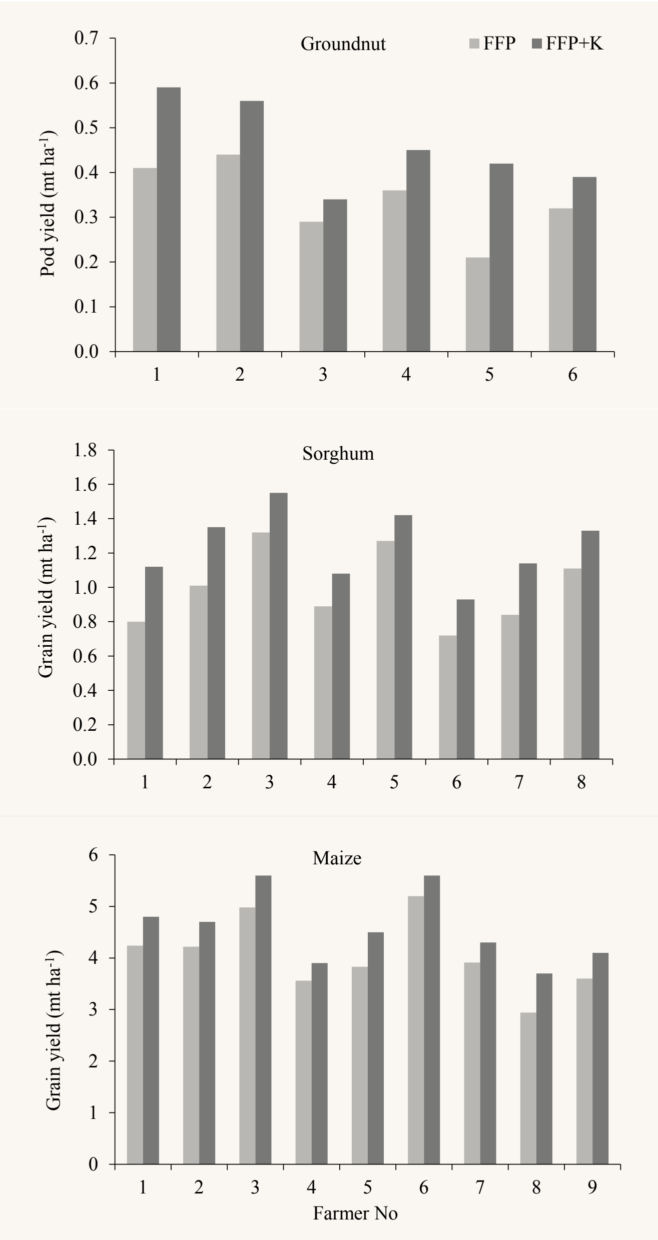

Fig. 4. Additional crop yields due to 30 kg K ha^{-1} application in groundnut, sorghum and maize in farmers' fields.

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The paper "Impact of Potassium on Crop Productivity, Use Efficiency, Uptake and Economics of some Rainfed Crops in Andhra Pradesh Southern India: On-Station and On-Farm Expriences" also appears on the IPI website at:

Regional activities/India

Dr. Cherukumalli Srinivasarao (left) receiving the IPI-FAI Award 2012 at the Annual Meeting of the Fertilizer Association of India (FAI), December 2012. Photo supplied by Ch. Srinivasarao.

IPI-FAI Award 2012

Dr. Cherukumalli Srinivasarao, Principal Scientist (Soil Science) has done pioneering research and extension work on potassium fertility constraints in various production systems covering food, fruit, and vegetable crops in different agro ecological regions of India. His contributions in soil K fertility assessment based on available as well as nonexchangeable K fraction of soil, development of K fertility maps of India and identification of priority districts in India where K application is essential and regular are highly useful for the farming community. He developed SSNM and INM strategies for meeting K needs of various crop production systems in India based on participatory soil sampling and Soil Health Cards. He extensively worked on soil health management in 85 villages in eight tribal dominant rainfed districts of Andhra Pradesh, delineated K deficiency in soils, documented K deficiency in several dryland crops, developed K recommendations based on individual farmers' field soil tests and crops grown, demonstrated positive impacts of K on farm productivity, quality of the produce, profitability and livelihoods of rainfed farmers.

Research Findings

Photo by IPI.

Increases in Yield and Vitamin C Levels of Tomato Grown on K_2HPO_4-enriched Zeolite in an Inert-Sand Substrate

Bernardi, A.C. de Campos[1], and M.R. Verruma-Bernardi[2]

Introduction

Plant nutrition research is highly useful in tackling low soil fertility, low levels of available mineral nutrients in soil and improper nutrient management. Removing these constraints improves the sustainability of food security and well-being of humans without harming the environment (Cakmak, 2002).

As far as mineral nutrition of tomato is concerned, the effect of potassium (K) and phosphorus (P) are well established. K plays a vital role in growth, plant productivity, metabolism, ionic balance, activation of several enzymes and plant defense systems (Marschner, 1995). K is the most prominent inorganic plant solute and is the only mineral nutrient that is not a constituent of organic structures. It plays a primary role in osmoregulation, the maintenance of electrochemical equilibria in cells and its compartments, and the regulation of enzyme activities (Hsiao and Läuchli, 1986). K is crucial to the energy status of the plant, translocation and storage of assimilates, and maintenance of tissue water status. K is of outstanding importance for crop quality as it improves fruit size and stimulates root growth. It is necessary for the translocation of sugars and formation of carbohydrates and provides resistance against pest and diseases and drought, as well as frost stresses (Marschner, 1995). Several studies have

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shown that K content during the growth period has a profound effect on sugars and acids. The involvement of K in quality formation can, to a large extent, be attributed to its function in stimulating transport of soluble assimilates such as amino acids and sugars to storage organs (grains, tubers and roots), and to activate their conversion into starch, proteins, vitamins, etc. K nutrition strongly influences acid concentrations (Wien, 1997) and especially ascorbic acid (vitamin C) levels.

Fresh tomato fruits are an important source of vitamin C hence production practices, including adequate plant K fertilization, are important to determine how levels can be increased. Vitamin C must be ingested in food form because the human body is unable to synthesize it (Lee and Kader, 2000). Byers and Perry (1992) indicate that vitamin C prevents cancer by inhibiting creation of nitroso compounds in the stomach and stimulation of the immune system. This vitamin also contributes to many others aspects of human health, such as immune response, pulmonary function, and iron absorption, preventing free radical-induced damage to DNA, and also lowering the risk or even preventing chronic diseases, such as CHD (Coronary Heart Disease) and cataracts (Weber *et al.*, 1996, Kalt *et al.*, 1999).

According to Balliu and Ibro (2002), nearly 70 percent of the total K uptake in tomato plants during harvest is located in the fruit and 16 percent in the leaves. The K uptake is rapid and fairly constant during vegetative growth and fruit expansion. Fruits of K deficient plants are not fleshy, their ripening is uneven and their appearance is blotchy. The dry matter content of the ripe tomato fruit is about 5-7.5 percent of the total weight, a high proportion of this dry matter consisting of sugars and organic acids, both of which contribute to the taste of the fruit. The organic acid content, mainly citric and malic acids, increases during fruit development. The importance of P as a plant nutrient in tomato plants in general is less well recognized than that of K, even though P and K are both essential plant nutrients. The main reason for this is that lower amounts of P (in the form of phosphate) are taken up by plants and tomato is particularly responsive to K application by increased growth and raised quality. In tomato, the P content of fruit and vegetative tissue is less than one tenth that of K. After uptake, phosphate can remain as free inorganic phosphate as well as being bound with organic constituents of major importance, including sugar phosphates. With nitrogen (N) bases, P makes up the life transmitting RNA and DNA molecules, and with adenine and ribose it forms adenosine triphosphate (ATP) (Marschner, 1986). This high energy compound, although present in only small concentrations in the plant, is essential in providing the energy required in numerous metabolic reactions. One such example is the transfer of sugars from the leaves in their transport to the fruits; P - like K - is highly mobile in the plant. When tomato plants are P deficient, foliage size is greatly reduced and P is transferred preferentially to the roots, photosynthesis is depressed, and the smaller leaves become a darker green. In extreme cases, the underside of the leaves become purple as a consequence of anthocyanin accumulation.

The experiment

The evaluation of K and P addition to a zeoponic substrate for growth of tomato (*Lycopersicon esculentum* L. cv. Finestra; Bernardi *et al.*, 2007, 2010), showed positive effects on fruit yield, quality and dry matter (DM) yield. The zeoponic system was termed by Mumpton (1999) as the growth of plants in synthetic soils consisting of zeolites with or without peat or vermiculite.

As decribed by Monte *et al.* (2010), zeolite mineral was concentrated by a gravitational process and dispersed into solution (NaCl 0.5 mol L^{-1}) to saturate the negative charges. This homoionic material was dispersed into a K_2HPO_4 1.0 mol L^{-1} solution and then centrifuged, filtered and dried. Concentration of P and K in zeolite were 11,289 and 41,925 mg kg^{-1} respectively.

Bernardi *et al.* (2007, 2010) tested four levels (20, 40, 80 and 160 g per pot) of K_2HPO_4-enriched zeolite in an inert-sand substrate. All other nutrients were supplied by nutrient solution. Fig. 1 illustrates the tomato fruit and DM production in relation to K and P concentration in the growth substrate. Results of these experiments indicate that enriched zeolite was an adequate slow-release source of nutrients to the plants. Tomato fruit and DM increased with the higher availability of K in the substrate. Higher fruit and DM yields (786 and 66 g per pot) were obtained with a mean dose of 6.57 g per pot. Nanadal *et al.* (1998) also

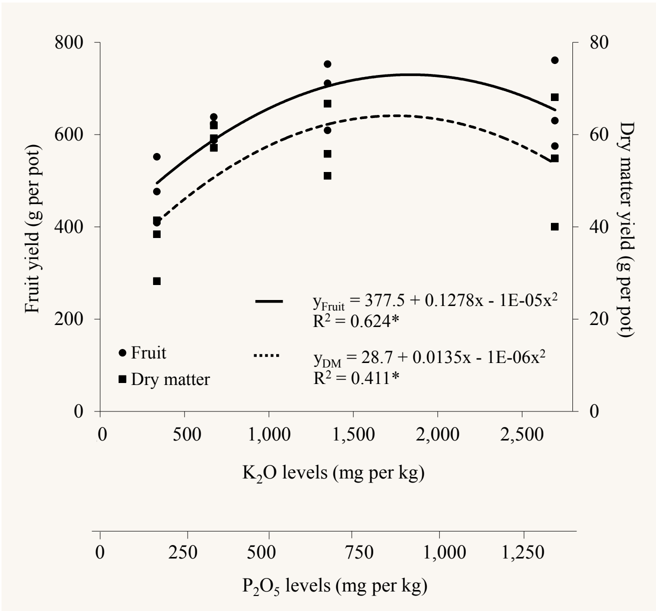

Fig. 1. Fruit and DM yield of tomato in relation to K and P levels in the substrate. Adapted from Bernardi *et al.*, 2007, 2010.

reported increased tomato yields with higher availability of P and K in the substrate.

Significant differences of vitamin C content in fresh tomato fruit, evaluated according to Ashoor *et al.* (1984), were also found in relation to K and P supply (Fig. 2). Dumas *et al.* (2003), in reviewing several papers, stated that the content of this vitamin in tomatoes could increase with the supply of combined fertilizers. As observed in our study, the highest level of 26 mg vitamin C 100 g^{-1} fresh tomato was obtained at 2.5 and 1.3 g of K_2O and P_2O_5 mg kg^{-1} substrate. Our values are consistent with those described in the literature, where the concentrations of vitamin C in tomatoes grown under greenhouse conditions ranged from 7 to 23 mg 100 g^{-1} of fresh fruit (Dumas *et al.*, 2003), and from 17 to 22 mg 100 g^{-1} in different cultivars under field conditions (Abushita *et al.*, 2000). Likewise, Sampaio and Fontes (2000), investigating yield and chemical composition of tomato in relation to K fertilization, obtained values of 20 mg 100 g^{-1} with applications of 180 kg ha^{-1} of K.

Increases in the concentration of vitamin C with increased availability of K has also been reported by Solubo and Olorunda (1977), Anac and Colcoglu (1995), Nanadal *et al.* (1998), Sampaio and Fontes (2000) and Balliu and Ibro (2002). On the other hand, Fontes *et al.* (2000) found no differences in the values of this vitamin as a function of varying doses of K.

As Vitamin C is a lactone of an acid-sugar, the higher concentrations in the fruits in the treatments of greater K and P availability of nutrients, probably relate to stimulated carbohydrate synthesis and transport of photosynthetic sugars. Both nutrient elements play an essential role in the loading and transport of sugars from leaves to fruits (Marschner, 1995).

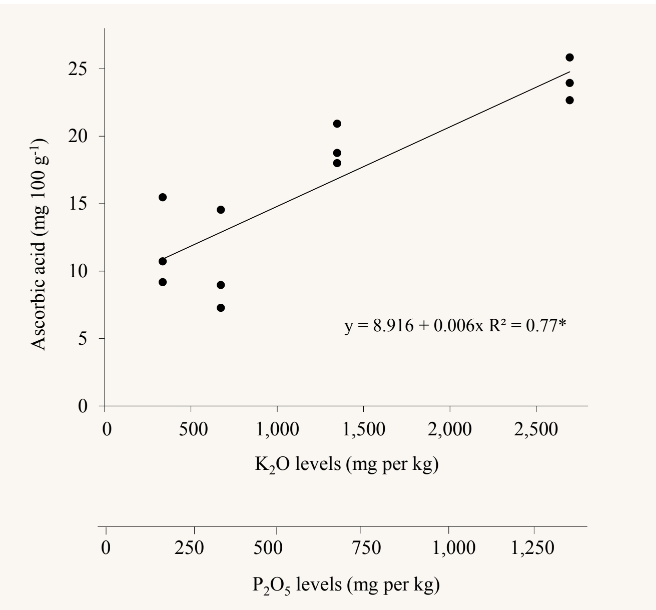

Fig. 2. Concentration of ascorbic acid (vitamin C) in fresh tomato fruits in relation to K levels in the substrate. Adapted from Bernardi *et al.*, 2007, 2010.

Conclusions

K functions in numerous ways at both cellular and whole plant levels, including acting as an enzyme cofactor in the synthesis and stability of proteins and synthesis of carbohydrates. Increasing levels of K and P supply to tomato plants, by addition to a zeoponic substrate in a pot experiment, raised fruit and total DM yields. Additionally, the concentration of vitamin C in the fruits was also raised by higher levels of K and P in the substrate. A maximum value of 26 mg vitamin C 100 g^{-1} FW was obtained with 2.5 and 1.3 g of K_2O and P_2O_5 mg kg^{-1} substrate, a value which is in accordance with other researchers' findings.

These results provide an example confirming that adequate mineral nutrient supply is a major contributor to enhancing crop production, maintaining soil productivity, as well as raising the quality of a crop product, thereby contributing to human nutrition.

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Regional activities/Latin America

Research Findings

Manual cultivation near Ismaelia. Photo by M. Marchand.

Country Report on Egyptian Agriculture and Summary of IPI Experiments

Abd el-Hadi, A.H.[1], and M. Marchand[2]

Introduction

Egypt lies in the northeastern corner of the African continent and has a total area of about 1 million km^2. It is bordered by the Mediterranean Sea in the north, by the Gaza Strip, Israel and the Red Sea in the east, by Sudan in the south and by the Libyan Arab Jamahiriya in the west. Its north-south extent is about 1,080 km and its maximum east-west extent about 1,100 km. The Egyptian terrain consists of a vast desert plateau interrupted by the Nile Valley and Delta, which occupy about four percent of the total area of the country.

Climate

Mild rainy winters and hot dry summers typical of a Mediterranean climate are experienced in the Mediterranean coastal areas, including the Nile Delta. South of Cairo, the rest of Egypt experiences a desert climate. The average temperature during summer months in the south may rise up to 41°C and around 35°C in the north. The spring season brings temperate climatic conditions accompanied by dust storms. Mild weather with bright sunny days and some rain is experienced in the winter

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season but the nights are cold. The average temperature during winter months is around 21˚C in the south and 13˚C in the north. The most humid area is along the Mediterranean coast, where the average annual rainfall is around 200 mm. Precipitation decreases rapidly to the south; Cairo receives an average of 29 mm of rain each year, and in many desert locations it may rain only once in several years.

Land and water resources

The majority of the country area is desert land. Most of the cultivated land is located close to the banks of the River Nile, its main tributaries and canals, and in the Nile Delta. Rangeland is restricted to a narrow strip, only a few kilometers wide, along the Mediterranean coast and its bearing capacity is quite low. There is no forest land.

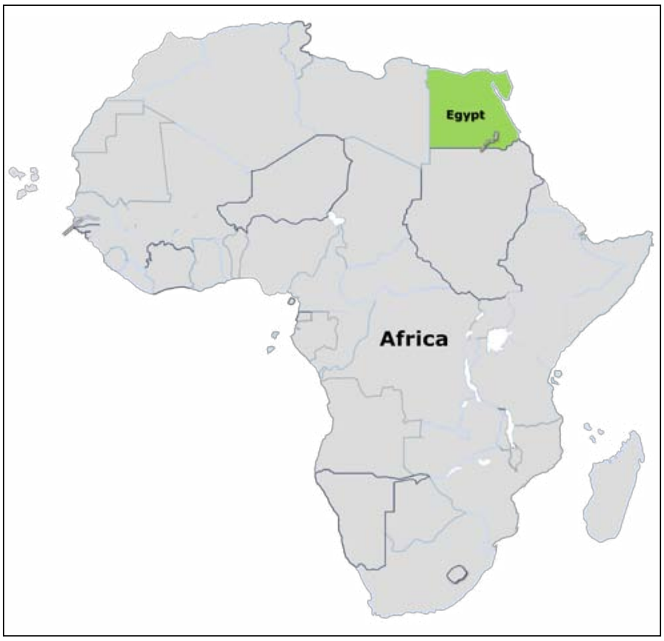
Egypt occupies a total area of around 100 million ha. The agricultural land area is about 3.2 million ha, covering three different production zones:

1. The old irrigated lands, an area of 2.3 million ha, lying in the Nile Valley and Delta, represent the most fertile soils in Egypt.
2. The "newly" reclaimed lands, a potential area of 0.8 million ha, which include the newly reclaimed desert lands of sandy and calcareous origin, where soil is poor in organic matter and in macro- and micronutrients.
3. The rain-fed areas, about 0.1 million ha of sandy soil, located in the Northwest Coast and North Sinai.

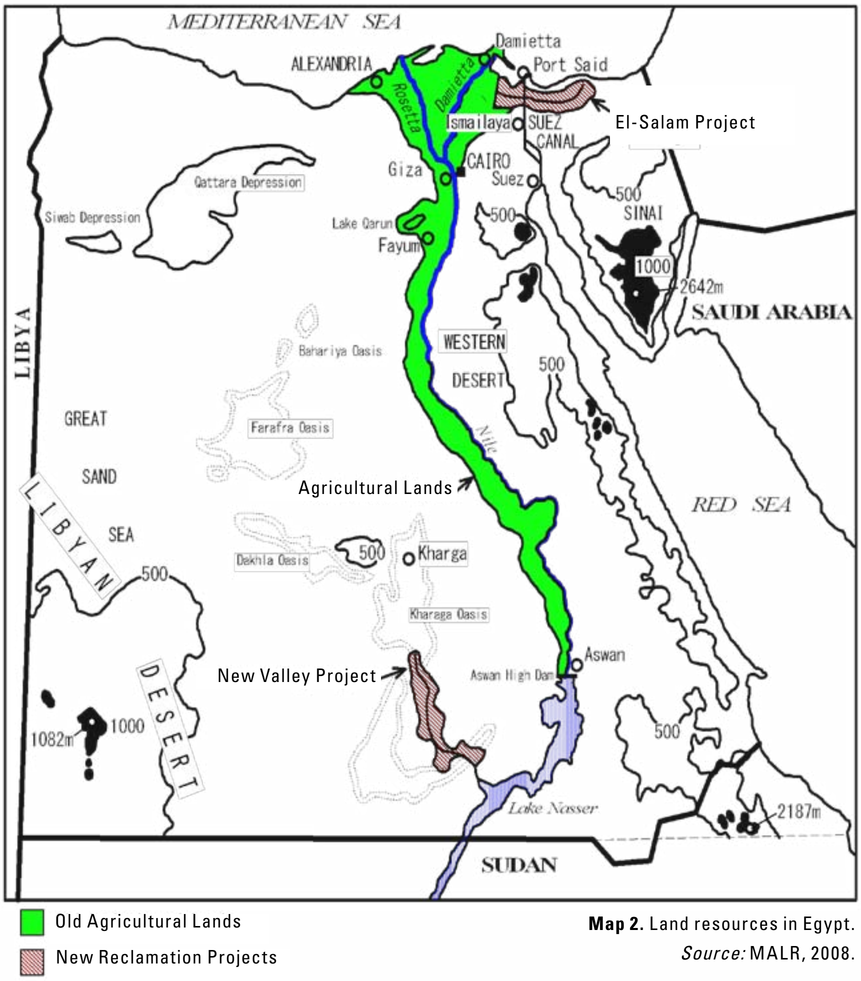
On a per capita basis, the area of cultivated land in Egypt is among the lowest in the world, and is estimated at 0.05 ha.

Soils

The Egyptian soils vary with respect to their texture, from sandy to heavy clay soils, as shown in Table 1. The average value of total soluble nitrogen is low and organic matter is also low, and the soil reaction is slightly alkaline. The available phosphorous values, determined by Oslen's method, are moderate. However, the available potassium (extracted by 1 N ammonium acetate solution) ranges between low and high. The DTPA extractable micronutrients (Zn, Mn and Fe) show lower values of Zn in sandy soils and sandy calcareous soils, and adequate amounts of Mn and Fe in all tested soils. See Table 1.



Map 1. Map of Egypt and the African continent.



Map 2. Land resources in Egypt.
Source: MALR, 2008.

Table 1. Typical analysis of Egyptian soils.

Location	North Delta	South Delta	East Delta	West Delta	Middle Egypt	Sinai	Toshka	Upper Egypt
Texture	Clay	Clay loam	Sandy	Sand calcar.	Loamy clay	Sandy	Sandy clay loam	Loamy
pH (soil; water1:2.5)	7.9-8.3	7.8-8.2	7.6-7.9	7.7-8.1	7.5-8.1	8.6-9.1	8.32-8.56	7.7-8.2
T.D.S. (%)	0.2-0.5	0.2-0.4	0.1-0.6	0.2-0.6	0.1-0.5	0.35-0.46	0.11-0.13	0.1-0.4
$CaCO_3$ (%)	2.6-4.4	2.0-3.1	1.0-5.1	11.0-30.0	2.3-4.9	2.17-7.47	2.2-3.5	2.5-5.1
O.M. (%)	1.9-2.6	1.8-2.4	0.4-0.9	0.7-1.5	1.5-2.0	0.17-0.29	1.5-2.0	1.2-1.9
Soluble N (ppm)	25.0-50.0	30-60	10.0-20.0	10.0-30.0	20.0-30.0	10.0-21.0	7.25-39	20.0-25.0
Available P (ppm)	5.4-10.0	3.5-16.5	2.0-20.0	1.5-10.5	2.5-20.0	0.1-0.37	3.26-12	3.0-18.0
Available K (ppm)	250-500	250-300	105-358	100-300	250-380	163-192	148-285	280-400
Available Zn (ppm)	0.5-4.0	0.6-6.0	0.5-1.2	0.4-1.5	0.8-3.9	0.8-1.6	0.98-1.85	0.5-4.0
Available Mn (ppm)	13.1-45.6	11.2-37.2	3.0-11.7	10.0-20.0	8.6-51.9	1.4-3.1	0.48-2.45	10.0-47.0
Available Fe (ppm)	20.8-63.4	19.0-27.4	6.7-16.4	12.0-18.0	13.0-37.0	3.0-4.0	1.02-1.98	12.4-40.8

Source: Soils Water and Environment Research Institute, Egypt.

Water resources

The River Nile is the main source of water for Egypt, with an annual allocated flow of 55.5 billion m^3 yr^{-1} under the Nile Waters Agreement of 1959. The chemical characteristics of Nile water are described in Table 2.

Underground water

Underground water is an important source of freshwater in Egypt. As underground water is a constant temperature and not exposed to pollution, it can be used directly without treatment and is a safe source of potable water.

Egypt is currently developing a water resources plan (ending in 2017), and under this framework, aims to save 6.5 billion m^3 of underground water.

Table 2. Some chemical properties of Nile water.

Parameter	Unit	Value
pH		7.3
EC	dS m^{-1}	0.37
Na^+	meq L^{-1}	0.89
Ca^{++}	meq L^{-1}	1.66
Mg^{++}	meq L^{-1}	0.95
Cl^-	meq L^{-1}	0.56
SO_4^+	meq L^{-1}	1.31
HCO_3^-	meq L^{-1}	1.8
Total N	ppm	4.5
NH_4^+	ppm	0.54
NO_3^-	ppm	1.43
Total P	ppm	0.17
K^+	ppm	1.9

Source: Abd el-Hady, 2007.

Rain water

Rain is a scarce resource for much of Egypt. The northwest coast of Egypt receives around 1.3 m^3 annually, which decreases gradually as you go south; southern Egypt receives only a trace of rain each year. Rainfall therefore remains a limited and unreliable source in agricultural development, but can continue to play a role in pasture cultivation in desert areas and irrigation in the North Coast.

Drainage water

Since the 1950's, Egypt has started to re-use agricultural drainage water, which is treated and mixed with Nile water for use in irrigation (Table 3). Stations were established along parts of the Nile Delta to lift and push drainage and Nile water into canals for land irrigation. The quantity of drainage water used was estimated at 8 billion m^3 for 2007/2008.

Water use

Total water withdrawal in 2008 was estimated at 76.6 billion m^3. This included 60 billion m^3 for agriculture (78.3 percent), 6.6 billion m^3 for municipalities (9 percent) and 7.6 billion m^3 for industry (10 percent). Apart from that, 0.2 billion m^3 was used for navigation, i.e. water used by ships for cooking, engines and other on board uses (Table 4).

Re-use of agricultural drainage water is through its return to rivers and as irrigation, and amounted to 8 billion m^3 yr^{-1} in 2007/2008. Of the 2.97 billion m^3 yr^{-1} of treated wastewater, 1.3 billion m^3 yr^{-1} is re-used for irrigation, while the rest is pumped into main drains where it mixes with drainage water and is then used for irrigation. Treated wastewater is usually used for landscape irrigation of trees in urban areas and along roads.

Table 3. Water resources in Egypt during 2002-2008 (in billion m^3).

Resources	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
Nile water	55.5	55.5	55.5	55.5	55.5	55.5
Ground water	6.1	6.1	6.1	6.1	6.2	6.5
Drainage water	4.4	4.8	5.1	5.4	5.7	8
Sewage recycling	0.9	1	1.1	1.2	1.3	1.3
Rain & flash floods	1.3	1.3	1.3	1.3	1.3	1.3
Desalination	0.06	0.06	0.06	0.06	0.06	0.06
Total	68.26	68.76	69.16	69.56	70.06	72.66

Source: Bahgat, 2008.

Table 4. Water resources usage in Egypt (in billion m^3).

Sector	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
Irrigation	57.6	58.1	58.5	59.0	59.3	60.0
Municipal	5.2	6.0	6.1	6.1	6.3	6.6
Industry	6.2	6.5	6.8	7.0	7.3	7.6
Evaporation	2.1	2.1	2.1	2.2	2.2	2.2
Navigation	0.2	0.2	0.2	0.2	0.2	0.2
Total	71.3	72.9	73.7	74.5	75.3	76.6

Source: Bahgat, 2008.

Table 5. Total cropped area in 2008/2009 (about 16.3 million feddan*).

Crop	Area (million feddan)
Wheat	3.20
Berseem and other forage crops	2.90
Maize	2.70
Vegetables	2.35
Orchard	1.60
Oil crops	0.52
Cotton	0.50
Legumes	0.43
Sugar beet	0.37
Sugar cane	0.32
Other crops (medicinal and aromatic plants; ornamentals)	0.30

*Feddan = 0.42 ha

Source: Agricultural Statistics, 2010

Cropping systems

The Egyptian climate is generally favorable all year round and is suitable for growing a wide variety of crops. Field crops cover roughly 90 percent of the total cropped area and 10 percent is vegetables and fruits grown on the old and new reclaimed land.

Under prevailing cropping patterns there are usually two crops a year in the same field giving a cropping index of 200 percent, whereas a cropping index of 300 percent is achieved in the vegetable areas. The perennial sugarcane and permanent orchard areas have a cropping index of 100 percent. The cultivated area is slightly more than 6.848 million ha (Table 5), with an average cropping intensity of 176 percent. There are three growing seasons in Egypt: winter - from November to May; summer - from April/May to October; and "Nili" - from July/August to October.

Most crops are grown in the Delta and the Nile Valley, with the exception of rice (Delta mainly) and sugarcane (Middle and Upper Egypt). The main winter crops are wheat and clover or berseem *(Trifolium alexandrinum)*. Berseem is grown over three months with two cuts as a soil improver (short berseem) usually preceding cotton, or over six to seven months, with four to five cuts as a fodder crop or grazed by tethered cattle (long berseem). Minor winter crops are (amongst others) pulses, barley and sugarbeet. In summer, cotton and rice are important cash crops, while maize and sorghum are major subsistence crops. Details of area cropped in 2008/2009 are given in Table 5.

Fertilizer requirements

Significant efforts have been focused on increasing crop production and tackling constraining factors. One key target is the proper fertilization of various crops which will obviously increase the demand for chemical fertilizers. Rate of increase in fertilizer use in Egypt has accelerated in recent years, especially for nitrogen fertilizers, followed by phosphate and potassium fertilizers. This is primarily due to the increase in cropping area, the increase in fertilizer application for various crops, and depletion of Nile irrigation water of some nutrients (K and micronutrients, together with the silt) due to the construction of the High Dam in Aswan.

Numerous studies have firmly established the deficiency of most Egyptian soils in organic matter and nitrogen (N) content. Phosphorus (P) availability to plants, however, ranges between sufficiency and marginality, although the total P content in most Egyptian soils is quite high. Potassium is moderate to high in the old lands, however there are sporadic responses to K fertilizer especially with some horticultural crops and on sandy as well as some calcareous soils.

Table 6. Fertilization requirements for various field crops (kg ha^{-1}).

Crops	Old land			New land		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
	kg ha^{-1}					
Cotton	60	22.5	24	-	-	-
Maize	120	15	24	140	30	48
Rice	40-60	15	24	-	-	-
Soybean	40	30	24	-	-	-
Beans	40	30-45	48	60	45	48
Wheat	90	22.5	24	100-120	30	24-48
Broad bean	15	30	24	15	30	48
Clover	15	22.5	24	20	30	24
Sunflower	30-45	15	24	45-60	30	24
Peanut	30	30	24	45	30	24
Sesame	30	22.5	24	45	30	24
Sugar beet	60	15	24	75-100	30	48

Source: Abd el-Hadi *et al.*, 2009.

The fertilizer requirements in Egypt are mainly estimated according to crop needs and the area allocated for each crop, as well as the optimum economical rates of fertilizers for each crop (Table 6) which are obtained from average results of long-term trials conducted on each crop under different agro-climatic conditions and the nutrient amounts removed by the crop (Table 7).

Other factors to be taken into consideration in estimating fertilizer requirements include:

1. Crop rotation and its effect on crop response to fertilizers.
2. The horizontal expansion in the newly reclaimed area.
3. Soil test values and plant tissue tests.
4. The residual effect of fertilizers and organic manures.
5. Crop intensification, whether by increasing the plant number per unit area or by intercropping.
6. The release of new varieties of various crops with high-yield potential.
7. The nutritional balance for various crops.
8. The fertilizing value of different sources of fertilizers.
9. Use of irrigation and drainage systems.

Fertilizer requirements are dependent on cropping conditions: the "old land" is the Nile Delta and the Nile Valley, where soils are better quality than in the "new land", or reclaimed lands from the desert, which are pure sand with low fertility (Fig. 1). The old land represents the traditional cropping area (arable land). It is two percent of the country. The extension of the cropping area in the desert is a prerequisite to ensure food security in Egypt.

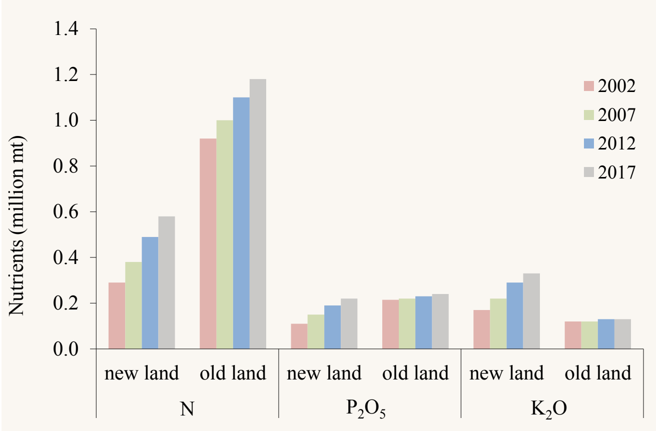


Fig. 1. Estimated fertilizer requirements in the new and old land in Egypt. *Source:* FAO, 2005.

Table 7. Nutrient amounts (kg ha^{-1}) removed by various crop plants (Abd el-Hadi *et al.*, 2009).

Crop	Yield	N	P_2O_5	K_2O	MgO	S
	mt ha^{-1}	-----	-----	-kg ha^{-1}-	-----	-----
Barley	5	150	55	150	25	20
Maize	6	120	50	120	40	25
Rice	5	100	50	160	20	20
Sorghum	4	120	40	100	30	15
Wheat	6	170	75	175	30	30
Potato	40	175	80	310	40	20
Sugar beet	45	200	96	300	90	35
Cabbage	70	370	85	480	60	80
Carrot	30	125	55	200	30	-
Cucumber	40	70	50	120	60	-
Eggplant	60	175	40	300	30	10
Lettuce	30	90	35	160	15	-
Okra	20	60	25	90	35	10
Radish	20	120	60	120	30	-
Onion and garlic	35	120	50	160	15	20
Spinach	25	120	45	200	35	-
Tomato	50	140	65	190	25	30
Bean	2.4	155*	50	120	20	25
Horse bean	2.4	160*	45	120	20	-
Pea	2.0	125	35	80	15	-
Apple	25	100	45	180	40	-
Banana	40	250	60	1,000	140	15
Citrus	30	270	60	350	40	30
Grape	20	170	60	220	60	30
Mango	15	100	25	110	75	-
Peanut	2	170*	30	110	20	15
Sesame seed	1	50	10	45	10	5
Rapeseed	3	165	70	220	30	65
Soybean	3	220*	40	170	40	20
Sunflower	3	120	60	240	55	15
Cotton (lint)	1	120	45	90	40	20
Sugarcane	100	130	90	340	80	60
Alfalfa	9	240*	65	170	40	25
Red clover	7	175*	45	140	50	20

*Leguminous plants obtain most of their nitrogen from the air.

Source: Principal Bank for Development and Agricultural Credit-Fertilizer Administration.

Fertilizer consumption

It should be noticed from the data reported in Fig. 2 that the ratio of $N:P_2O_5:K_2O$ was 74.64:13.68:1 in 1979/1980 which declined to 20.7:3.28:1 in 2008/2009 since the consumed amount of K_2O increased from 6.7 thousand tonnes in 1979/1980 to 55 thousand tonnes in 2008/2009, and this has a positive effect on NPK balance.

The highest amounts of fertilizer were consumed during the period (2004-2007), with an average of 1,556.9 thousand tonnes/

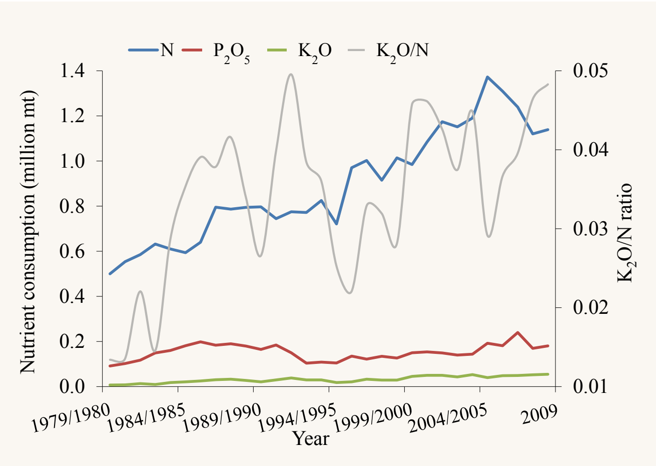


Fig. 2. Consumption of N, P and K fertilizers and the ratio K_2O/N during the period 1980-2009. *Source:* IFA, 2010.

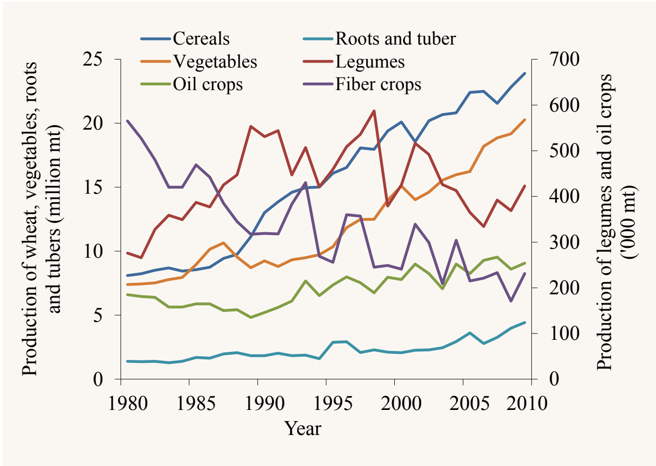


Fig. 3. Total crop production year^{-1}. *Source:* Central Administration for Agricultural Economic, Economic Affairs Sector, MALR.

year; although this increase was accompanied by an increase in crop production during the same period.

From the data presented in Table 7, N fertilizer consumption significantly increased during the period 1980 to 2009, whilst P and K consumption were much lower and more stable.

Crop production

From 1980 to 2009, cereal production increased from 8.1 to 23.897 million mt; legumes increased from 276 to 423 thousand mt; oil crop production increased from 185 to 254 thousand mt; roots and tuber crop production increased from 1.394 to 4.429 million mt; vegetable production increased from 7.402 to 20.275 million mt in 2009; while fiber crop production decreased from 565 to 231 thousand mt (Fig. 3). The higher increase observed in cereal and vegetable crops was accompanied by a steady increase in N fertilizer consumption.

The Activities of the International Potash Institute (IPI) in Egypt

Introduction

The Soil, Water and Environment Research Institute (SWERI), in collaboration with IPI, carried out long-term experiments during the period 1981 to 1990 to evaluate the effect of K application on various crops on farmers' fields under typical prevailing crop rotation. During 1992 to 1995, a series of long-term experiments were carried out in the eastern part of Nile Delta (sandy and sandy loamy soils) to study the efficiency of K on crop production under saline and water stress conditions.

Experimental programs

1. Long-term field trials were conducted at six different Agricultural Research Stations representing different types of soils during seven successive years (1993-2000) to compare effectiveness of KCl (MOP) and K_2SO_4 (SOP) on different crops. The trials were repeated for an additional five years till 2005, on farmers' fields under their traditional agriculture practices.
2. Another long-term field trial was also initiated from the year 2005/2006 till 2012 to investigate the interaction effect of N, P and K on crop yields.
3. From the beginning of the 2009/2010 season, a series of experiments were planned to investigate the interaction effect between K fertilizers and various amount of irrigation water, as well as different irrigation methods.

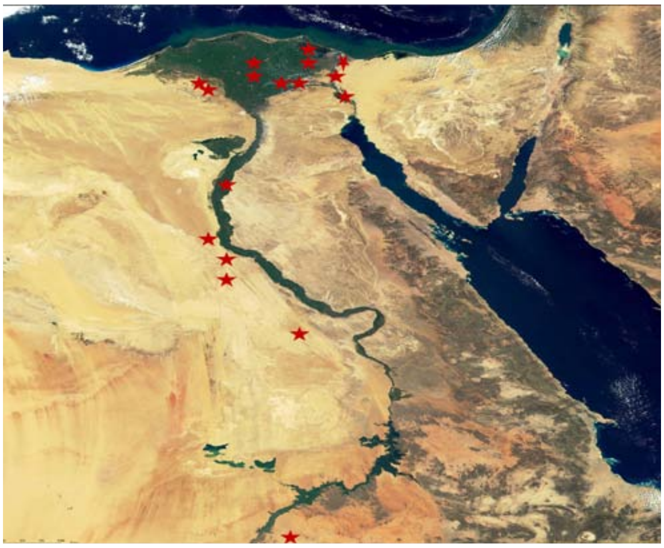
Workshops and training programs

SWERI, in collaboration with IPI, held dozens of workshops in various Research Stations and Governorates dealing with the importance of balanced fertilization to achieve the highest crop yield in addition to solving some agricultural problems faced by farmers.

In addition, IPI provided support in the publication of booklets concerning K fertilization and symptoms of nutrient deficiency in some important crops, all produced in Arabic. Twenty-five papers from the obtained results were published at international and local scientific workshops and in various Journals through the period (1984 to 2010). Four PhD theses were obtained through the project (in the field of K fertilization).

Conclusions

Egyptian agriculture is an example of semi-arid to arid cropping systems, characterized by a limited cropping area. Water availability is a limiting factor in most parts of the country and competition in water use between population, industry and agriculture is a source of concern. Through the years, crop productivity has increased as a result of increasing fertilizer use,



Map 3. Location of IPI's experimental programs in Egypt.
Source: Jacques Descloitres, MODIS Rapid Response Team, NASA/GSFC.

Discussing experiment results of potato crop near Nubaria, west branch of the Nile delta. Photo by M. Marchand.

a strong focus on providing information to fertilizer distributors and retailers, and farmer training to achieve better efficiency for agricultural inputs. The increase in production, especially regarding food production, has been achieved through the development of new cropping areas, so called "new reclaimed lands", in the Sinai desert and in the Toshka region, which means the development of specific irrigation techniques. The role of SWERI and IPI is to promote a better NPK ratio as well as to raise awareness amongst farmers of other limiting factors that occur in the particular Egyptian conditions.

The main challenges are an improvement in crop production to feed an increasing population and to use Nile water in the most efficient way. Concerning nutrient management, the objective of SWRI and IPI cooperation is to convince farmers of a better practice in the use of fertilizers. To achieve this goal, it is necessary to prove through experiments in Research Stations, to show through field demonstrations and finally to explain the use and benefit of balanced fertilization. Communication and education are the two keywords for the success of SWERI and IPI activities and the development of Egyptian agriculture.

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The paper "Potash Fertilizers in Africa: Background, Assessment and Prospects" also appears on the IPI website at:

Regional activities/WANA

Doing Extension

Recent Efforts made by Indian Potash Limited (IPL) for Promoting Balanced Fertilization in India

Pal, B.[1], and S.K. Bansal[2]

Increase in farm gate prices of muriate of potash (MOP) in India from Rs 4,600 per tonne in 2008 to Rs 17,000 in 2012 has led to a drastic reduction in MOP consumption by farmers in India. During 2012-13, MOP consumption is expected to be only around 40-45 percent of 2011-12 levels. The decline in consumption has been taken as a serious challenge by Indian Potash Limited (IPL), the current leader of potash sales in the country. Recent efforts made by IPL to address the situation are detailed below.

A stakeholder meeting, including potash producers, researchers and industry players, was called by Dr. P.S. Gahlaut, IPL Managing Director, in December 2012 in New Delhi to discuss and plan potash promotion for different crops and regions in general, and particularly for sugarcane. The meeting was attended by IPL senior officials, potash producers active in India and research institutes, including the International Potash Institute (IPI), Potash Research Institute of India (PRII), the International Plant Nutrition Institute (IPNI) and the Indian Sugar Manufacturers Association (ISMA). Various strategies, including publishing simple crop leaflets highlighting the economic benefits of potash application even under the increased price regime, as well as TV and radio talks, audio-visual films etc., were discussed and planned for implementation. It was agreed that similar promotion efforts need to be conducted per specific crops in all major growing areas in India.

Follow-up action was quickly initiated:

1. A one-page, very colourful but simple leaflet on sugarcane was brought out in Hindi and other regional languages. Mass copies of the leaflet were distributed to different sugar factories for dissemination among farmer members and other farmers in the vicinity.
2. Large-scale farmers' meetings are being conducted in different states.
3. A TV talk show on "Benefits of Potash Use in Sugarcane" in Hindi was delivered by Dr. Bhisham Pal (IPL) in the Krishi Darshan (Farm Programme) of the National TV Channel called Door Darshan on 1 February 2013.
4. A series of ten-minute radio talks as Potash Pathshala (Potash school) on All India Radio, Delhi has been produced for broadcast covering ten talks by experts on various topics of potash use during January-March 2013.
5. A special PowerPoint presentation with voice over in several languages on "Yield and Economic Benefits of Potash in Different Crops" is currently being prepared. In addition, all relevant information on different crops' responses in different regions is being collected to provide a precise calculation of the economic benefits of potash application. These will be used by IPL field staff for raising awareness amongst farmers that potash use is beneficial even after recent price increases.

In conclusion, this large-scale communication strategy to Indian sugarcane growers represents a different extension approach, in which selected complementing activities are integrated and targeted to a large group of farmers with clear messages on potash fertilization for a specific crop and timeframe. IPL intend to undertake similar activities for other crops during 2013.

Farmers discuss ways to improve nutrient management. Bihar, India, 2013. Photo by IPI.

This report also appears on the IPI website at:

Regional activities/India

[1]Indian Potash Limited (IPL), New Delhi, India
[2]Potash Research Institute of India (PRII), Gurgaon, India

Events

May 2012

Training Workshop on "Assessing Crop Production, Nutrient Management, Climatic Risk and Environmental Sustainability with Simulation Models" at the University of Georgia, Griffin, Georgia, USA, 14-19 May 2012

Report from DSSAT by Jagadish Timsina, Consultant to International Rice Research Institute (IRRI) and recipient of IPI partial support

Today, more than ever, increased crop production depends on judicious use of various resources such as water, nutrients (including N, P, and K), and pesticides. In addition, issues such as climate change, climate variability, soil carbon sequestration, biofuels, long-term food security and environmental sustainability have become important issues global issues.

Computer simulation models of the soil/plant/atmosphere system can make a valuable contribution to furthering our understanding of the processes that determine crop responses and predicting crop performance, resource use and environmental impacts for different environments and management scenarios. User-oriented simulation models greatly facilitate the task of optimizing crop growth and deriving recommendations concerning crop management. They can also be used to determine the potential impact of climate change on crop production, soil fertility, system sustainability, or provide management scenarios for adapting to climate change and variability.

International Consortium for Agricultural System Analysis (ICASA), Agricultural Models Intercomparison Project (AgMIP), and Decision Support System for Agrotechnology Transfer (DSSAT) Foundation jointly organized an international training workshop "Assessing Crop Production, Nutrient Management, Climatic Risk and Environmental Sustainability with Simulation Models" at the Griffin Campus, University of Georgia from 14 to 19 May 2012. The overall goal of this event was to familiarize participants with comprehensive computer software for the simulation of crop growth and yield, soil and plant water, nutrient and carbon dynamics and their application to real world problems.

Specifically the program focused on: (i) operation of the Windows-based Decision Support System for Agrotechnology Transfer (DSSAT) Version 4.5 software (www.DSSAT.net), (ii) description of the DSSAT-Cropping System Model (CSM) and its modules, such as CROPGRO and CERES, and the science embedded in the models, (iii) minimum data requirements and experimental data collection for systems simulation, (iv) integration of crop simulation models with database management and geographical information systems, and (v) application of the DSSAT-CSM model to improve management of cropping systems by optimizing crop, water and nutrients (N, P, and K). Forty-one participants took part from sub-Saharan Africa, Asia, North and South America, Europe, and Australia.

The program (i) described a practical approach for simulating effects of soil, weather, management, and pest factors on crop production, (ii) demonstrated how processes of crop growth and development, water use, uptake of water and nutrients and carbon dynamics can be simulated, (iii) made extensive use of "hands on" sessions that applied the DSSAT-CSM model to cropping systems, (iv) described procedures for collecting and managing crop, weather and soil data for model calibration and validation, (v) gave participants ample opportunity to work with their own data and determined the accuracy of the models for application to specific problems, (vi) analyzed management alternatives for single seasons or over long-term crop rotations, (vii) concentrated on specific applications that include irrigation, fertilizer and nutrient management, soil carbon sequestration, and climate change and climate variability, and (viii) assessed economic risks and environmental impacts associated with agricultural production.

The program made extensive use of the Windows-based DSSAT-CSM v4.5. CSM is a general cropping system model for simulating crop growth and development and soil and plant water, N, P, and K, and carbon dynamics, and includes tools and utility programs for managing soil, weather, genetic, crop, economic and pest data, and application and analysis programs. CSM is comprised of the CROPGRO module for soybean, peanut, common bean, chickpea, faba bean, cowpea, tomato, bahia, brachiaria, and cotton, the CERES module for rice, maize, sorghum and millet, the SUBSTOR module for potato, the CROPSIM-CERES module for wheat and barley, the CANEGRO model for sugarcane, and the CROPSIM module for cassava. The CENTURY model for the simulation of soil carbon and nitrogen has also been incorporated in CSM. There is a simple K model within DSSAT-CSM which will be included in the official released version DSSAT v4.6.

The trainers for the workshop were Prof. Jim Jones (University of Florida), Prof. Gerrit Hoogenboom (Washington State University), Prof. Ken Boote (University of Florida), Dr. Upendra Singh (International Fertilizer Development Centre), and Dr. Cheryl Porter (University of Florida). Dr. Jagadish Timsina, a Freelance Consultant based in Melbourne, Australia (and currently a consultant to IRRI) received partial support from IPI to attend this training workshop. Dr. Timsina is also one of the participants at the 12th International IPI symposium "Management of Potassium in Plant and Soil Systems in China" in cooperation with the China Agricultural University from 24 to 27 July 2012 and is also involved in the evaluation and refinements of the K model embedded within DSSAT 4.6 due for release in early 2013.

Dr. Timsina felt that the workshop provided comprehensive information on systems simulation and the new developments in DSSAT. The workshop was particularly useful in understanding the new developments on the K model which need extensive evaluation and possibly some refinements for its application for K fertilizer recommendations for the intensive cropping systems of smallholder farmers in Africa and Asia.

What is DSSAT?

Decision Support System for Agrotechnology Transfer (DSSAT) is a software application program that comprises crop simulation models for over 28 crops (as of v4.5). DSSAT is supported by database management programs for soil, weather, and crop management and experimental data, and by utilities and application programs. The crop simulation models in DSSAT simulate growth, development and yield as a function of the soil-plant-atmosphere dynamics, which have been used for many applications ranging from on-farm and precision management to regional assessments of the impact of climate variability and climate change. It has been in use for more than 20 years by researchers, educators, consultants, extension agents, growers, and policy and decision makers in over 100 countries worldwide. See details on www.dssat.net.

April 2013

ISSPA 2013, 13th International Symposium on Soil and Plant Analysis, Queenstown, New Zealand, 8-12 April 2013. The symposium theme is "New Opportunities for Soil and Plant Testing", with the emphasis on new methodologies and emerging technologies. The program will comprise a mixture of oral and poster presentations. There will be full days of oral sessions on the Tuesday and Thursday, and on the Friday morning. Details of the sessions and topics are available on the symposium website.

July 2013

WSF 2013, the 4th China International Water Soluble Fertilizer Conference and Exhibition, Beijing, China, 2-4 July 2013, focusing on technological innovation, will give particular attention to technology, innovation and promotion of water soluble fertilizers and their use in Fertigation and Foliar applications systems in China and other regions of the world, in Asia in particular. The event is co-oganized by CNCIC and New Ag International. For more details go to the conference website.

August 2013

17th International Plant Nutrition Colloquium - Plant nutrition for nutrient and food security, Istanbul Convention and Exhibition Center (ICEC), Turkey, 19-22 August 2013. The main theme of the 17th International Plant Nutrition Colloquium (IPNC) is "Plant nutrition for nutrient and food security". **IPI is sponsoring IPNC (Platinum Sponsor) and will conduct a Special Session on Potassium on 21 August 2013 between 14:00-17:30 h.** See more on the program on the International Plant Nutrition Colloquium website.

It is hoped that the colloquium will be an excellent venue for discussion, exchange and transfer of knowledge, as well as for creating new and fostering existing collaborations in the fields of plant mineral nutrition, plant molecular biology, plant genetics, agronomy, horticulture, ecology, environmental sciences and fertilizer use and production. For more information please contact Mr. Michel Marchand, IPI Coordinator WANA and Central Europe.

September 2013

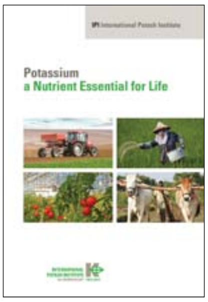
The Second International Sympsium on Agronomy and Physiology of Potato (Potato Agrophysiology 2013), Prague, Czech Republic, 5-19 September 2013. More details on the symposium website.

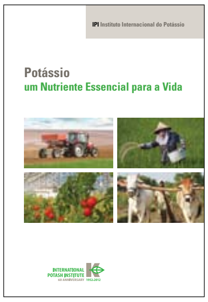
Publications

Fertirrigación - Una herramienta para una eficiente fertilización y manejo del agua (Fertigation - A tool for Efficient Water and Nutrient Management)
Kafkafi, U., and J. Tarchitzky; translated to Spanish by R. Melgar. 2012.

This IFA-IPI publication in Spanish is now available for download from IPI website.

***e-ifc* No. 32 | November 2012**
IPI's 60th anniversary issue newsletter is available in English and Chinese. For hardcopies contact ipi@ipipotash.org.



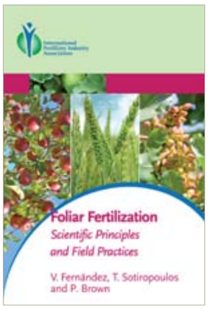


Potassium - a Nutrient Essential for Life
Potássio - um Nutriente Essencial para a Vida
Potassium is one of the key elements for life on earth. It is required in large quantities by all plants and animals and is obtained by plants from the soil in which they grow. Animals obtain their potassium from plants, either directly or by eating other animals (and animal products) which have fed on plants.

This booklet summarizes the main issues related to potash fertilizers, with following topics discussed:

- How much potassium is needed by humans?
- How much potassium is needed by plants?
- Potassium deficiency and its symptoms
- Potassium in the soil
- Potassium production and reserves
- Potassium and the environment
- Potash fertilizers

The booklet also contains two large newly drawn schematics on "Potassium Functions within the Plant" and "The Potassium Cycle in Soil and Agriculture" and a few color pictures. The publication is available in English and Portuguese on the IPI website.



New IFA publication "Foliar Fertilization: Scientific Principles and Field Practices"
Fernández, V., T. Sotiropoulos, and P. Brown.

Foliar fertilization is a widely used crop nutrition strategy of increasing importance worldwide. Used wisely, foliar fertilizers may be more environmentally friendly and target oriented than soil fertilization though plant responses to foliar sprays are variable and many of the principles of foliar fertilization remain poorly understood. The aim of the book is to provide up-to-date information and clarification on the scientific basis of foliar fertilization and plant responses to it with reference to the underlying environmental, physiological and physico-chemical determinants. Information drawn from research, field trials and observational studies, as well as developments in formulation and application techniques, are discussed.

This book is a contribution to IFA's efforts to promote nutrient stewardship through the use of the 4Rs: right product(s) at the right rate, at the right time and in the right place (see www.fbmp.info).

The publication can be downloaded from the IFA website. You can also order hardcopies from the IFA Secretariat by sending an e-mail to publications@fertilizer.org.

in the Literature

Relationship between Chloride Salts of Sodium and Potassium with Seedling Growth of BRRI dhan 41

Mandal, T., M.Z. Hossain, M.S. Jahan, and G.M.M. Rahman. 2012. Bangladesh J. Agric. and Environ. 8(1):19-25.

Abstract: A laboratory experiment was conducted at Agronomy Laboratory of Agrotechnology Discipline, Khulna University, Khulna, Bangladesh during 10 September to 1 October 2008 to determine relationship between chloride salts of sodium and potassium with germination and seedling growth of BRRI dhan 41. Potassium chloride and sodium chloride were used as two salt sources and each sources had five different levels of salt viz. 0, 75, 150, 225, and 300 mM. Data were collected on germination percentage, energy, capacity & speed and the length of root and shoot length as well as dry weight of root and shoot per plant. There were wide variations in all parameters of germination, shoot length, root length and dry weight of root and shoot due to the treatment with the two different salt sources. Germination percentage, energy, capacity & speed and the seedling growth (shoot length) of the variety gradually decreased with increasing concentration of salt solutions. Germination and the length of root & shoot were negatively related to salt levels.

Potassium Use Efficiency of Maize Hybrids

M. Ahmad alias Haji A. Bukhsh, R. Ahmad, A. Ali, M. Ishaque, and A. Rehman. 2012. Journal of Animal & Plant Sciences 22(3):728-732

Abstract: Maize hybrids exhibit better potassium use efficiency (KUE) and utilize soil N in an efficient way, thus reduce input cost and conserve environment. For the screening of hybrids with proper dose of K, experiment were laid out in randomized complete block design with split plot arrangement, randomizing maize hybrids in main plots (H_1=Pioneer-3012, H_2=Pioneer-3062, H_3=Pioneer - 30D55) and K application levels (K_0=0, K_1=100, K_2=150, K_3=200 and K_4=250 kg ha^{-1}) in subplots with four replications. It was observed that Pioneer-30D55 significantly gave higher KUE (1.94) than Pioneer-3012 (1.86), yet it was at par with Pioneer-3062 (1.92). K application at all levels significantly increased KUE over control. All K levels except control produced statistically similar KUE. As far as N present in soil after harvest, Pioneer-30D55, probably due to its efficient root system left minimum N (0.042 %) in the soil and significantly differed with Pioneer-3062 (0.043%) and Pioneer-3012 (0.044%), which also significantly differed with each other. Minimum N %age left in soil after crop harvest (0.046) was observed, when 200 kg K ha^{-1} was applied which significantly differed with N %age left in soil after harvest crop (0.045) obtained when 250 kg K ha^{-1} was applied, where as maximum N %age left in soil after harvest (0.042) was recorded in control. It was therefore concluded that Pioneer-30D55 was the most efficient hybrid.

Influence of Rootstock on cv. Cornalin Behaviour in the Central Valais

Spring, J.-L., T. Verdenal, V. Zufferey, K. Gindro, and O. Viret. 2012. Revue suisse Viticulture, Arboriculture, Horticulture 44(5):298-307.

Abstract: The agronomical and oenological behaviour of the Vitis vinifera cv. Cornalin was studied in relation to the choice of the rootstock at the Research station Agroscope Changins-Wädenswil ACW, in Leytron (VS). The following rootstocks were chosen for this trial: 3309 C, 5BB, Fercal, 41B MGt, 101-14 MGt and 161-49 C. The rootstocks mainly influenced the vigour and the mineral uptake of the graft. 41B MGt and 161-49 C were less vigorous than the other rootstocks. They also had a lower nitrogen and potassium uptake. 41 B presented a high magnesium uptake as well as fewer bunch stem necrosis symptoms whereas 5BB, Fercal and 101-14 MGt had a lower magnesium uptake and more bunch stem necrosis symptoms. The wines issued from the rootstocks 41 B and 161-49 C were slightly more acidic. The rootstock 101-14 MGt appeared to be more sensitive to drought.

Grain Sorghum - an Arable Crop with Attractive Properties, as yet Unknown in Switzerland

Hiltbrunner, J., U. Buchmann, S. Vogelgsang, A. Gutzwiller, and H. Ramseier. 2012. Recherche Agronomique Suisse 3(11-12):524-531.

Abstract: With 40.5 million hectares under cultivation, *Sorghum bicolor* (L.) Moench is the world's fifth-most important arable crop. Although primarily cultivated in warmer regions, the area devoted to this crop in Europe has increased over the past few years - among other things because sorghum produces attractive yields even when little water is available. In order to increase the sparse information on cultivating grain sorghum currently available in Switzerland, trials were conducted from 2009 to 2011 in various Swiss regions with several varieties. In favourable environmental conditions, the earliest maturing varieties achieved yields of up to 110 dt ha^{-1} with 16 % humidity at the day of the harvest in small-plot trials. Because of sorghum's greater need for warmth than maize, planting in cold-air zones or in basins, or early sowing should be avoided. This will ensure a relatively quick juvenile development and good pollination. A piglet feeding trial showed that Swiss-produced sorghum is of comparable quality to the imported grain, and meets feeding requirements. Preliminary infection trials with Fusarium species resulted in low infection rates and low deoxynivalenol (DON) contents. As evidenced by the successful cultivation of Sorghum bicolor in favourable maize-growing areas of Switzerland, changing climatic conditions make

it essential for Swiss farmers to have access to more detailed information of different types of millet and sorghum grown in Switzerland.

DOC Trial: Nutrient Supply in Winter Wheat – Where is the Deficit?

Gunst, L., W. Richner, P. Mäder, and J. Mayer. 2013. Recherche Agronomique Suisse 4(2):75-81.

Abstract: The nutrient supply of winter wheat was one of the topics investigated by the DOC long-term system comparison from 1978 to 2003. The aim of this trial is to provide evidence of nutrient-related yield limitations in organic farming systems. Substantial differences in yield between «organic» and «conventional» farming systems and different fertilisation intensities were primarily attributed to the delivery of nutrients - in particular, nitrogen - to the plants. Because the soil phosphorus supply was adequate in all DOC systems over the entire trial period, phosphorus was ruled out as a co-limiting factor. The plant analyses of straw and grain exhibited high figures and a low differentiation for phosphorus, thus confirming the soil findings. By contrast, potassium was identified along with nitrogen as a co-limiting factor in the organic systems at the low fertilisation intensity and in the unfertilised control. This was indicated by the differentiation of potassium content in the above-ground biomass and the available soil potassium content. Despite this, both the biodynamic and bio-organic system exhibited a balanced potassium supply at the high fertilisation intensity. Both bio-systems may therefore be considered sustainable at this fertilisation intensity.

Fertiliser Research – Some Unanswered Questions

Tandon, H.L.S. 2012. Indian J. Fert. 8(7):26-31.

Abstract: Expansion in the area of soil fertility and fertilizer research has resulted in the generation and publication of voluminous amount of information. While this is a welcome development, there are cases where data generation has over taken data interpretation and its in house quality assessment. This has resulted in wide gaps in our information in terms of unanswered questions as also some hard to explain results reported. This paper raises some issues, giving specific examples from published research, to highlight the fact that while a lot progress has been and is being made, any vital questions remain unanswered. This is primarily because many research projects follow a pre-set protocol of the line of work with insufficient provision to take an investigation to its logical conclusion. Another reason is adoption of short cuts by bypassing accepted research procedures for commercial gains from new products. Unanswered questions reduce the scientific and well as practical applicability of the findings of fertilizer research. This problem can be rectified at the level of researchers and also by the directors of research.

Effect of Nitrogen and Potassium Nutrition in Pomegranate Grown in Laterite Soil

Ghosh, S.N. 2012. Indian J. Fert. 8(7):56-58.

Abstract: To find out the nitrogen and potassium requirements in pomegranate cv. Ruby grown in laterite soil of West Bengal, an investigation was carried out for three consecutive years which started when the plant age was 5 years. Results indicated that growth of the plants was not so much affected due to different doses of nitrogen and potassium. But fruit yield and weight of the fruit were significantly and constantly improved with the yearly application of 300 g each of nitrogen and potassium per plant. Fruit quality in respect of juice content, T.S.S. and sugar was not appreciably increased due to nitrogen and potassium nutrition, however, Vitamin-C content, on the other hand, was significantly greater with the application of 300 g of nitrogen and 200 g of potassium per plant per year.

Long-Term Effects of Nutrient Management on Soil Health and Crop Productivity Under Rice-Wheat Cropping System

Singh, J.P., J. Kaur, D.S. Mehta, and R.P. Narwal. 2012. Indian J. Fert. 8(8):28-48.

Abstract: An ongoing long-term experiment under rice-wheat cropping was selected to investigate the effect of organic and fertilization on the sustainability of rice-wheat system. Application of fertilisers along with organic manures (FYM, press mud and green manure) produced significantly higher grain yield of rice compared to application of fertilizer alone. Green manuring with Sesbania aculeata before rice transplanting almost saved 50% of NPK fertilisers. The grain yield of rice and wheat decreased significantly with time in control and with imbalanced application of NPK fertilisers. The decrease in rice yield amounted to 0.055 to 0.134 Mg ha^{-1} yr^{-1} and in wheat yield from 0.038 to 0.116 Mg ha^{-1} yr^{-1}. The data on soil fertility parameters suggested that the gradual decline in soil organic matter and available Zn content of the soil were the major factors contributed towards this yield decline. Balanced application of NPKZn fertilsers with and without organic amendments either increased or maintained the sustainability of the rice-wheat cropping system. Thirteen years of rice-wheat cropping system without any fertilisers or organic amendments had deleterious effects on soil health resulting in significant decrease in organic C, available N, P, K and DTPA-extractable micronutrients. However, soil health with respect to contents of organic carbon, available N, P, K, Zn, Cu, Fe and Mn was either maintained or improved significantly with the balanced application of NPKZn alone or in combination with organic manures. Continuous application of FYM, press mud and green manure for thirteen years sequestered 14.5, 15.8 and 5.3% of the added carbon in soil, respectively. Integrated use of fertilisers with organic manures led to marked increase in the contents of various pools/forms of organic carbon and nitrogen and resulted in

redistribution of micronutrient contents from non-available forms (carbonate and crystalline iron oxides) to readily available (water-soluble plus exchangeable) and potentially available (organic fraction and manganese oxides and amorphous iron oxides) forms in soil.

Influence of Potassium and Zinc Fertilization on Productivity, Quality, Nutrient Uptake, Morpho-Physiological and Bio-Chemical Parameters of Wheat

Gajanand Jat, S.P. Majumdar, Santosh Choudhary, and N.K. Jat. 2012. Indian J. Fert. 8(9):20-27.

Abstract: A field experiment was conducted at the experimental farm, S.K.N. College of Agriculture, Jobner, Jaipur, Rajasthan during the Rabi season of 2007 and 2008 to study the effect of potassium and Zn fertilization on productivity, quality, nutrient uptake, morpho-physiological and bio-chemical parameters of wheat (*Triticum aestivum*). Treatments comprised of four levels each of fertilizer potassium (0, 20, 40 and 60 kg K_2O/ha) and Zn (0, 3, 6 and 9 kg Zn/ha) in randomized block design with four replications. Results revealed that the productivity of wheat (grain and straw yield) was increased significantly with application of K and Zn. Indicating the better osmoregulation and adaptive characteristics of plant the morpho-physiological parameters viz., relative leaf water content and transpiration rate of wheat were significantly increased, whereas osmotic potential decreased with the application of K and Zn. Application K and Zn increased significantly the bio-chemical parameters of wheat crop (total phenol, allantoin, proline, lysine, chlorophyll and protein content) indicating the higher produce quality from human and animal nutrition point of view (lysine and protein content) and higher stress resistance in crop against biotic and abiotic stresses (total phenol, allantoin, proline and chlorophyll content). The application of K increased significantly the N, P, K, S and Zn content in grain and straw, whereas the increasing levels of Zn increased N, K, S and Zn content in grain and straw indicting the enhancement in nutritional quality of wheat produce. Due to high nutrient content and higher yield the uptake of nutrients was also higher in the produce. With increase in K and Zn levels Physiological Efficiency and Apparent Recovery of applied K and Zn were decreased while Nutrient Harvest Index was increased up to 60 kg K_2O and 6 kg Zn/ha.

Soil Potassium Fertility and Management Strategies in Andhra Pradesh Agriculture

Srinivasarao, Ch., and K. Surekha. 2012. Indian J. Fert. 8(10):40-56.

Abstract: Declining soil potassium has emerged as an important productivity constraint in Indian agriculture. The K deficiency in soils and crop plants is particularly a serious management issue in red, lateritic, acidic, alluvial and coastal sandy soils. A variety of soils such as red and lateritic followed by black, alluvial, coastal sandy soil occur in different agro-climatic zones of Andhra Pradesh. Present paper examines the potassium supplying characteristics of these soils types in terms of properties contributing to K availability, forms of available K, soil K reserves as determined by step and constant rate K, release kinetics, quantity/intensity parameters, dynamics under long-term intensive cropping, crop response to applied K in irrigated and rainfed conditions. Potassium balance in soil under continuous cropping and the role of nonexchangeable K in crop K needs and its inclusion in soil testing was highlighted. Significant responses to applied K was obtained in both irrigated rice and several rainfed crops like maize, cotton, groundnut, castor, chickpea, sunflower etc. to applied K in the range of 40-80 kg K_2O ha^{-1}. Crop K requirements and recommendations and future research needs on various aspects of K management in soils of A.P. have been indicated. Large-scale cultivation K exhaustive crops like banana, cotton, maize etc. cannot be supported by K deficient red soils unless sufficient external K application of efficient recycling of crop residue is done.

Soil Fertility Management Strategies for Maximising Cotton Production of India

Srinivasarao, Ch., D. Blaise and M.K. Venugopalan, K.P. Patel, D.P. Biradar and Y.R. Aladakatti, S. Marimuthu, G.S. Buttar and M.S. Brar, and S. Ratna Kumari and V. Cheng Reddy. 2012. Indian J. Fert. 8(12):80-95.

Abstract: Cotton is the most important commercial fibre crop in our country. The Bt transgenic hybrids introduced for cultivation in 2002, now occupies more than 90% of the cotton area. Although, it contributed significantly to productivity and production increases, average productivity levels are still lower than the world average. Poor soil fertility is one major constraint in achieving potential yield levels. A deficiency of at least a single nutrient (N) is most common and in most of the cases it is a multiple nutrient (N, P, K, secondary nutrients - S and micronutrients - Zn, B) deficiency. The results from vast experiments conducted on the Asiatic and Upland cotton cultivars and the hybrid cultivars, indicate it is not sustainable to rely on single nutrients. Among the nutrient management options, balanced fertilization and site-specific nutrient management (SSNM) approaches have been found to be suitable alternatives. However, very little is known about the latter especially for the Bt transgenic hybrids. Significant response to the application of micronutrients has been reported and the cost benefit ratio is highly favourable. Application of organics along with the fertilisers not only enhanced yields but also improved yield stability in the long-term. The main constraint is the availability of adequate quantities of organic sources of plant nutrients. Most of the cotton growing fields in the states of Maharashtra, Andhra Pradesh, Gujarat, Punjab and other northern regions, Tamil Nadu, Karnataka etc. have multi-nutrient deficiency

and more attention is required for better nutrient management practices as cotton is one of the most nutrient exhaustive crops. Target yields of Bt cotton were achieved in tune with the application nutrients up to a target yield of 3.0 t/ha (165:75:120:20:20 kg/ha NPK+ $ZnSO_4$+ $FeSO_4$), while yield of 3.5 t/ha was possible in treatment applied with nutrients for a target yield of 4.0 t/ha (220:100:110:25:25 kg/ha NPK+ $ZnSO_4$+ $FeSO_4$) at Dharwad on Vertisols. The cotton responds to application of K @ 120 kg/ha in calcareous soils of Saurashtra. Response to B application in light textured and highly percolated as well as calcareous soils of North Gujarat and Saurashtra regions is reported. Large numbers of on-farm evaluation farmer participatory SSNM and Integrated Nutrient Management (INM) trials in major cotton growing districts of Andhra Pradesh (Warangal, Khammam, Nalgonda and Adilabad), Gujarat (Anand), Punjab, Karnataka, Maharashtra, Tamil Nadu etc. indicate the substantial improvement of cotton yields due to addition of deficient nutrient in soils. Cotton grown in light textured red soils showed moderate to severe magnesium deficiency which resulted in reduction of boll number and poor plant growth. BC ratio of better nutrient management was recorded up to 4 in some of the field demonstrations. Foliar spray of nutrients also showed significant economic benefits. Small dose of nitrogen after intermitted droughts also benefited the cotton in improving foliage and boll size. Application tank silt (40-60 t/ha) in light textured red soils and addition of FYM/compost resulted in the better tolerance of cotton to intermittent droughts and prolonged wilting of foliage due to water stress during drought spells.

Measures to Sustain and Restore Declined Productivity in Alfisols under Long-Term Fertiliser Experiments

Muneshwar Singh, and R.H. Wanjari. 2013. Indian J. Fert. 9(2):24-32.

Abstract: Acid soils (Alfisols) covers sizeable areas in the states of Kerala in South, Assam, Arunachal, Meghalaya in North East, Uttaranchal and Himachal Pradesh in North and Chhattisgarh, Jharkhand and Orissa in East. Nearly 25-30 mha cultivable land having pH less than 5.5 is associated with several inherent problems like inadequacy of P, K, Ca, Mg and B and toxicity of Cu, Al and Fe. Soil acidity and poor fertility have very strong positive relationship. Long-term fertilizer experiments played a vital role to enhance and sustain the productivity of these soils. In Alfisols, use of nitrogenous fertilizer without ensuring supply or availability of other nutrients in right proportion and soil amendments hat detrimental effect on productivity and soil health. At Palambur application of P enhanced the average crops productivity by 16.8 in maize and 12.1 q ha^{-1} in wheat and application of K resulted increase in productivity of maize by 29.4 and wheat by 18.7 q ha^{-1}. At Palampur, S is another nutrient which increased the crop productivity significantly. Application of soil amendments like lime and FYM coupled with recommended doses of N, P, K and S increased the yield to the extent of 9.0 and 5.8 q ha^{-1} and 14.3 and 8.29 q ha^{-1} in maize and wheat respectively. A similar effect of lime and FYM was also recorded at Bangalore and Ranchi. Thus, balanced application of nutrients coupled with soil amendments ensured increase in productivity approximately by 1.5 to 2.0 t ha^{-1} annually which could give predictably additional production of 40 to 50 mt grain annually. The superimposition of nutrients (P, K and FYM) in N plots which are degraded due to continuous application of N alone for 32 years proved that these plots can be rejuvenated within a period of 2-3 years.

An Overview of Soil Fertility Management, Maintenance, and Productivity in Kenya

Gicheru, P. 2012. Archives of Agronomy and Soil Science 58(1):22-32.

Abstract: Soil fertility-related issues are a major concern to Kenya. For more than a decade, the country has experienced a declining trend in agricultural production as exemplified by low yields of major crops. Crop yields of no inputs declined by over 70% in 11 years. Continuous cropping without fertilizer caused declines in soil organic carbon and microbial biomass size and activity compared to farmyard manure alone or in combination with inorganic fertilizer. In fertilizer trials throughout the country, nitrogen (N) and phosphorus (P) were deficient in 57% and 26% of the sites, respectively. With declining productivity and soil nutrient depletion, many farmers have taken the initiative to improve the situation by use of both inorganic and organic nutrient sources such as manures, composts and traditional fallows where possible. There is strong evidence that application of fertilizer increases crop production, especially for maize. Among the bio-physical factors, a soil fertility decline remains the single most important constraint to food security in this region. After soil moisture stress, low soil fertility is the most important constraint limiting crop productivity in sub-Saharan Africa.

Productivity and Fertility of Soils in the Indo-Gangetic Plains of South Asia

Bijay Singh and Varinderpal Singh. 2012. Archives of Agronomy and Soil Science 58(1):33-40.

Abstract: Fertile soils are a fundamental asset for a sustainable rice-wheat cropping systems followed in 13 Mha in the Indo-Gangetic plains (IGP). Managing practices for the rice-wheat cropping system are changing and in turn influencing soil fertility parameters. In long-term rice-wheat cropping, soil organic carbon content declined only in soils having high initial organic carbon content. Otherwise, soil organic carbon content tends to remain unchanged or increase with continuous cropping and fertilizer/manure applications. Available P content of the soil also increased with P additions through fertilizers or manures. Soil quality deterioration with respect to K supplying power is being largely overlooked. Deficiency of zinc is widespread in

the IGP, but with the extensive use of zinc sulfate, it has reduced in some areas. Deficiency of Fe, Mn, and B is also increasing. The western transects of the IGP are more productive not only because radiation decreases and minimum temperature increases from eastern to western IGP but also due to the application of large amounts of fertilizers and availability of assured irrigation in western transects. Since more nutrients are being removed than added through fertilizers, farmers have to apply increasing doses of fertilizers to sustain the productivity levels.

Soil Fertility and Crop Nutrition Research at an International Center in the Mediterranean Region: Achievements and Future Perspective

Ryan, J., and R. Sommer. 2012. Archives of Agronomy and Soil Science 58(1):41-54.

Abstract: The Mediterranean climate allows for rainfed cropping in the relatively moist cool period from autumn to late spring/ early summer. Drought has a constant influence. Soil fertility was partly maintained by fallowing, nitrogen-fixing plants, and animal manures. Considerable changes have occurred due to land use pressure, i.e. decreasing fallow and increasing crop diversification, irrigation, and chemical inputs, especially chemical fertilizers. Generally, N use has increased about 20-fold, while phosphate has also increased significantly. Due to adequate reserves in the soils, there is a limited potassium fertilizer use. Awareness of the significance of micronutrients has developed. This presentation gives a broad overview of nutrients in relation to soil properties and crops, emphasizing nutrient dynamics in agroecosystems and nutrient use efficiency. Chemical fertilizers have contributed significantly to increasing crop output in the Mediterranean region. Fertilizers and nutrients are considered in the broadest sense, i.e. agricultural production, human and animal health, and the environment. Attention is given to the potential contribution of soil and cropping systems to the emission of greenhouse gasses and how soil management is likely to need to respond to the likelihood of climate change. Projections about future changes related to soil resources of the Mediterranean region are seen in the light of global trends.

Fertility and Soil Productivity of Colombian Soils under Different Soil Management Practices and Several Crops

Alvaro García-Ocampo. 2012. Archives of Agronomy and Soil Science 58(1):55-65.

Abstract: In the Caribbean, valleys of the Andes, Oriental Plains and Andean region of Columbia, there is a great diversity of soils, soil quality and ways and hazards of soil degradation caused by large variations in parent materials, climatic conditions, biodiversity and the physiographic position of the land. Soil and environmental characteristics, soil use and soil degradation in Columbia are specified. There are also opportunities for increased agricultural production. The high degree of soil diversity provides ecological niches for the successful cultivation of modern crop varieties. Alternative cropping practices are suggested. To promote sustainable effects in Colombian soils, a reduction of and change in soil cultivation practices are proposed. Sugarcane fields planted in Alfisols, Vertisols or Mollisols support production levels of >14 t ha^{-1} $month^{-1}$ with high sugar production. In Andean or Caribbean soils, tropical fruit production can be maintained at >40 t ha^{-1} $year^{-1}$. Oil palm fruit can reach production levels of 33-35 t ha^{-1}. Combining practices results in an improvement in physical, chemical and biological soil properties, maintaining high production levels in soils of low, medium or high fertility. It is concluded that the productivity of Colombian tropical soils is a function of soil quality and management.

Integrated Nutrient Management for Sustainable Cassava Production in South Western Nigeria

Odedina, J., S. Ojeniyi, and S. Odedina. 2012. Archives of Agronomy and Soil Science 58(1):132-140.

Abstract: Due to cost, availability and technical reasons, agriculture with high chemical fertilizer input has not been practiced in Nigeria. Animal manures are not available in the required quantities and are often low in one or more of the major nutrients: N, P, and K. This study investigated the effect of an integrated use of organic manures and inorganic fertilizer on cassava production and soil parameters. Single applications of manures and an inorganic fertilizer at recommended rates served as references. Crop responses were highest with integration of manures with no productivity gaps when compared with the rates of single applications of the recommended inorganic fertilizer and manures. Nutrients were made most available when manures were integrated with inorganic fertilizer. Root yield was highest with the integrated use of manures and fertilizer while stem yield was highest with the single applications of manure. Lowest responses were obtained in the control treatment without fertilization for all parameters. Crop and soil productivity can be sustained with the integration of different manures as a viable alternative to the single applications of either manure or inorganic fertilizer.

Application of Potassium and Magnesium on Turmeric *(Curcuma longa)* to Increase Productivity in Inceptisols

Karthikeyan Pullipalayam Kandasamy, Muthuraman Ravichandran, P. Imas, and M. Assaraf. 2012. Archives of Agronomy and Soil Science 58(1):147-150.

Abstract: Turmeric *(Curcuma longa)* is a tropical rhizomatous crop. However, inadequate nutrient management and nutrient mining has led to low productivity of fresh rhizome yield in the major turmeric growing regions in South India. In order to study

the effect of potassium and magnesium on turmeric production and on its quality attributes of the crop under conditions of adequate supply of nitrogen and phosphorus, a pot experiment was carried out on the Irugur soil series (Inceptisols) in the western zone of Tamil Nadu. The experimental design was a randomized block design with six treatments: K1 - control (no potash), K2 - (40[a] + 4[b]), K3 - (80[a] + 8[b]), K4 - (120[a] + 12[b]), K5 - (160[a] + 16[b]), K6 - (200[a] + 20[b]) ([a]kg of K_2O ha^{-1}/[b]kg of $MgSO_4$ ha^{-1}) replicated threefold. The treatment (K6) recorded highest tiller count (14 $plant^{-1}$), rhizome yield (963 g $plant^{-1}$), and curcumin content (4.28%), which was statistically significant to all other treatments. These results suggest that the turmeric crop grown under intensive cropping systems requires large amounts of potassium and to certain extent requires magnesium for increasing productivity, enhancing quality, and for maintaining nutrient ratios in turmeric crop.

Enhancement of Rice Productivity and Soil Fertility through System Integration of Organic and Mineral Fertilizers in Vertisols

Venkataraman Sriramachandrasekharan, Rengaraj Manivannan, and Muthuraman Ravichandran. 2012. Archives of Agronomy and Soil Science 58(1):158-164.

Abstract: Field experiments were conducted in a Vertisol for two years to study the response of lowland rice to N from organic and mineral fertilizer tested at N equivalence. The treatments consisted of different organic materials as N fertilizer, viz composted coir pith green manure, sugarcane trash compost, vermicompost, poultry manure and farmyard manure (FYM) applied at 100% N and combination of 50% N from above organic materials and 50% N from urea besides 100% N through urea and control. The recommended dose of fertilizer (RDF) was 120:60:60 N, P_2O_5 and K_2O kg ha^{-1}. The results revealed that addition of organics or urea or both enhanced the growth, rice yield and nutrient status over control. The highest grain yield (4.95, 5.33 t ha^{-1}) and straw yield (7.31, 7.73 t ha^{-1}) for the two years were noticed with vermicompost plus urea (50% N each) which was on par with poultry manure plus urea (50% N each). Combined use of organic fertilizer along with mineral N recorded higher concentrations of NH_4-N and NO_3-N in soil and increased total N uptake. Nutrient use efficiency was compared to individual application. It was more in vermicompost- amended soil followed by green manure and poultry manure.

Moisture Conservation and Fertilizer Use for Sustainable Cotton Production in the Sub-Humid Savanna Zones of Nigeria

Azubuike Chidowe Odunze, Abdoulaye Mando, Jean Sogbedji, Ishiaku Yoila Amapu, Bitrus Dawi Tarfa, Ado Adamu Yusuf, Abu Sunday, and Hassan Bello. 2012. Archives of Agronomy and Soil Science 58(1):190-194.

Abstract: In the arid and semi-arid regions, soil moisture deficiency largely limits sustainable crop production. In the Nigerian dry Savanna (Northern Guinea savanna, arid and semi-arid zones), dry spells commonly occur between June and July, often lasts beyond three weeks. Rainfall is unevenly distributed and results in insufficient soil moisture for crop production. Soils at the uplands are commonly sandy loam to loamy sand at the surface horizons, have inherently poor fertility status, poor moisture retention capacity and rapidly degrade due to sheet erosion, continuous cultivation and overgrazing. The study on cross banding of ridges to conserve moisture and use of boron in association with nitrogen, and without boron was therefore conducted in Sabon Gari Garu areas in Katsina State, in the dry savanna of Nigeria during the 2007 and 2008 cotton cropping seasons. Data obtained were statistically analyzed. Results show that treatment with tied ridges + NPK + boron (415.70 kg ha^{-1} and 312.47 kg ha^{-1} cotton in respective years) resulted in significant higher cotton lint yields in 2007 and 2008 than NPK + boron treatments (245.20 kg ha^{-1} and 255.16 kg ha^{-1} cotton in 2007 and 2008, respectively). Cross banding of ridges is recommended for farmers to conserve soil moisture and application of NPK + boron fertilizers.

Changes in Fertilisation and Liming of Soils of the Czech Republic for the Past 20 Years

Lošák, T., P. Čermák, and J. Hlušek. 2012. Archives of Agronomy and Soil Science 58(1):238-242.

Abstract: Some basic soil fertility parameters have been monitored in the Czech Republic since 1961, at intervals of three to six years, as a part of the national agrochemical soil testing programme. This mandatory programme governs the wording of later regulations on fertilisers and covers in particular the determination of soil reaction and content of available nutrients (P, K, Mg and Ca). In specific cases (e.g. application of sewage sludge to soil, soil testing in organic farming, soil damage caused by flooding, etc.), soil physical and microbiological parameters are also measured. The results for the past 20 years (1989-2008) show a decreasing tendency in pH value and content of available nutrients in agricultural soils. The land parcel identification system (LPIS) is used for testing, and all sampling areas are fixed in the national mapping system (S-JTSK). All the results are available to farmers and government bodies.

Potassium Release from Sand, Silt and Clay Fractions in Calcareous Soils of Southern Iran

Mahdi Najafi Ghiri, Ali Abtahi, Soheila Sadat Hashemi, andFatemeh Jaberian. 2012. Archives of Agronomy and Soil Science 58(12):1439-1454.

Abstract: The release of non-exchangeable potassium from 24 calcareous soils of divergent mineralogy, from southern Iran, was examined. Sand, silt and clay particles were fractionated after dispersion with an ultrasonic probe. Samples were extracted with 0.01 M $CaCl_2$ for 30 successive 2-h periods. The clay fraction released the largest amount of K in each soil. Cumulative K released ranged from 175 to 723, 35 to 128, and 71 to 146 mg kg^{-1} contributing 20-90, 4-39 and 2-54% for clay, silt and sand fractions, respectively. The lower proportion of K released from sand and silt fractions can be explained by the presence of a high content of $CaCO_3$ and quartz in these fractions. The release kinetics for the non-exchangeable K data showed that parabolic diffusion and power function were the best fitting kinetic models. This indicated that slow diffusion of K from the mica interlayer positions is the main rate-controlling process. Cumulative K released and constant b values of parabolic diffusion model correlated significantly with the mica content of the clay fraction.

No-Till and Strip-Till Corn Production with Broadcast and Subsurface-Band Phosphorus and Potassium

Fernández, F.G., and C. White. 2012. Agron. J. 104(4)996-1005.

Abstract: Fertilizer placement is often designed to improve nutrient availability. Our objective was to determine the effect of P and K rate and placement in no-till and strip-till on grain yield; water, P, and K values in the soil; and the distribution of corn (*Zea mays* L.) roots. A 4-yr field experiment was setup near Urbana, IL, with a corn-soybean [*Glycine max* (L.) Merr.] rotation. Tillage/fertilizer placement was the main plot [no-till/broadcast (NTBC), no-till/deep band (NTDB), and strip-till/deep band (STDB)]; deep band was 15 cm beneath the crop row. Phosphorus fertilizer rate (0, 12, 24, and 36 kg P ha^{-1} yr^{-1}) was the subplot, and K-fertilizer rate (0, 42, 84, and 168 kg K ha^{-1} yr^{-1}) was the sub-subplot. Measurements included grain yield and yield components, grain and shoot P and K concentrations, root parameters, and soil-water, P, and K values. Strip-till/deep band produced greater kernels row^{-1} and 9.43 Mg ha^{-1} yield that was 7.8% greater than NTBC and 7.9% greater than NTDB. Deep banding increased soil P and K test values beneath the crop row and lowered soil surface test values compared with broadcast applications, but had no effect on root distribution. Across treatments, greatest apparent P and K uptake occurred in the surface layer where most roots were present and where precipitation replenished water to a greater extent than deeper layers. Relative to NTBC, STDB had 24% greater apparent-P and 23% greater apparent-K uptake rates. The results indicate that improved conditions for nutrient uptake provide a competitive advantage for production with STDB relative to no-till treatments.

The Effects of Chloride and Potassium Nutrition on Seed Yield of Annual Canarygrass

William E. May, W.E., S.S. Malhi, C.B. Holzapfel, B.X. Nybo, J.J. Schoenau, and G.P. Lafond. 2012. Agron. J. 104(4):1023-1031.

Abstract: The year-to-year variability of seed yield in annual canarygrass (*Phalaris canariensis* L.) is a major concern among growers. A field experiment was conducted at 13 site-years across Saskatchewan to determine the response of annual canarygrass seed yield to K and Cl, and to provide better recommendations to producers on the use of KCl fertilizer in annual canarygrass based on soil test results. Potassium did not affect the yield or development of annual canarygrass over a range of 155 to 717 kg K ha^{-1} in the top 15 cm of soil. Chloride had a large impact on annual canarygrass seed yield; seed yield increased by approximately 24% when Cl was added in the form of KCl or $CaCl_2$ when averaged across all sites. The seed yield increased because the application of Cl increased panicle size (seeds $panicle^{-1}$). The magnitude of the response tended to increase as level of Cl in the soil decreased. Annual canarygrass growers need to measure Cl when using soil tests to determine fertilizer requirements. It is recommended that 9.1 kg Cl ha^{-1} in the form of 20 kg ha^{-1} of KCl be applied when the Cl level in the surface soil (0-15 cm) is below 70 kg Cl ha^{-1}. The findings encourage growers to conduct individual field test strips to determine the strength of the Cl response.

Soybean Yield and Chemical Composition in Response to Phosphorus-Potassium Nutrition in Kashmir

M. Kaleem Abbasi, Majid Mahmood Tahir, Waleed Azam, Zaheer Abbas and Nasir Rahim. 2012. Agron. J. 104(5):1476-1484.

Abstract: Soybean [*Glycine max* (L.) Merr.] has increasing nutritional, commercial, and economical value, and P and K nutrition may be needed to increase yield and profit. A 2-yr (2008-2009) field experiment with rainfed soybean was conducted in the hilly region of the state of Azad Jammu and Kashmir (AJK), at Rawalakot, Pakistan. The aim of the study was to evaluate the effects of P-K fertilization on soybean root nodulation, seed yield, seed composition and N, P, and K uptake. The experiment was conducted in a randomized complete block design with three replications. Treatments included three levels of P (60, 90, and 120 kg P_2O_5 ha^{-1}), two levels of K (40 and 80 kg K_2O ha^{-1}), and a control, represented as P_0, P_{60}, P_{90}, P_{120} and K_0, K_{40}, and K_{80}, respectively. Results indicated that number of root nodules increased with P-K fertilization to 75 and 136 compared with 68 in the control.

Yield responses to P-K fertilization occurred to all rates, and the highest yield was observed in the combined treatment of $P_{120}K_{40}$. Total N, P, and K uptake in the plant (shoot + seed) tended to follow yield responses, while seed protein was increased by 8 to 13% due to P and 11 to 19% due to K. Application of P or K alone or in combination significantly increased oil content. This study demonstrates that P- and K-deficient soils are likely to produce crops with low yields and low seed oil levels, and appropriate P-K management could be an effective approach to increase and sustain soybean production in the mountain ecosystems.

Yield and Potassium Balance in a Wheat-Maize Cropping System of the North China Plain

Chun-e He, Zhu Ouyang, Zhen-rong Tian and Harwood D. Schaffer. 2012. Agron. J. 104(4):1016-1022.

Abstract: This study examined the effects of long-term K fertilization on crop yields and K use efficiency and balance under a wheat (*Triticum aestivum* L.)-maize (*Zea mays* L.) cropping system in the Fluvo-Aquic soil of Yucheng Comprehensive Experiment Station in the North China Plain (NCP). Results showed that the native K supply could maintain annual grain yields at stable levels at 10.7 Mg ha^{-1} for >19 yr with applications of N and P alone. The application of K alone significantly improved maize yield by 46% but wheat showed no response. The agronomic efficiency, physiological efficiency, and partial factor productivity but not apparent use efficiency of wheat were significantly lower than the average values previously reported. In addition, only 43% of K found in the aboveground biomass of wheat and maize came from an annual application of fertilizer. The application of K caused a large K surplus, even with balanced fertilization, in which 33% of applied K was left in the soil, mostly in the 0- to 20-cm depth due to its surface application. The data indicated that the native K supply in the NCP might sustain normal wheat yields for about 10 to 30 yr. Generally, in a Fluvo-Aquic soil with a high content of soil available K, soil K can be used. In this study, 471 kg ha^{-1} yr^{-1} K input was excessive for the growth of maize and wheat, and at least 120 to 150 kg ha^{-1} yr^{-1} K could be saved with the use of balanced fertilization.

Alfalfa Nitrogen Credit to First-Year Corn: Potassium, Regrowth, and Tillage Timing Effects

Yost, M.A., J.A. Coulter, M.P. Russelle, C.C. Sheaffer, and D.E. Kaiser. 2012. Agron. J. 104(4):953-962.

Abstract: Compared with corn (*Zea mays* L.) following corn, N guidelines for first-year corn following alfalfa (*Medicago sativa* L.) in the U.S. Corn Belt suggest that N rates can be reduced by about 168 kg N ha^{-1} when ≥43 or 53 alfalfa plants m^{-2} are present at termination. These guidelines have been questioned by practitioners, however, as corn grain yields have increased. We conducted experiments at 16 locations in Minnesota to address questions regarding N availability to first-year corn after alfalfa relating to the effect of carryover fertilizer K from alfalfa and the amount and timing of alfalfa regrowth incorporation. Corn grain yield, silage yield, and fertilizer N uptake were not affected by carryover K or amount or timing of regrowth incorporation. Maximum corn grain yield ranged from 12.0 to 16.1 Mg ha^{-1} among locations but responded to fertilizer N at only one. At that location, which had inadequate soil drainage, the economically optimum N rate (EONR) was 85 kg N ha^{-1}, assuming prices of US\$0.87 kg^{-1} N and US\$132 Mg^{-1} grain. The EONR for silage yield across 6 of 15 locations where it was measured was 40 kg N ha^{-1}, assuming US\$39 Mg^{-1} silage. These results demonstrate that on highly productive medium- to fine-textured soils in the Upper Midwest with ≥43 alfalfa plants m^{-2} at termination, first-year corn grain yield is often maximized without fertilizer N, regardless of alfalfa regrowth management or timing of incorporation, but that small N applications may be needed to optimize silage yield.

How Different Long-Term Fertilization Strategies Influence Crop Yield and Soil Properties in a Maize Field in the North China Plain

Bingzi Zhao, Ji Chen, Jiabao Zhang, Xiuli Xin, Xiying Hao. 2013. J. Plant Nutr. 176(1):99-109.

Abstract: The impact of fertilization on maize (*Zea mays* L.) yield and soil properties was investigated in a long-term (>18 y) experimental field in N China. A completely randomized block design with seven fertilizer treatments and four replications was used. The seven fertilizer treatments were (1) compost (COMP), (2) half compost plus half chemical fertilizer (COMP1/2), (3) balanced NPK fertilizer (NPK), (4-6) unbalanced chemical fertilizers without one of the major elements (NP, PK, and NK), and (7) an unamended control (CK). In addition to maize yield, soil chemical and biological properties were investigated. Compared to the balanced NPK treatment, maize yield from the COMP treatment was 7.9% higher, from the COMP1/2 was similar, but from the NP, PK, NK, and CK treatment were 12.4%, 59.9%, 78.6%, and 75.7% lower. Across the growing season, microbial biomass C and N contents, basal soil respiration, and fluorescein diacetate hydrolysis, dehydrogenase, urease, and invertase activities in the COMP and COMP1/2 treatments were 7%-203% higher than the NPK treatment. Values from all other treatments were up to 60% lower than the NPK treatment. Maize yield is closely related to the soil organic C (OC) and biological properties, and the OC is closely related to various biological properties, indicating that OC is a suitable indicator for soil quality. Our results suggest the most limiting nutrient for improving the yield or soil quality was P, followed by N and K, and balanced

fertilization is important in maintaining high crop yield and soil quality. Additionally, increases in OC, N, and biological activities in COMP and COMP1/2 treatments imply that organic compost is superior to the chemical fertilizers tested.

Read on:

Closing Yield Gaps through Nutrient and Water Management
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Clipboard

IPI K gallery

K gallery is now available for iPad, iPhone and all Android systems. An App update was released for iPads, and new Apps were prepared for iPhone and Android tablets and smart phones. New features added like search by crop or deficiency symptoms and an easy procedure for adding new pictures was installed.

We aim to reach hundreds of high quality pictures to demonstrate the effect of potash application on plants and harvested products. We maintain the K gallery free of charge and encourage you to send and contribute to this free source of information which is available to all.

Farmers' iPad

Farmers enjoy scrolling through IPI's K gallery App at a farmers' day in Dholi, Bihar, India. Photo by IPI.

Phosphate and Potash Deficiency Correction and Nutrient Offtake Calculator

This soil deficiency correction and crop nutrient offtake calculator is made for farmers and crop nutrition advisors in England, Wales and N Ireland. It enables a quick calculation of the phosphate (P_2O_5) and potash (K_2O) offtakes by most UK crops at harvest. Simply enter the crop details and yield, click "calculate" and the nutrient offtakes (and fertilizer recommendation) appears. If the soil Index is below the target level, more nutrients will be required to compensate for both offtake and buildup of soil fertility, and vice versa. The App can be freely downloaded from the PDA website.

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

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