Optimizing Crop Nutrition

INTERNATIONAL POTASH INSTITUTE

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Editorial

Dear Readers,

Agricultural research is driven by many factors, including its impact on food security, farmers' incomes, expansion into marginal lands, and so forth. Yet, many crops are "deprived" of the concerted research efforts crops such as maize, wheat and rice have enjoyed during recent decades. Cassava, for example, is defined by the FAO as a neglected "orphan crop". Despite its growing demand and production potential, FAO points out that governments are yet to make the much needed investments in value-added research that would make cassava starch products competitive on an international scale. There are many reasons for this, and mostly it is the fact that this crop is being grown mainly in areas that have little or no access to improved varieties, fertilizer and other production inputs. It is also produced mostly by small-scale farmers often cut off from marketing channels.

Coconut is another crop important to small-scale farmers in what FAO describes as "Low Income Food Deficit Countries". Since 1990, average world yields have been increasing by only 1.1 per cent each year. It will be interesting to see how the productivity of this crop will be affected by the doubling in the price of coconut oil between 2006-08 to its current price of USD 1,000/mt. However, there is no doubt that agricultural research should provide the tools for increasing productivity and enabling farmers to take advantage of this price opportunity.

IPI has recently conducted research work on coconut, and in this latest edition of *e-ifc* we feature more about the response of this crop to different levels of potassium in different agro-climatic zones in Sri Lanka, the fourth largest coconut producer in the world. This is our modest contribution to increased productivity in a crop so important to many poor farmers.

I wish you all an enjoyable read.

Hillel Magen

Director

IPI and NATESC (China) summarizing a three-year fertigation experiment in apple through a workshop and field visit to the orchard. Penglay, Yantai, Shandong, China. Photo by IPI.

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I Site-specific nutrient management in coconut plantations

H.A.J. Gunathilake[(1)], H.M.S.K. Herath[(1)], and V. Nosov[(2)].

Table 1. Area, yield and fertilizer consumption in the coconut sector of Sri Lanka.

Year	Area	Yield	Fertilizer application							
			N	P_2O_5	K_2O	MgO	N	P_2O_5	K_2O	MgO
	'000 ha	*nuts/ha*	----------- *'000 t* -----------				----------- *kg/ha* -----------			
2002	442.4	5,407	4.2	3.0	7.9	0.6	9.5	6.8	17.9	1.4
2003	442.4	5,791	4.1	3.1	8.8	0.5	9.3	7.0	19.9	1.1
2004	394.0	6,486	4.3	2.5	7.2	0.4	10.9	6.3	18.3	1.0
2005	394.8	6,370	4.3	2.3	6.7	0.5	10.9	5.8	17.0	1.3
2006	394.8	7,054	3.3	3.0	7.0	0.3	8.4	7.6	17.7	0.8

Sources: 1) Plantation Sector Statistical Pocket Book 2007, Ministry of Plantation Industries of Sri Lanka, 2007; *2)* The Review of Fertilizer Year 2006. National Fertilizer Secretariat of Sri Lanka, 2007.

Introduction

Adequate fertilization of coconut palm is very important to increase the yield as well as the quality of coconut production in Sri Lanka. Most soils throughout the country are highly weathered and of low fertility. Soil fertility management is thus important and exceptionally so in coconut plantations as coconut is a perennial plant with a continuous productive life. However, mineral fertilizer use in the coconut sector of Sri Lanka is still low and stagnant (Table 1). Although 80-90 per cent of estates (>8 ha) are regularly fertilized, these estates represent only about 18 per cent of the total land area devoted to coconut production. The remaining 82 per cent, is occupied by smallholders (<8 ha) who apply considerably lower fertilizer rates as compared with the average levels indicated in Table 1.

An experimental site in a coconut plantation in Sri Lanka. Photo by IPI.

Research and extension activities play a significant role in achieving the national production target of 3,000 million nuts per year, an eight per cent increase over 2006 production levels. The launching of awareness programs and the initiation of field demonstrations among coconut growers at farmers level are the most effective strategies to optimize fertilizer use in coconut.

Materials and methods

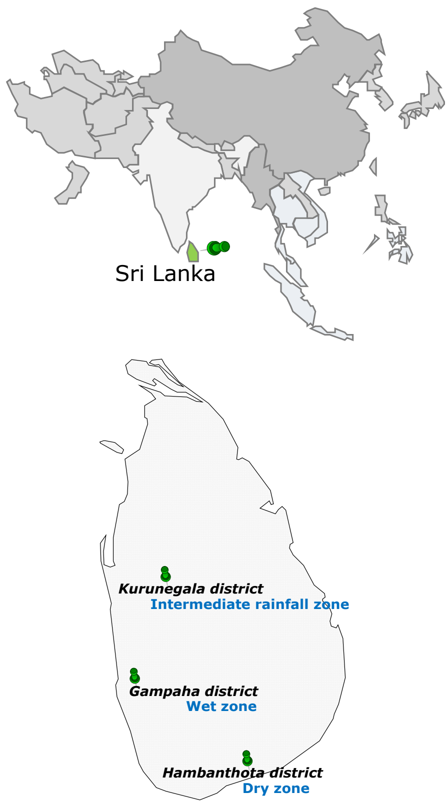
In this IPI-CCB project, three demonstration experiments were conducted in 2006-2007 in the following locations (see map):

1. A wet zone (annual rainfall >2,500 mm): Milathe, Kiridiwala, Gampaha district;
2. An intermediate rainfall zone (1,500-2,500 mm): Olagama, Ridigama, Kurunegala district;
3. A dry zone (<1,500 mm): Mulgirigala, Hambanthota district.

The selected coconut plantations had not been fertilized for a long period of time, thereby allowing the effect of fertilizer application to be revealed clearly after the start of fertilization. Visual nutrient deficiency symptoms, especially N- and K-deficiency symptoms, could be observed in palms in all three locations.

The plot size was about 0.25 ha for each treatment (with ~40 palms per plot). The experimental plots were separated by a guard row to maintain a buffer zone in between treatments. Two fertilizer treatments were applied in each location (Table 2). Fertilizers were applied manually as a single dose application. Other cultural practices were adopted as recommended by the Coconut Research Institute of Sri Lanka.

The total nut yield of each treatment was recorded during 2006 and 2007. The average nut yield per palm per year was then calculated.



Maps of the region and Sri Lanka with precipitation zones.

(1) Coconut Cultivation Board (CCB), Sri Lanka

(2) International Potash Institute

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Soil samples were taken one year after the first fertilizer application (just before the application of fertilizers during the second year).

Typical coconut plantation in Sri Lanka. Photo by IPI.

Table 2. Treatment description.

Treatment	Description	APM*	N	P_2O_5	K_2O	Dolomite
		---------------- *kg/palm/yr*				----------------
1	50% recommended dose	1.5	0.18	0.09	0.48	0.5
2	100% recommended dose	3.0	0.37	0.18	0.96	1.0

* APM – Adult Palm Mixture (12-6-32): 3 kg APM consists of 0.8 kg of urea, 0.6 kg of rock phosphate (30% P_2O_5), and 1.6 kg of MOP.

Results and discussion

Soil physical and chemical properties

Soil texture varied between experimental sites from sandy loam to sandy clay loam (Table 3). Coconut performs well within these soil textural classes if other conditions are good. Soils at the Dry zone site were classified as alfisol whereas those at the other two locations were ultisols. Soils are acidic or slightly acidic, with a low salinity level. Available P (Olsen) is medium to high, available K ranges from low to medium (outside the manure cycle).

Yield response of coconut palm to mineral fertilizers

The majority of palms showing nutrient deficiency symptoms started to recover after three months following the first fertilizer application. Leaves turned from yellow to a more greenish color that was more obvious in treatment 2 (100% recommended dose of APM) as compared to treatment one (50% recommended dose of APM). Palms in the surrounding areas, where fertilizers were not applied, remained under nutrient deficient conditions. A considerable increase in nut yield was observed 3-4 months after the start of fertilizer application in all the locations.

<u>1) Wet zone</u>

The nut yield of coconut obtained during the year 2006 was 43.1 and 54.3 nuts/palm/year in treatments one and two, respectively (Fig. 1). Thus, nut yield increase in treatment two over the treatment one was 26 per cent.

In 2007, nut yield increased from 45.2 nuts/palm/year (treatment one) to 70.5 nuts/palm/year (treatment two). Hence, there was a yield increment of 56 per cent.

<u>2) Intermediate zone</u>

Coconut yield in treatments one and two during 2006 was 37.5 and 52.3 nuts/palm/year, respectively (Fig. 1). This gives a yield increase of 39 per cent in treatment two as compared to treatment one.

In 2007, the yield of nuts in treatments one and two was 51.5 and 73.4 nuts/palm/year, accordingly. Thus, there was 43 per cent nut yield increase.

Table 3. Some soil properties in experimental plantations.

Location	Treatment	Soil texture	pH_{H2O}	EC	Available P (Olsen)	Available K
				dS/m	*mg/kg soil*	*meq/100 g soil*
Wet zone (Gampaha district)	Control*	Sandy loam	5.32	0.17	16.7	0.09
	1		5.35	0.30	11.3	0.23
	2		5.56	0.38	14.6	0.34
Intermediate zone (Kurunegala district)	Control*	Sandy loam	5.91	0.22	23.4	0.12
	1		5.80	0.20	11.3	0.47
	2	Sandy clay loam	5.94	0.29	17.1	0.71
Dry zone (Hambanthota district)	Control*	Sandy clay loam	5.96	0.25	10.5	0.27
	1		6.21	0.89	13.0	1.07
	2		6.31	0.64	18.0	0.34

* Soil samples taken from outside the manure cycle.

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<u>3) Dry zone</u>

Nut yield in treatments one and two during 2006 was 39.2 and 51.9 nuts/palm/year, respectively (Fig. 1). The yield increase in treatment two over treatment one was 32 per cent.

In 2007, nut yield increased from 52.6 nuts/palm/year (treatment1) to 68.8 nuts/palm/year (treatment two). This gives a nut yield increment by 31 per cent.

Conclusions

High fertilizer use efficiency was clearly observed in all the locations as experiments were conducted in the long-term non-fertilized coconut plantations with low soil fertility. Coconut palms strongly responded to the recommended dose of mineral fertilizers compared to the half-recommended rate. The highest average response to mineral fertilizers was observed in the Wet and Intermediate zones of Sri Lanka (41%) followed by the Dry zone (32%). Fertilizer response, in fact, is associated with favorable climate (sunshine hours and rainfall). In the Dry zone, the low rainfall (low soil moisture) is the most critical factor to restricting yield.

The recommended use of mineral fertilizers for coconut is much needed to increase coconut yield and to maintain soil fertility in Sri Lanka.

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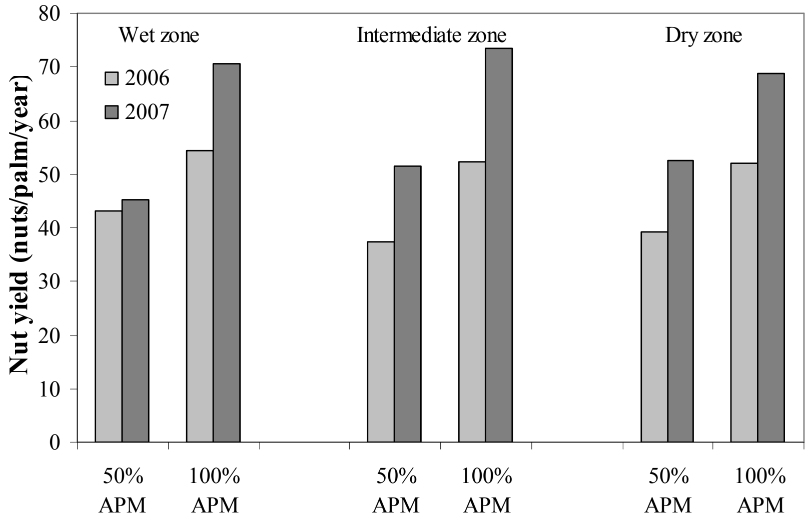

Fig 1. Coconut yields in the Wet, Intermediate and Dry zone sites, 2006 and 2007.

Sri Lankan farmers gathering to discuss the results of the demonstration experiments. Photo by V. Nosov.

About coconut

Coconut is grown globally on more than 10 million ha, mostly in "Low Income Food Deficit Countries" (FAO). The main growing countries are the Philippines, Indonesia, India and Sri Lanka (3.5, 2.6, 1.9, and 0.4 million ha, respectively; data for 2007).

Productivity of coconut is improving, although globally the rate is only one per cent per year from 1990 to 2007.

Typical removal rate of nutrients is shown in the adjacent table.

Nutrient removal by coconut monoculture at yield level of 7,500 nuts/ha, or equivalent of 150 palm/ha.

Part	N	P	K	Mg
	kg/ha			
Inflorescence	7.9	1.9	16.3	3.2
Fronds	33.4	3.3	43.6	20.3
Nuts				
Nut water	0.3	0.1	3.3	0.1
Shell	1.8	0.1	3.1	0.2
Kernel	19.9	2.8	10.5	1.6
Husk	10.6	1.2	63.2	2.5
Total by nuts	*32.6*	*4.2*	*80.1*	*4.4*

Adapted from Gunathilake and Manjula, 2006. Balanced fertilization for sustainable coconut and coconut-intercrop systems in Sri Lanka. Pp 415-425. *In*: Balanced fertilization for sustaining crop productivity. D.K. Benbi, M.S. Brar and S.K. Bansal (eds.). IPI proceedings, ISBN 978-3-9523243-2-5.

Research findings

II Feeding the rice crop's needs: A Filipino farmer's experience

F.G. Palis[(1)] *and G. Gabinete*[(2)].

Rice crises

The global rice crisis that has spiralled with the soaring prices of other commodities has placed our Asian people in a difficult situation. Our Asian consumers are struggling to meet the high prices of various everyday items, particularly rice, the staple food of Asia, the continent which accounts for half of the world's population. The rice producers, or farmers, on the other hand are facing formidable challenges to increase rice production and make it a profitable enterprise. The increasing price of fertilizers presents a particular challenge to rice producers. In the Philippines, the sharp increase of fertilizer prices has challenged farmers to be creative, resourceful, and adaptive in their practices associated with nutrient management.

Plate 1. A proud farmer, Mr. Johnny Tejeda, showing his rice crop following the SSNM recommendations. Photo by Lorelei dela Cruz.

The farmer

This is a story of a Filipino rice farmer, Mr. Johnny Tejeda, who took the risk of deviating from the traditional way of applying fertilizers by practicing site-specific nutrient management (SSNM), a new way of applying fertilizers. SSNM is a fertilizer best management practice, which provides guidelines for "feeding" rice with nutrients, as and when needed (Fig. 1). By applying need-based nitrogen (N), phosphorus (P), and potassium (K) fertilizer, farmers can achieve higher profits from optimized fertilizer use and reduced incidence of pests and diseases. Dr. Roland Buresh, a soil scientist of the International Rice Research Institute (IRRI) has affirmed that "SSNM can enable rice farmers to increase their profit by optimally supplying their crop with essential nutrients."

Fondly called Johnny, Mr. Tejeda is a 46 year-old rice farmer with 1.3 hectares of land in Cordova Norte, Tigbauan, Iloilo, Philippines. The province of Iloilo is one of the top five rice-producing provinces in the country, and is the rice granary of the central Philippines. The municipality of Tigbauan is a 30-minute drive from Iloilo city, which is composed of 52 villages with a total population of 57,000. Ninety percent of the municipality's approximately 9,000 hectares is devoted to agriculture with about 4,550 hectares in rice and an average farm size of 0.5 hectares.

"Life is so tough nowadays," says Johnny. "The gasoline cost is so high that it shoots up the cost in preparing the land for rice cultivation. Fertilizer inputs are so expensive," he adds. In 2007, the price of urea was Philippine pesos (PhP) 850, but now it is PhP 1,950. NPK fertilizer was PhP 700 in 2007, but now it is PhP 1,840. "Indeed farmers need to be resourceful, creative, and updated with new cost-reducing technologies particularly related to fertilizer management practices," continues Johnny.

Filipino farmers generally believe fertilizers are "vitamins" to the plants helping protect the plants from illness or diseases (*malayo sa sakit*). They consider fertilizers also as food (*pagkain*) to plants and thereby essential to make the plants grow fast and healthy. Otherwise, they believe that plants are "malnourished" without fertilizers. This approach has led Filipino farmers often to associate fertilizers with N, with more attention being given to urea, as it is perceived that N results in good

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Table 1. Amount of fertilizer applied (in bags/ha and nutrients, kg/ha) before and after use of SSNM by Mr. Johnny Tejeda, 2007 wet season.

Number of bags/ha per application	Before SSNM			After SSNM			
	1st (20 DAS)	2nd (40 DAS)	Total bags	1st (12 DAS)	2nd (28 DAS)	3rd (38 DAS)	Total bags
Urea	2	2	4	0	1.5	1.5	3
14-14-14*	1	1	2	3	0	0	3
Total bags applied	3	3	6	3	1.5	1.5	6
Amount of nutrients per application, kg/ha	**Before SSNM**			**After SSNM**			
	1st (20 DAS)	2nd (40 DAS)	Total nutrients	1st (12 DAS)	2nd (28 DAS)	3rd (38 DAS)	Total nutrients
N	53	53	106	21	35	35	91
P_2O_5	7	7	14	21	0	0	21
K_2O	7	7	14	21	0	0	21

* 14-14-14 is a typical NPK fertilizer used in the Philippines.

growth and health to the plants. And for farmers, healthy plants with good growth are associated with the greenness of the rice plants.

Direct sowing of rice seed, rather than transplanting is a common practice in Iloilo. Planting time for the wet season is usually during the months from May-July, depending upon the availability of rain, and harvest is during August to October. The dry season on the other hand is from October-November to February-March. Iloilo farmers usually apply N fertilizer twice in a season.

Johnny used to apply fertilizer twice a season, at 20 and 40 days after sowing (DAS) in both wet and dry seasons. On a per hectare (ha) basis, he normally applied two bags of urea and one bag of NPK (14-14-14) at both 20 DAS and 40 DAS giving a total 106 kg N/ha, 14 kg P_2O_5/ha, and 14 kg K_2O/ha (Table 1).

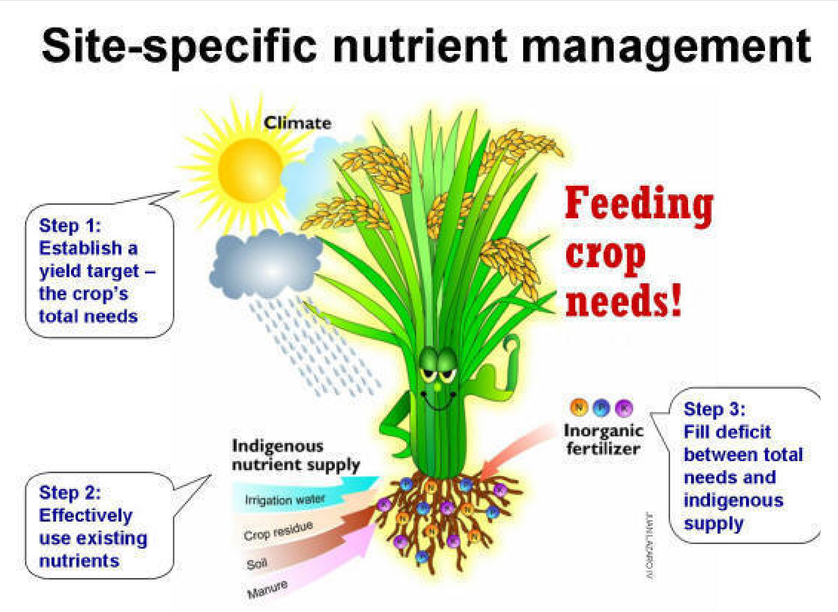

Fig. 1. A diagrammatic presentation of the site-specific nutrient management (SSNM) approach (IRRI, 2006).

His normal yield in each season was about four to five metric tons per hectare of un-milled rice grain expressed at 14 per cent moisture content.

"SSNM has really helped me a lot," exclaims Johnny. "Imagine, when I practiced SSNM during the last 2007 wet and dry season, my yield markedly increased. Since then, I have continued practicing SSNM." The increase in yield was independently verified by a field technician who harvested grain from crop cut in the fields in both seasons. The yield of air dried, un-milled grain increased from 4.1 mt/ha with the farmer's fertilizer practice up to 6 mt/ha with SSNM in the wet season. In the dry season the increase with SSNM was from 4.6 mt/ha up to 6.5 mt/ha.

In 2007, IRRI scientists led by Dr. Buresh in collaboration with Dr. Greta Gabinete, a professor at the West Visayas State University established an SSNM demonstration in Johnny's and a neighboring rice field for farm validation. An individual demo plot was 100 m^2. According to Johnny, while the experiment was on-going, he quietly imitated the SSNM practice in the remaining large portion of his field of about 1.2 ha. His farm neighbor, who was an agricultural technician, told him that SSNM validation experiments had worked in other villages. This farm neighbor gave him the SSNM recommendations. Believing his farm neighbor, he took the risk because of the rising prices of fertilizers, the increasing cost of living, and an opportunity of improving his rice yield.

With SSNM, Johnny applied fertilizer three times, as a replacement to his usual two applications. His first application was at 12 DAS using three

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bags 14-14-14 (NPK). His second and third applications were at 28 and 38 DAS using 1.5 bags urea per hectare for each application. In effect, before and during SSNM, he used a total of six bags of fertilizer per hectare, but the nutrient composition and timing of application differed (Table 1).

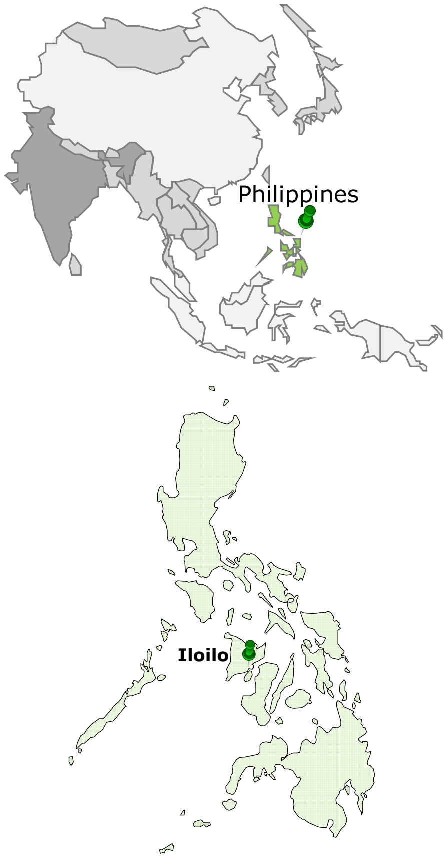
When asked what he could say about the SSNM technology, Johnny replied:

When I first practiced SSNM in the 2007 wet season, I was not able to sleep well for around 10 days after my first fertilizer application. I observed that the color of my rice plants was not green and they were not growing well compared to most farmers' fields; although, growth and color of the leaves were comparable with the neighboring SSNM demo plot and the experimental plots in my field. Before I slept, I kept on thinking and wondering why it seemed that there was no fertilizer response on my rice crop. I was really frightened and anxious that my crop might fail. So, within those 10 days, I was uneasy and kept moving around the rice fields in the village, comparing the growth of the rice plants. But 10 days after the second fertilizer application, I was so amazed because the growth stand of my rice crop was far better than those farmers' fields not applying the SSNM recommendations. The stems were so hard and the roots were so deeply rooted. Also, my plants were not infested with pests and diseases and did not lodge. Those plants that had accelerated growth and bright green leaves after the first fertilizer application had lodged long before harvest and were infested with pests and diseases. I realized that SSNM enabled the rice crop take a balanced food or diet before "vitamins" or urea were supplied.

Johnny proudly and confidently stood before his field with a smile showing the good stand or foundation of his crop (Plate 1). At this stage, he is just waiting for his harvest in the second week of August 2008. Plate 2 shows him ready to harvest his crop with eagerness and expectation to get another high yield. He further reported that many of his neighboring farmers are now starting to follow SSNM. He recounted:

Actually, when my neighboring farmers saw the good performance of my crop after my second application, they kept on asking me what SSNM is about. At the same time, they monitored my field whenever we do our small group discussion in the farm surroundings. We farmers normally discuss or converse about many things on the farm, especially dealing with our rice crop. My constant interaction with the researchers doing experiments in my rice field, and with the agricultural technician, enriched me with knowledge about SSNM that I happily shared with my co-farmers during our "huntahan" in the farm or spontaneous farm discussion. At harvest time of the 2007 wet season, it was known in my village that, my yield was high, increasing from 120 to 184 bags of fresh un-milled grain from my field, making my neighboring farmers eager to imitate me in using SSNM.

Plate 2. Johnny checking his field for harvest. Photo by Artyel Gabinete.



Map of the region and the Philippines with the site.

About SSNM

The concept of SSNM for rice was developed in the mid-1990s and has been systematically transformed and refined since 2000 in collaboration with national agricultural research and extension (NARES) through the Productivity and Sustainability Workgroup of the Irrigated Rice Research Consortium (IRRC). Research identified a mismatch between the timing used by farmers to apply N fertilizer and the growth stages at which the rice plant needs supplementary N. This lack of synchrony between N supply and plant N need resulted in luxuriant vegetative growth and a crop architecture that is favorable for

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diseases and insect pests. This is further confounded by insufficient use of K. SSNM provides farmers with guidelines for managing N, P, and K that fit local conditions and are easily understood by farmers and extension workers. More so, it ensures that farmers obtain good returns for their cash investment in fertilizers.

The rolling out of SSNM is really timely for the global rice crisis and the high fertilizer prices, particularly in the Philippines. The Philippine government has incorporated SSNM from the current 2008 wet season into the national agriculture program, in line with the country's Rice Self Sufficiency Plan which is in partnership with IRRI. The dissemination of SSNM will be facilitated by the development of new "Nutrient Manger for Rice" software that enables extension workers and farmers to rapidly develop nutrient management guidelines for specific fields based on a farmer's response to about ten easy-to-answer multiple choice questions. In the province of Iloilo, SSNM is currently piloted by extension workers in 20 municipalities. The "Nutrient Manager for Rice" software was field tested in mid 2008, and it is set for release on CD in the local language in September 2008.

The adoption of SSNM technology in the Philippines may have started with our farmer Johnny, but with the implementation of SSNM in the country coupled with government support in mobilizing extension staff, hopefully SSNM will be adopted by thousands if not millions of Filipino farmers.

Acknowledgment

The process that systematically established the scientific basis for SSNM, evaluated and refined SSNM in farmers' fields through partnerships across Asia, and is now disseminating improved nutrient management for rice across Asia was made possible through more than a decade of support from the Swiss Agency for Development and Cooperation (SDC), the International Fertilizer Industry Association (IFA), the International Potash Institute (IPI), and the International Plant Nutrition Institute (IPNI). The authors greatly acknowledge Dr. Roland Buresh, key scientist for the validation and refinement of the SSNM technology, for patiently teaching them the logic and science behind SSNM to effectively reconcile farmer and scientific knowledge on nutrient management. Likewise, the assistance of Ms. Lorelei dela Cruz and Mr. Artyel Gabinete in the conduct of the fieldwork are greatly appreciated.

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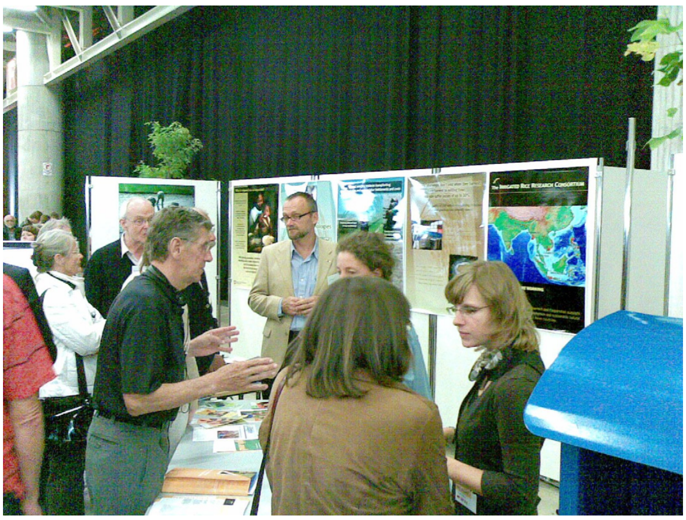
A rice drum seeder in Fribourg, Switzerland?

At the Annual Development Cooperation Conference 2008 - Forum Fribourg, organized by the Swiss Agency for Development and Cooperation (SDC), 22 August 2008, a drum seeder was presented at the International Rice Research Institute (IRRI) exhibition. SDC is the main supporter of the Irrigated Rice Research Consortium (IRRC) at IRRI. Photo by IPI.



Dr. Achim Dobermann (center, light colored suit), Deputy Director General for Research, IRRI, talks to visitors of the IRRC activities in SE Asia at the IRRI exhibition corner in Fribourg. Later, Dr. Dobermann delivered a talk titled "Our daily portion of rice – Results of Swiss Cooperation with the International Rice Research Institute IRRI". Photo by IPI.

Research findings

III Balanced fertilization for increasing and sustaining crop productivity

IPI-BFA-BRRI International Workshop, Hotel Razmoni Ishakha, Dhaka, Bangladesh, 30 March – 1 April 2008. Short abstracts from the symposium.

Edited by M.S. Islam[1], and V. Nosov[2].

Introduction

The international workshop on "Balanced fertilization for increasing and sustaining crop productivity" was held in Dhaka, Bangladesh on 30 March – 1 April 2008. This event was conducted under the sponsorship of IPI and the Bangladesh Fertilizer Association (BFA). The Bangladesh Rice Research Institute (BRRI) also actively participated as a co-organizer. The workshop focused on discussing balanced fertilization, particularly in the context of potassium nutrition and its effect on soil fertility, yields, quality, and sustainability of agricultural systems. Prominent national and international scientists delivered presentations, including leading specialists from the International Rice Research Institute (IRRI, Philippines), Netherlands Development Organization (SNV), Potash Research Institute of India (PRII), Tamil Nadu Agricultural University (TNAU, India), Fertilizer Association of India (FAI), BRRI, Bangladesh Agricultural Research Institute (BARI), Bangladesh Agricultural University (BAU) and University of Dhaka (UD). The workshop papers were published in a special issue of the Bangladesh Journal of Agriculture and Environment (Vol. 4, 2008).

Mr. A. Huq, President, Federation of Bangladesh Chambers of Commerce and Industry opened the inaugural session. Mr. K.U. Ahmed, Chairman, BFA; Dr. M.A.M. Miah, Head, Soil Science Div., BRRI; IPI Director and Regional Coordinator also delivered a welcome address. Dr. C.S. Karim, Advisor, Ministry of Agriculture of Bangladesh closed the workshop as the chief guest of the valedictory session.

Session I: Agricultural policies and their impact on fertilizer consumption

Dr. B.A.A. Mustafi (BRRI) presented a paper on "**Development of agricultural policies in Bangladesh**". He emphasized that agriculture is the driving force of the Bangladesh economy, contributing about 21 per cent to the country's GDP. In order to achieve the GDP growth rate of six to seven per cent per year, Bangladesh agriculture must grow by at least four per cent per year. This is possible only through the increase in agricultural productivity based on modern agricultural technology. It is one of the major objectives of the National Agricultural Policy. The expansion of modern agricultural practices together with intensified cultivation leads to increasing demand for fertilizers. Thus, emphasis should be given on procurement and distribution of fertilizers in both private and public sectors. Moreover, steps should be taken to maintain a fertilizer buffer stock at regional and district levels. A constant monitoring of supply, storage, price and quality of fertilizers at various levels is also strongly required.

"**Outlook for fertilizer consumption and food production in Bangladesh**" was the title of the presentation made by **Dr. A.L. Shah (BRRI)**. According to recent estimates, about 5.1 million tons more rice will be needed to feed the growing population of the country in 2009-10 as compared to the baseline of 2006-07 (29.75 million tons of rice). The estimated requirement of mineral fertilizers for only rice production to the year 2009-10 is about 2.0 million tons for urea, 0.4 million tons for TSP and 0.3 million tons for MOP. This volume of potash fertilizers is very close to the current level of MOP consumption in the country but across all crops. Thus, there is a considerable potential for developing balanced fertilization in Bangladesh.

Dr. R.K. Tewatia (FAI) in his paper on "**Emerging aspects of balanced fertilizer use in India**" pointed to a remarkable growth in fertilizer application in India to about 114 kg/ha in 2006-07. The Government and industry make concerted efforts to encourage balanced use of fertilizers with a target to achieve the NPK ratio of 4:2:1 at national level. However, the country is now facing various problems including inadequate and imbalanced

Maps of SE Asia and Bangladesh.

(1) *Technical Advisor, Bangladesh Fertilizer Association.*

(2) *IPI Coordinator East India and Bangladesh.*

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fertilizer use, a distorted NPK consumption ratio, wide interstate/ district variation in fertilizer consumption and nutrient mining leading to multinutrient deficiencies. Moreover, increasing deficiencies of secondary and micronutrients have started to decrease the response of applied NPK. Hence, the adoption of fertilizer best management practices should be encouraged in view of low fertilizer use efficiency and declining factor productivity. Extension agencies should ensure that farmers use fertilizers in accordance with soil and crop requirements and deficiency of any nutrient does not become a limiting factor in achieving optimum yields.

Session II: Integrated nutrient management in rice-based cropping systems

A presentation on "**Implementing field-specific nutrient management in rice-based cropping systems**" was made by **Dr. R. Buresh (IRRI)**. Scientific principles for optimally supplying rice with essential nutrients under the site-specific nutrient management (SSNM) approach were discussed. This approach enables rice farmers to tailor nutrient management to the specific conditions of their fields through the pre-season determination of crop needs for fertilizer N, the within-season distribution of fertilizer N to optimally meet crop needs, and the pre-season determination of fertilizer P and K rates to match crop needs and maintain soil fertility. The optimal fertilizer N rate typically ranges between 40 to 60 kg N per metric ton of increase in grain yield obtained from N fertilization. The leaf color chart (LCC) is a tool for dynamically adjusting the within-season rates and timing of fertilizer N to match the spatial and temporal needs of the crop for N. Fertilizer P and K rates are determined with a range of tools including soil testing, nutrient omission plots, historical fertilizer and nutrient addition plots. The IRRI website (www.irri.org/irrc/ssnm) features the principles for nutrient management and techniques for implementing SSNM.

Dr. S.K. Bansal (PRII) delivered a lecture on "**Integrated nutrient management in rice-wheat systems of Indo-Gangetic Plains**". The notion of declining efficiency of fertilizer use in rice-wheat systems in South Asia was considered by Dr. Bansal as overly simplistic. Apparent diminished returns from increasing fertilizer applications in

Dr. M.S. Islam was born in 1946 into a farming family in Gaibandha, a northern district of Bangladesh. Shortly after obtaining an MSc (Ag.) in Soil Science from the Agricultural University of East Pakistan (now Bangladesh), he joined the Bangladesh Agricultural Development Corporation. After serving one year he then moved on to the Bangladesh Agricultural University where he was appointed as a lecturer in Soil Science. In 1973 after being awarded a Commonwealth Scholarship he studied at the University of Aberdeen and obtained a PhD degree in Soil Science in 1976. Before returning to his post in the Bangladesh Agricultural University, his postdoctoral studies continued in Aberdeen, then later in the University of Ghent, Belgium where he was responsible for the development of a modern soils laboratory.

In 1978 Dr. Islam joined Bangladesh Agricultural Research Institute (BARI) as Principal Scientific Officer in the Division of Soil Science where he built up a modern soil and plant analysis laboratory in the Division which has served as a lead laboratory in the country. In his work in the Institute he initiated integrated nutrient management and maximum yield research in the country. He also acted as Principal Investigator of many contract research projects of USAID, World Bank, FAO, PPI-PPIC, including a Canadian CIDA-funded project on Potassium Studies in Soils and Crops of Bangladesh. He was promoted to Chief Scientific Officer; Director (Research) then later to Director General, the post from which he retired in 2004. At BARI Dr. Islam also served as Director for Tuber Crop Research Centre and Director for Administration. Dr. Islam was also deputed to the Bangladesh Agricultural Research Council where he worked three years as Member-Director (Soils).

Dr. Islam is now serving as Technical Advisor to Bangladesh Fertilizer Association (BFA) which publishes the Bangladesh Journal of Agriculture and Environment twice yearly. He is also Chief Editor for the Bangladesh Journal of Progressive Science and Technology.

Besides BFA activities, Dr. Islam has promoted renewable energy through Grameen Shakti, an NGO, and is also a faculty member at the State University of Bangladesh in the Department of Environmental Science

Dr. Islam has visited many countries in the world, attending and contributing to seminars, symposia, conferences and workshops. To his credit, he has published more than 220 scientific research articles dealing with soils, fertilizers, soil chemistry, plant nutrition, environment, and renewable energy.

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the region may be explained by the imbalance in the supply of NPK with application of K often being too low. Changes in soil fertility under rice-wheat cropping, resulting in yield decline, are widely reported. These include decreases in soil organic matter and declines in soil N, P, K and S supply as well as declines in the content of available Zn, B, Cu, Fe and Mn. It was demonstrated that spectacular yield increases with N-fertilizer application in high-yielding varieties of rice resulted in depletion of large quantities of K from the soil. For example, a yield decline of 0.11 mt/ha for rice and 0.04 mt/ha for wheat was registered with time when currently recommended rates of NPK were applied in a long-term experiment conducted in the Punjab (Ludhiana). In this case, the depletion of soil K was mainly responsible for yield decrease because of a negative balance of -170 kg K_2O/ha/yr. Actually, the annual K-balance in India is estimated as -37.5 kg K_2O/ha of gross cropped area. Moreover, the balance of K worsens over time. According to soil fertility monitoring, both exchangeable and non-exchangeable K reserves are exhausted because of inadequate K-fertilizer application, raising serious concerns about soil fertility maintenance.

In a paper on "**Potassium fertilization in rice-rice and rice-wheat cropping systems in Bangladesh**", **Dr. M.A.M. Miah (BRRI)** reported that in various experiments conducted in the Central and NW region of Bangladesh that K-fertilization significantly increased the production of rice-rice and rice-wheat cropping systems. In the control (native fertility) K plots of the long-term BRRI experiment (1985-2000), the yearly grain yield of rice decreased sharply with time from 10 to 6.2 mt/ha. Moreover, the yield gap between the balanced treatment and the control K treatment widened sharply with time. However, a severe depletion of soil K was registered for both treatments: the balance of K in fertilized and omitted plots was -141 and -132 kg/ha/yr, respectively.

It has been also shown that K-fertilization at 50 kg K/ha appeared to be sufficient and economically most viable to produce optimum grain yield of rice in both dry and wet season on clay loam soil at Gazipur. In the NW region of Bangladesh, the rate of 66 kg K/ha was required for the highest yield of T-aman rice and wheat on sandy loam soil. Optimal fertilization with K increased rice grain yield by 16 per cent over the control K plot on clay loam soil, while yield increase due to K application on sandy loam soil was as high as 30 and 53 per cent for rice and wheat, respectively.

Session III: Integrated nutrient management in horticultural crops

D. N. Kumar (TNAU) in a paper on "**Balanced fertilization for sustainable yield and quality in tropical fruit crops**" indicated that fruit production in India is hardly sufficient and meets only 46 per cent of national demand. Hence, there is a strong need to increase the production and productivity of fruit crops and judicious nutrient management is regarded as key to achieving these goals. The author presented TNAU fertilizer recommendation for mango, banana, citruses, papaya, pineapple and sapota. It has been noted that fruit plants generally need higher amount of K followed by N and P. The importance of K-fertilization for improving fruit weight, fruit number and fruit yield per plant was demonstrated in detail for papaya. K-fertilizer use improved also major quality parameters of papaya fruits such as sweetness, latex yield and its quality. The enzyme activity of latex, as assessed in terms of tyrosine units produced by papain, revealed the positive effect of potassium.

The results presented indicate that yield and quality parameters of fruit crops depend on the method of fertilizer application. When compared to conventional methods, fertigation proved to be the most efficient method of fertilizer application to fruit crops.

A paper on "**Integrated nutrient management for sustainable yield of major vegetable crops in Bangladesh**" was delivered by **Dr. M.S. Khan (BARI)**. He stressed that the production of vegetables in Bangladesh is inadequate and, to meet the growing demand, the production has to be increased by at least eight times (up to 11 million tons) by 2015. However, a gradual increase in cropping intensity with imbalanced fertilization depletes soil fertility in Bangladesh. Thus, BARI recommends the INM package formulated with mineral fertilizers (50-75 per cent from earlier recommendations developed for mineral fertilizers alone) and also organic manures. As a result, higher yields of tomato, cabbage, broccoli, okra as well as higher production of homestead vegetable cropping patterns (radish-tomato-red amaranth-Indian spinach, tomato-okra-Indian spinach) are obtained compared to the same levels of nutrients supplied in the form of mineral fertilizers alone. Compared to cow dung, poultry manure appeared as the best organic manure regarding yield sustainability and regeneration of soil fertility.

Dr. S. Noor (BARI) in her paper on "**Integrated nutrient management for sustainable yield of major spice crops in Bangladesh**" noted that spices are still falling behind demand with a yearly deficit of about 1.2 million tons. Because of shrinking land resources, the high demand in spice crops could be met only by increasing yield per hectare. The author reinforced that intensive crop cultivation with imbalanced fertilization resulted in severe

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degradation of soil fertility in Bangladesh. Research activities recently conducted by BARI indicate the need for including S, Zn and B into fertilizer packages for crops such as onion, garlic, chili, ginger, turmeric, coriander and black cumin. Updated recommendations for both mineral and organic fertilizers are based on crop response and economical profitability.

Session IV: Balanced fertilization and environmental issues

Mr. H. Magen (IPI) in his presentation on "**Putting potassium in the picture: achieving improved nitrogen use efficiency**" stressed that potassium proves to be an efficient supplement for increasing the nitrogen use efficiency (NUE) over a wide range of crops, soils and agro-climatic conditions. The reporter assessed crop yield at a constant level of N application with increasing levels of applied potassium from a large number of field experiments conducted by IPI on various crops in Asia and Europe. A typical gain of 10 to 30 per cent increase in NUE was achieved by applying a moderate dose of potassium to maize, rice, wheat, rye and sunflower. When combining potassium application and advanced water management, gains can be much higher (like 70 per cent increase in NUE in fertigated sugarcane in India). Thus, applying potassium and improving nutrient management practices offer an immediate and rewarding strategy to raise NUE and thereby reduce the undesirable flow of nitrogen into the environment.

Participants visiting the Bangladesh Rice Research Institute, Gazipur. Photo by V. Nosov.

A presentation on "**Soil fertility history, present status and future scenario in Bangladesh**" was made by **Dr. M.S. Islam (BFA)**, who reviewed soil fertility research activities in Bangladesh since their initiation in 1905. It was stressed that Bangladesh has a wide variety and complexity of soils which are depleted and there is urgent need for replenishment with organic and mineral fertilizers. The efficiency of fertilizer use is generally low because of imbalanced fertilizer application (under use or sometimes over use) resulting in huge wastages which the country cannot afford. Therefore, the practice of balanced fertilization should receive top priority to sustain/increase crop productivity. Food security is crucial for poverty stricken people, when the country is facing challenges of increasing population and shrinking natural resources which includes agricultural land. There is also a big gap between yields obtained in research and those found in farmers' fields. Promotion of balanced fertilization for different crops and cropping patterns at the various National Agricultural Research System institutes are passed on through the Department of Agricultural Extension and different NGOs and private companies. Field advisors should be trained properly in modern methods of soil fertility management. These advisors will in turn train the farmers who will adapt balanced fertilization practice in their farms to increase crop productivity. The livelihood of farmers will thus be improved at the same time maintaining soil fertility for generations to come.

Dr. M.F. Islam (SNV) reported on major features of the Fertilizer Recommendation Guide (FRG) 2005 in a paper on "**Development of fertilizer recommendations in Bangladesh**". It was again underlined that low fertilizer use efficiency at farm level necessitates the updating of current practices of fertilizer application to different crops grown in various environments. Since 1997, considerable progress has been made on soil fertility research by different national research institutes in the country. All these data have been collected and incorporated in the revised FRG 2005. Nevertheless, more research is needed on nutrient management in risk-prone ecosystems, multiple cropping systems, no-tillage/ minimum tillage systems and hill farming. Furthermore, further research activities are required on developing fertilizer recommendations for improving both yield and quality of traditional fruit crops. More ecosystem based information on mineralization and

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nutrient release pattern of organic materials need to be generated for standardization of organic fertilizers.

A presentation on "**Role of micronutrients in balanced fertilization for sustainable crop production in Bangladesh**" was made by **Dr. M. Jahiruddin (BAU)**. As mentioned, until 1980, the farmers of Bangladesh applied three nutrients (NPK) to the soil and, thereafter, application of S and Zn was found necessary, particularly for rice cultivation. Maize and rice are the most sensitive crops to Zn-deficiency which particularly occurs in calcareous and submerged soils. Zn-fertilization is important in improving crop yield as well as nutritional (e.g. protein) and seed quality. In the 90s, B-deficiency of crops was also reported. It is much observed in Rabi crops, particularly mustard, wheat and chickpea and less reported in rice. There is sporadic information on Cu, Mo and Mn deficiencies in the country. Imbalanced use of mineral fertilizers, minimum application of organic manure, increasing cropping intensity, use of modern crop varieties, nutrient leaching, and the widespread occurrence of light textured soils favour the emergence of micronutrient deficiencies in soils of Bangladesh.

Dr. S.M.I. Huq (UD) presented a paper on "**Effect of balanced fertilization on arsenic and other heavy metals uptake in rice and other crops**". It was apparent from the reported results that balanced fertilization in low land rice, though is necessary to keep the yield at optimum levels, cannot avoid the accumulation of As and other heavy metals in plants. On the other hand, upland crops like kangkong and amaranthus behave differently: balanced fertilization can improve the crop nutrient quality vis-à-vis As and other heavy metal accumulation in them. However, further research is required for an in-depth investigation of these phenomena in fields.

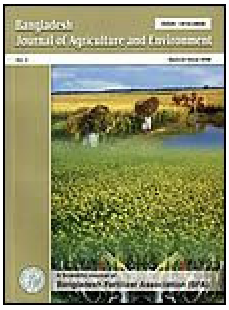
Field Programme

A field visit to BRRI was organized in-between two conference days. Dr. Md. Nur-E-Elahi, Director General of BRRI, informed delegates of the current research activities being carried out by the Institute. There was also a good opportunity to observe long-term fertilizer experiments conducted at BRRI.

Read more about food production in Bangladesh

On 28 August 2008, FAO published a special report titled "FAO/WFP Crop and Food Supply Assessment Mission to Bangladesh". Chapter 6.1 lists various recommendations, including advice on fertilization practices.

See the full report at http://www.fao.org/docrep/011/ai472e/ai472e00.htm.



The proceedings of the symposium were published in the **Bangladesh Journal of Agriculture and Environment, special edition**. To order a copy, contact the Assistant Editor, Bangladesh Journal of Agriculture and Environment (BJAE), Bangladesh Fertilizer Association, City Heart Building (10th Floor), Room #8, 67 Naya Paltan, Dhaka-1000, Bangladesh. Phone/Fax: +88-02-9352410, 9348714 E-mail: bfa_urbora@dhakacom.com Website: http://www.bfa-fertilizer.org/

The special edition can also be downloaded at the IPI website.

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Workshop Recommendations

The principal recommendations of the workshop may be summarized as follows:

- The lack of knowledge in balanced fertilization among the farmers is one of the main reasons for imbalance in nutrient application. The knowledge gap should be minimized through also the establishment of demonstration plots, and the distribution of information in communicable form including electronic media. Time, dose and cost effective methods of fertilizer application should be considered in these programs.
- The extension service providers should be trained with updated information on the importance of using balanced fertilization so that the information can be disseminated to the farmers as and when necessary.
- Emphasis should be given to include micronutrients in the balanced fertilization program. The application of organic fertilizers should also be stressed.
- Soil testing facilities should be developed at district level since this ensures proper application rates of fertilizers.
- A buffer stock of fertilizers should be maintained at regional and district level. The distribution system needs to be modified for quick availability of all fertilizers to the farmers at the right time to help them using balanced fertilization.
- The economics of mineral fertilizer use should be estimated taking into account input costs and values of agricultural production and the profitability of fertilizers needs to be regularly monitored.

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IV Effects of potassium foliar spray on olive, peach and plum, Part 1: olive experiments

M. Ben Mimoun[1], M. Ghrab[2], M. Ghanem[1], and O. Elloumi[1].

Introduction

The fruit tree industry is one of the most important agricultural sectors in Tunisia, with more than 2 million hectares planted mainly with olive (1.5 million ha), almond (257,000 ha), pistachio (44,000 ha) and palm date (26,000 ha). Citrus and stone fruits are also economically important crops (Table 1). Owing to water scarcity, the sector is characterized by significant disparities between regions and growers. For example, olive tree orchards have been found to vary from very low density (17 trees/ ha in the center and south of the country) to very high density with more than 1,250 t/ha, the difference depending mainly on water availability for irrigation. Water scarcity is the main limiting factor for Tunisian agriculture.

Mineral nutrition is one of the major tools to optimize fruit yield and quality (Tagliavini and Marangoni, 2002). Potassium is known not only to play an important role on olive yield and quality but also on water-use efficiency (Arquero *et al.*, 2006), which indicates its importance for the Tunisian fruit sector where trees have been traditionally grown on calcareous soils under rainfed conditions.

Nutrient uptake depends on nutrient supply to the root system i.e. nutrient availability and the nutrient requirement level and the uptake period (Chapin, 1991). Fine textured soils are characteristically K^+ fixing soils, where soil-surface application is almost without effect (Mengel, 2002). Fertigation relative to broadcast application has been shown to increase K mobility in the soil (Nielsen *et al*. 1999; Uriu *et al*. 1980; Southwick *et al*. 1996). Weinbaum *et al*. (1994) suggested that this effect of K fertigation in significantly improving K uptake resulted from increasing rhizosphere soil solution K concentration. However, limitation in tree capacity to take up K during the high demand period can present a problem (Weinbaum *et al*. 2002) especially in K^+ fixing soils.

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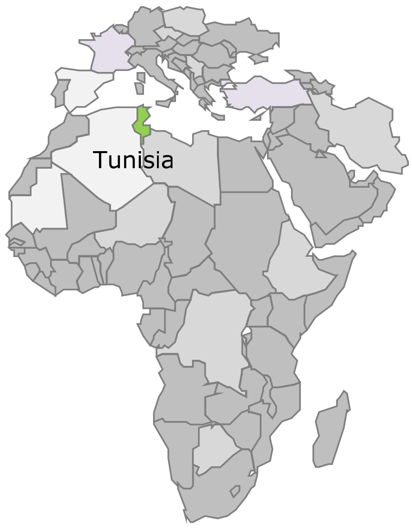
Dr. Mehdi Ben Mimoun at the experimental site, Sfax. Photo by M. Marchand.

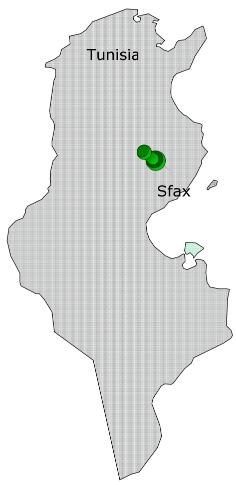
Table 1. Fruit and nut production area and productivity in Tunisia (2006).

Fruit tree crop	Area	Yield
	ha	*'000 mt*
Olive	1,560,000	850
Almond	257,000	56
Pistachio	44,000	1.6
Date	32,600	131
Apple	25,500	120
Grape	25,000	54
Peach	23,000	73
Fig	23,000	30
Citrus	18,000	247
Pomegranate	13,000	70
Apricot	11,600	28
Pear	11,000	65
Plums	6,500	15

Foliar application of nutrients is in general helpful to satisfy plant requirement and has a high efficiency (Inglese *et al*. 2002). Potassium is particularly well adapted to this form of fertilization because soon after foliar spraying takes place it is rapidly translocated from the leaves (Mengel, 2002). Foliar application is thus an attractive means of K application to trees especially in arid zones where a lack of water under low rainfall conditions in summer drastically depresses absorption of soil nutrients.

In 2003, IPI coordinating research in the WANA region working jointly with the Fruit Tree laboratory of the Institut National Agronomique de Tunisie (INAT) began a project to evaluate the effect of potassium foliar spraying on different fruit crops (olive, citrus, pistachio, peach and plums) under different growing conditions.





Maps of the region and Tunisia showing the experimental area.

Research findings

The purpose of this paper is to present results obtained from the olive experiment under rainfed conditions. Results from fertigated orchards of peach and plum will be reported in another publication.

Table 2. The different potassium treatments.

Treatments	Method	Quantity of K	Relative quantity
		kg K_2O/ha	
Control		0	
F50	Foliar spray	13	50% of tree removal
F100	Foliar spray	27	100% of tree removal
S100	Soil spreading	27	100% of tree removal
S200	Soil spreading	54	200% of tree removal

Materials and methods

This experiment was carried out over a period of five years beginning 2003 on a fine sandy soil at the Olive Institute experimental station which is located 26 km north of Sfax in the center of Tunisia. The zone is characterized by a semi-arid climate with an annual precipitation of 200 mm. A commercial olive orchard growing the cultivar Chemlali (the most important olive oil cultivar in Tunisia) was used for this experiment. The trees 24 x 24 m apart were grown using standard cultural practices of the Sfax region, i.e. under rainfall condition and without any fertilization.

At the beginning of the season, an estimate of potassium requirement was made based on the removal of nutrients contained in the yield (200 kg/tree) and the pruned wood. The total tree removal was estimated as 26.71 kg K_2O/ha (1.57 kg K_2O/tree). Potassium was applied by two different methods and on two quantities as indicated in Table 2. The same procedure was carried out annually from 2003-2007.

Potassium was applied as potassium sulfate (K_2SO_4).

The soil spreading treatments were carried out by one application made during the period of flower bud swelling.

The foliar fertilization treatments were applied using a 100 liter/tree spray, with K concentration of a maximum of three per cent as follows:

- 30% of K total tree removal during the flower bud swelling
- 40% of K total tree removal during the second fruit development stage
- 30% of K total tree removal just at the beginning of the fruit color change.

Four single tree replications were used for each treatment. The vegetative growth of the shoots was measured once a month. Every 15 days after fruit set, fruit weight was measured on a sample of 200 fruits (50 per tree). At harvest yield per tree was determined and the oil extracted using an oil mill on four samples of 2.5 kg olives per treatment.

Leaf samples were collected in July each year from all treatments. About 40 fully expanded mature leaves per each tree were collected. In all cases, leaves were taken from the middle portion of the current season's terminal shoot growth. Leaf samples of the same treatment from each block were combined as samples of 100–120 leaves for determining leaf K concentration.

Results and discussion

Vegetative growth

No significant effect of the different potassium fertilization treatment was observed on vegetative growth (Fig. 1).

Fruit maturity and quality

The pattern of fruit growth was also not influenced by fertilization treatment (Fig. 2). Although fruit growth was higher during stage three for the 100 per cent foliar treatment, this increase was not statistically significant. Similar results were observed by Inglese *et al.* (2002).

Leaf Analysis

For each of the four years of the experiment the leaf concentration of K was higher for foliar treatments at F100 than the control (Fig. 3). However, the K concentration varied between "on"

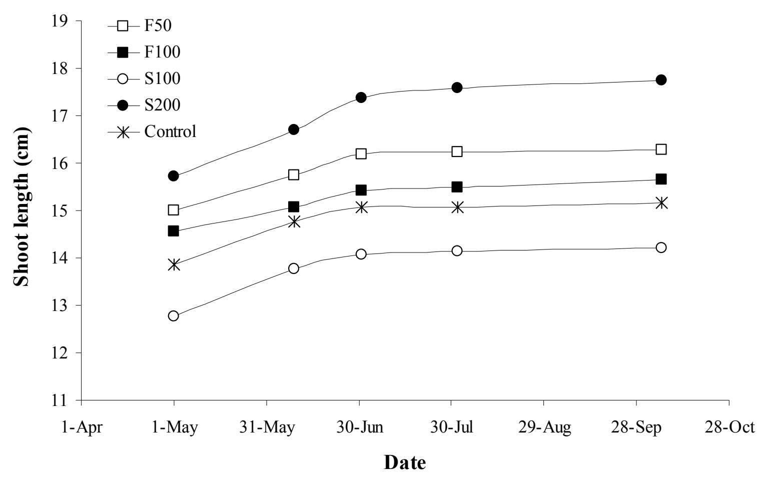


Fig. 1. The shoot growth (cm) for the different potassium fertilization treatments in 2003.

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and "off" years for all the treatments: the values were higher during the off year and were above the sufficiency threshold of 0.8 per cent for olive (Freeman *et al*., 1994) and vice versa. Fernandez-Escobar *et al.* (1999) observed the same results. These workers concluded that the high leaf K accumulation following the "off" year and the rapid decline after March of the "on" year suggest a large K demand by the reproductive structures of olive.

Yield and quality

After five years of experiments, potassium applied either as foliar or in the soil increased yields of olives. A significant difference in the cumulated yield was observed between foliar spray at 100 per cent nutrient replacement for K removal (F100) and the control (Table 3). The increase in yield is higher than 200 kg/tree, representing an almost additional yearly harvest yield for this very alternating cultivar. In other work, Restrepo-Diaz *et al*. (2008) did not observe any effect of potassium foliar fertilization on olive under rainfed conditions. However they stopped their experiments after only three years.

We assume that since F100 was applied in a split application (three times as compared to only one application to the soil) and the fact that the foliar applied K was more available to the tree, that these advantages contributed to the significant yield increase resulting from this form of application.

Potassium application to the soil and in foliar form significantly increased fruit weight and Flesh to Pit Ratio (Table 4). Foliar application of K (F100) proved to be best treatment with an increase of approx. 33 per cent in fruit weight and 24 per cent in Flesh to Pit Ratio, over the control. This beneficial effect may possibly have arisen as a consequence of a higher availability of assimilates.

At the same time, potassium application significantly decreased oil content in the fruit. As the oil content is negatively correlated with fruit weight and yield, we assume that the decrease in the oil

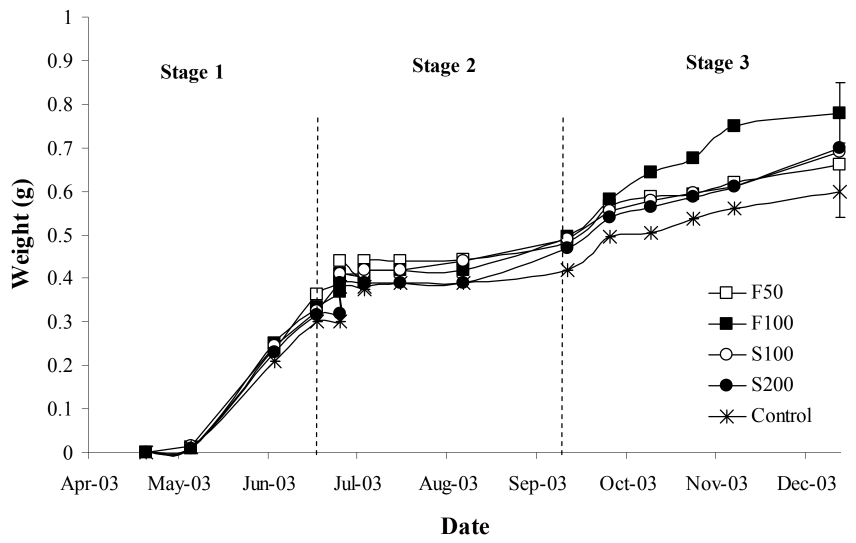

Fig. 2. The fruit growth (g, single fruit basis) for the different potassium fertilization treatments in 2003.

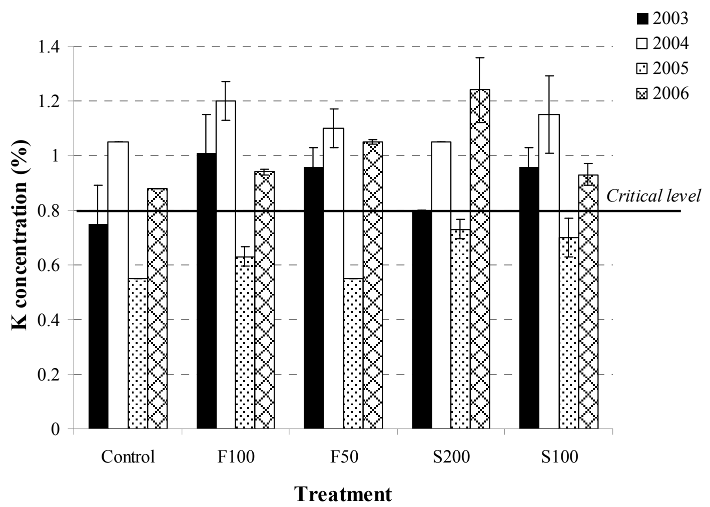

Fig. 3. The effect of fertilization treatments on K leaf concentration of Chemlali olive cultivar for the years 2003, 2004, 2005 and 2006. Bars represent SE.

Table 3. Average and cumulated yield in kg/tree during the period between 2003 and 2007. Different letters indicated statistical differences among means by Duncan's Multiple Range Test (p≤0.05).

Treatments	K application	Average yield					Cumulated yield
		2003	2004	2005	2006	2007	
	kg K_2O/ha	*kg/tree*					*kg/ha*
Control	0	143.75 a	0.00	34.25 a	56.25 a	84.8 a	5,423 a
F50	13	161.25 a	0.00	47.50 a	48.75 a	200.5 ab	7,786 ab
F100	27	183.25 a	0.00	71.25 b	36.25 a	237.0 b	8,972 b
S100	27	145.25 a	0.00	45.00 a	38.75 a	112.0 ab	5,797 a
S200	54	156.25 a	0.00	71.25 b	42.50 a	109.0 ab	6,443 ab

Note: Chemlali olive cultivar is an important alternate bearing cultivar with no yield after a good year which explains the absence of yield in 2004 after the excellent 2003 yield.

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content is due to dilution caused by the higher yields.

Fig. 4 shows the oil yield achieved in the different treatments (i.e. the product of yield and oil content). Clearly, the treatment of F100 (foliar application of potash at a rate to fully compensate for the removal of K in crop and buds) yielded approx. 50 per cent more oil than the control, thus offering the farmers a significant additional income.

Table 4. The effect of different potassium treatments on fruit pomological characteristics in 2003. Different letters indicated statistical differences among means by Duncan's Multiple Range Test (p≤0.05).

Treatments	K application	Fruit Weight	Flesh to Pit ratio	Oil content
	kg K_2O/ha	*g*		*%*
Control	0	0.61 a	2.94 a	21.68 bc
F50	13.35	0.66 b	3.19 b	20.30 a
F100	26.71	0.81 d	3.65 c	20.18 a
S100	26.71	0.70 c	3.25 bc	21.26 b
S200	53.38	0.69 bc	3.10 b	22.01c

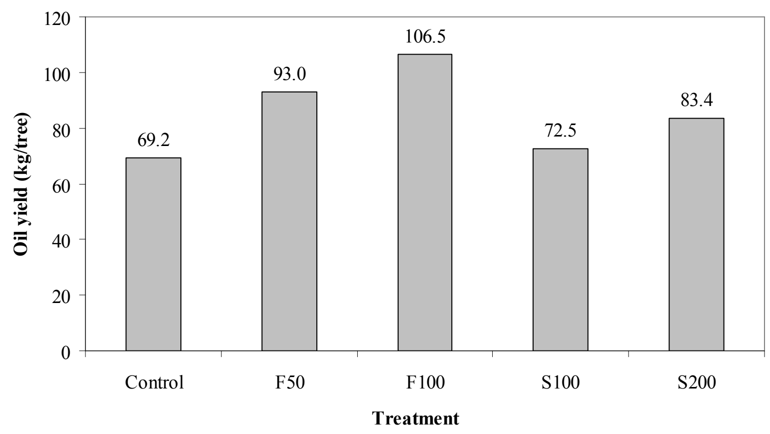

Fig. 4. Oil yield of olive trees for the different treatments (oil, kg/tree).

Conclusions

This study shows the importance of potassium fertilization in increasing the yield and oil yield of rainfed olive. The effect of split foliar application of potassium was superior to soil application which implies that this technology is preferable. Restrepo-Diaz *et al.* (2008) recommended foliar application in orchards growing under rainfed conditions because the lack of moisture in the soil during the growing period that could limit K uptake by the roots, which is the case for the majority of Tunisian olive orchards. Our calculations for potassium application rates based on removal of K in fruit and tree buds seem to be in good agreement. More work is still required in order to assess whether this balance is sustainable and profitable over longer periods. The results of this experiment demonstrate the need for a long term approach in such conditions, as both the fruit type (olive) and the climatic conditions pose a challenge in the analysis of data from field experiments.

Acknowledgements

Special thanks go to the International Potash Institute (IPI) for its support to this research.

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IPI Events

In September 2008:

IPI Satellite Colloquium during the Chinese Soil Science Congress: "Potassium in Sustainable Development of Chinese Agriculture", 26th September 2008, Beijing, China.

This satellite event is jointly organized with the Institute of Soil Science, Nanjing, Chinese Academy of Sciences (CAS; ISSAS) and the Chinese Agriculture University (CAU). Nine speakers will deliver presentations on issues of efficient use of natural resources to enable food security, soil fertility, K fertilization and stresses, K use patterns and response, and reports from IPI experiments in China.

All presentations will uploaded to the IPI website after the event.

In November 2008:

Workshops in Bayindir, Izmir and Nusaybin, Mardin, Turkey.

IPI and the EGE University, Izmir, will hold two one-day workshops for farmers and extension workers. Topics to be discussed will include the main uses of potassium in various crops, K deficiency symptoms, K in soil and plant physiology. See more at IPI website.

In July 2009:

IPI-Corvinus University Budapest international symposium on "Nutrient management and nutrient demand of energy plants", 6-9 July 2009, Budapest, Hungary.

The symposium will be jointly organized by IPI and Corvinus University Budapest. Venue: Mercure Budapest, Hungary. Topics will include quality requirements of crops for biofuels, new and traditional crops for biofuel, energy and CO_2 balance of crops grown for biofuels, and optimal crop rotation and nutrient balance for biofuel plants. The post-symposium tour will be to a biofuels plant and farmers growing energy crops. Registration fee will cover participation at all oral and poster presentations, welcome reception, lunch, morning and afternoon coffee break during the two symposium days, and symposium dinner. The post-symposium tour will be charged separately. For more details see IPI website or contact IPI Coordinator Dr. T. Popp.

In November 2009:

IPI-OUAT-IPNI international symposium on "Potassium role and benefits in improving nutrient management for food production, quality and reduced environmental damages", Orissa University of Agriculture and Technology (OUAT), Bhubaneswar, 5-7 November 2009.

The symposium is be co-sponsored by the Indian Council of Agricultural Research (ICAR), Fertilizer Association of India (FAI), Bangladesh Fertilizer Association (BFA) and the Pakistan Agricultural Research Council (PARC). The Scientific Committee, chaired by Dr. J.S. Samra, has selected the following sessions: 1) Nutrient management to meet challenges of food security; 2) Potassium and nutrient use efficiency; 3) Role of potassium and mineral nutrition in alleviation of stress; 4) The effect of quality and nutritional value of agricultural products on human health: the role of potassium; 5) Spatial variability of soil properties and Site Specific Nutrient Management (SSNM); 6) The role of extension in increasing agricultural productivity; 7) Potassium and the environment; and 8) Nutrient mining and input output balances.

More details will appear regularly on IPI and IPNI websites, or contact Dr. M. Assaraf, IPI Coordinator India.

Other Events

In November 2008:

17th International Symposium of CIEC, 24-27 November 2008, Cairo, Egypt.

The International Scientific Centre for Fertilizers (CIEC) is organizing a symposium titled "Plant nutrient management under stress conditions", hosted by the National Research Center (NRC), Egypt. For more details contact nrc-mic@link.net or oeabk@yahoo.com. Details also on IPI website.

In December 2008:

Second International Symposium on Papaya, 9-12 December 2008, Madurai, Tamil Nadu, India.

This symposium is being jointly organized by the International Society for Horticultural Science (ISHS), Leuven, Belgium in collaboration with Tamil Nadu Agricultural University, Coimbatore, India and other scientific organizations. The theme of the symposium is "Papaya for nutritional security". For further details, please contact the organizing secretary, Dr. N. Kumar, Professor (Horticulture), Tamil Nadu Agricultural University, Coimbatore 641 003, India. E-mail: kumarhort@yahoo.com, Phone: +91 422-6611310/6611377, (R): +91 422-2436046; Fax: +91 422-6611399, Mobile: +91 936 312 1916. Web: www.ishs-papaya2008.com. Details also on IPI website.

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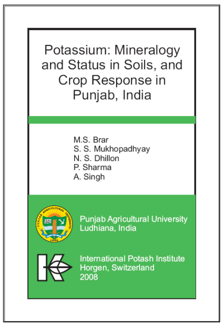
New publications

Potassium: Mineralogy and Status in Soils, and Crop Response in Punjab, India. 69p., 2008, ISBN 978-3-9523243-9-4, DOI 10.3235/978-3-9523243-9-4. By M.S. Brar, S.S. Mukhopadhyay, N.S. Dhillon, P. Sharma and A. Singh, Department of Soils, Punjab Agricultural University, Ludhiana, India.



This bulletin aims to demonstrate the importance of potassium in soil-plant systems. It focuses on the relations between soil and mineral K, its various forms in soil and its unchecked depletion from farmlands. The situation in the state of Punjab, India, exemplifies the grave situation of soil nutrient depletion, especially potassium. Between 1960-2005, production of food grains has increased more than eight-fold in the state, while production of cotton has tripled. Each increment in production has resulted in a steep rise in soil nutrient depletion. This is reflected in the fact that potassium levels in soils have not been replenished. The bulletin also challenges the myth that potassium is rarely a limiting nutrient in the soils of Punjab. A few experiments that demonstrate that potassium is in fact limiting in soils, must be viewed in the context of the large-scale potassium exhaustion in Punjab over the last 50 years, caused by irrigation and intensive cultivation, with little potassium credit to the soils.

Potassium: Mineralogy and Status in Soils, and Response in Punjab, India is available for download at

http://www.ipipotash.org/publications/detail.php?i=257

To order a hard copy, please contact Dr. M.S. Brar, Senior Soil Chemist, PAU, Email: brarms@yahoo.co.in

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Translated to Hindi: "Rice: A Practical Guide to Nutrient Management". 170p., 2008, ISBN: 978-3-9523243-3-2; DOI: 10.3235/978-3-9523243-3-2. T.H. Fairhurst, C. Witt, R.J. Buresh, and A. Dobermann (eds)., translated to Hindi by B. Mishra, G.B. Pant University of Agriculture and Technology (G.B. PUAT), Pantnagar, India.

पोषक तत्व प्रबंधन की व्यवहारिक मार्गदर्शिका

The first edition of Rice: A Practical Guide to Nutrient Management (ISBN 978-981-05-7949-4) was published in 2002, reprinted in 2003 and in 2005. A second edition was published in 2007.

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

For the same reasons, the Hindi version will soon be available on the websites of IPI, IRRI and IPNI.

To order a copy of the newly published Hindi version, please email to ipi@ipipotash.org.

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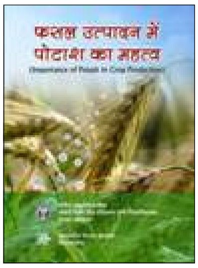
Importance of Potash in Crop Production. 12p., 2008. By IPI and the Regional Research Station (RRS), CCS Haryana Agricultural University, Bawal-123501, Haryana.



This 12 page booklet describes the functions and benefits of potash application in Haryana predominantly to wheat, mustard, cluster bean and pearl millet. The booklet is in Hindi, and is distributed to farmers in the region by the regional research station. Download the booklet or order a hard copy on the IPI website at http://www.ipipotash.org/publications/detail.php?i=256

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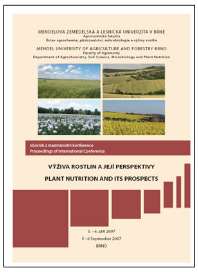
Plant nutrition and its prospects. Proceedings of the International Conference, Brno, 5-6 September 2007 (in Czech and English abstracts). 425p., 2008, ISBN 978–80–7375–068–8. Edited by Dr. Petr Škarpa, Mendel University of Agriculture and Forestry, Brno, Faculty of Agronomy, Department of Agrochemistry, Soil Science, Microbiology and Plant Nutrition. IPI Coordination Central Europe provided financial support to this symposium.



For copies contact Dr. Petr Škarpa, Department of Agrochemistry, Soil Science, Microbiology and Plant Nutrition Mendel University of Agriculture and Forestry, Brno, Zemědělská 1, 613 00 Brno, Czech Republic. Tel: +420 545 133 345; Fax: +420 545 133 096; or e-mail: xskarpa@node.mendelu.cz

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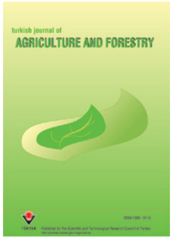
Turkish Journal of Agriculture and Forestry, Volume 32, Issue 3, (2008). ISSN: 1300-011X.

http://mistug.tubitak.gov.tr/bdyim/toc.php?dergi=tar&yilsayi=2008/3



This special issue contain papers presented at the IFA Agriculture Conference on "Optimizing of Resource Use Efficiency for Sustainable Intensification of Agriculture", held in Kunming, China, from 27 February to 2 March, 2006.

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K in the literature

Impact of different nitrogen fertilizers and an additional sulfur supply on grain yield, quality, and the potential of acrylamide formation in winter wheat. Weber, E.A., W. D. Koller, S. Graeff, W. Hermann, N. Merkt, and W. Claupein. J. Plant Nutr. Soil Sci. 171(4):643-655 (2008).

http://dx.doi.org/10.1002/jpln.200700229

Abstract:

The amino acid asparagine (Asn) plays a key role in acrylamide (AA) formation in strongly heated cereal foodstuffs. The influence of different nitrogen (N) fertilizers (calcium ammonium nitrate, CAN; urea ammonium sulfate solution, UAS, applied according to the CULTAN method; urea; urea ammonium nitrate, UAN; ammonium nitrate sulfate containing the nitrification inhibitor 3,4-dimethyl pyrazole phosphate, Entec 26®; and a combination of liquid manure and CAN) at a nitrogen level of 180 kg N/ha and an additional sulfur (S) supply on grain yield, quality, Asn concentration, and the potential of AA formation of winter wheat were studied in a 2-year field experiment. Grain yields varied between 61 und 104 dt ha^{-1} dry matter depending on cultivar (cv), fertilization, and year. Quality demands concerning crude protein concentration and sedimentation value were reached when CAN, CAN+S, urea, or a combination of liquid manure and CAN were applied. Asparagine concentrations in flours varied from 2.6 to 13.6 mg per 100 g flour dry matter depending on cultivar, fertilization, and year. In both years, a close nonlinear correlation between crude protein concentration and the concentration of free Asn with r^2_{2004} = 0.93 and r^2_{2005} = 0.94 was observed. Nitrogen fertilizers leading to high crude protein concentrations caused significantly increased Asn concentrations. In both years, a correlation between the concentration of free Asn and the potential of AA formation with r^2_{2004} = 0.72 and r^2_{2005} = 0.84 was found. The application of S (CAN compared to CAN+S) had no beneficial effect on the Asn concentration and the potential of AA formation, most likely because S concentration in grains was sufficient even without additional S supply.

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Influence of Phosphorus, Nitrogen, and Potassium Chloride Placement and Rate on Durum Wheat Yield and Quality. May, W.E., M.R. Fernandez, C.B. Holzapfel, and G.P. Lafond. Agron. J. 100:1173-1179 (2008).

http://agron.scijournals.org/cgi/content/abstract/100/4/1173

Abstract:

Information regarding the impact of P and KCl rate and placement in conjunction with N rate on durum wheat (*Triticum turgidum*L. var. *durum*) is limited in the Great Plains. Our objectives were to determine the effects of N, P, and KCl fertilizer rate and P and KCl placement on grain yield and quality of durum wheat grown on low P soils. Nine combinations of N and P fertilizer and five combinations of N, P, and KCl applied with the seed and in a side band, were compared over 3 yr at Indian Head SK, in fields with soil P levels <9 kg/ha. Grain yield increased 15% as N application increased from 45 to 140 kg/ha. Grain yield increased by 10% as the P rate increased from 0 to 17 kg/ha under dry conditions in 2003, but not in 2002 and 2004. No interaction was detected between N and P for grain yield. Grain yield was unaffected by KCl application and P or KCl placement, in the high K soils included in the study. Grain protein increased from 123 to 150 g/kg as N fertilizer rate increased, but decreased from 140 to 136 g/kg as more P was applied. However, Red smudge decreased as P increased. Results from this study indicate that N application does not affect the amount of P required by durum wheat and that yield responses to P can occur in soils low in P under dry conditions.

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Ability of sorption-desorption experiments to predict potassium leaching from calcareous soils. Jalali, M., and Z. Kolahchi. J. Plant Nutr. Soil Sci. 171:1-10 (2008).

http://dx.doi.org/10.1002/jpln.200625197

Abstract:

When potassium (K^+) fertilizers are applied to the soil, K^+ is subject to displacement through the soil profile. Leaching can play an important role in agricultural K^+ losses that can decrease groundwater quality. To avoid overfertilization, estimation of K^+ leaching from soil is important. The ability of the soils to retain K^+ against leaching varies according to the adsorption coefficient of the soils. The aim of this study was to relate the K^+ leaching from a wide range of

K in the literature

calcareous soils to the values obtained from a sorption-desorption experiment. The soil columns were leached with 10 mM $CaCl_2$ solution and the leachate was analyzed for K^+. The breakthrough curves for K^+ were different, and the amounts of K^+ leached varied considerably between different soils. In these calcareous soils where crops are irrigated with water containing significant concentrations of Ca^{2+} and other cations, large amounts of K^+ will be leached. Cumulative K^+ leached after five pore volumes leaching with 10 mM $CaCl_2$ was significantly ($r = 0.776$, $p < 0.01$) related to the equilibrium K^+ concentration. The results of this study enabled us in many cases to estimate the K^+ leaching from soil without conducting column experiments, minimizing the laboratory work.

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High Potassium Aggravates the Oxidative Stress Induced by Magnesium Deficiency in Rice Leaves. Ding, Y., C. Chang, W. Luo, Y. Wu, X. Ren, P. Wang, and G. Xu. Pedosphere 18(3):316-327 (2008).

http://dx.doi.org/10.1016/S1002-0160(08)60021-1

Abstract:

Magnesium (Mg) deficiency in plant affects photosynthesis and many other metabolic processes. Rice (*Oryza sativa* L. cv. 'Wuyunjing 7') plants were grown in hydroponics culture at three Mg and two potassium (K) levels under greenhouse conditions to examine the induction of oxidative stress and consequent antioxidant responses in rice leaves due to Mg deficiency. At low Mg (0.2 mmol L^{-1} Mg supply for two weeks after transplanting) and high K (6 mmol L^{-1}) for 21 days, the rice plants showed severe Mg deficiency and a significant decreases in the dry matter production. The Mg deficiency in leaves decreased chlorophyll concentrations, photosynthetic activity, and soluble protein, but significantly increased the concentrations of soluble sugars and malondialdehyde (MDA) and the activities of superoxide dismutase (SOD, EC 1.15.1.1), catalase (CAT, EC 1.11.1.6) and peroxidase (POD, EC 1.11.1.7). In addition, Mg concentrations in the leaves and in the shoot biomass were negatively related to the activities of the three antioxidative enzymes and the concentration of MDA in leaves. There were very significant interactive effects between Mg and K supplied in the culture solution on shoot biomass yield, chlorophyll content, photosynthesis rate, the activities of SOD, CAT and POD, and MDA content in the leaves of rice. It is suggested that the high K level in the nutrient solution aggravated the effect of low Mg supply-induced Mg deficiency and created the oxidative damage in rice plants.

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

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

To produce oil from copra requires dehusking, separating the nuts from the shells, and drying in the sun. This time consuming and laborious task is usually carried out by women. Tamil Nadu, India. Photo by IPI.

IPI new Coordinator

New IPI Coordinator

Dr. Menachem Assaraf has been nominated as the IPI Coordinator for China and India, effective from May 2008. Dr. Assaraf is taking the position of Dr. Patricia Imas who recently went on maternity leave after many productive years of coordination experience in the regions.

Dr. Assaraf, 44 years old and married with three children, was born in Morocco but grew up in Israel. He currently lives close to Beer Sheeva in the Negev desert, and works as a Research and Business Development Manager for Agrochemicals, at ICL-Industrial Products. Dr. Assaraf is responsible for numerous multinational, large- and medium-scale projects of new product development. In this work he is cooperating with various research and development organizations, including universities, laboratories, extension specialists, growers, dealers, regulators, and others.

Dr. Assaraf completed his BSc, MSc and PhD at the Hebrew University of Jerusalem, Faculty of Agriculture, Department of Plant Protection. His MSc thesis focused on "The Enhanced Microbial Degradation of the Fungicide Benomyl (Benlate) in Soil". His PhD thesis, supervised by Prof. Y. Katan with Dr. C. Ginzburg, covered "The Weakening Effect of Sensitive and Thermo-tolerant Biotype Propagules of the Pathogen *Fusarium oxysporum* f.sp. *niveum* by Sublethal Stress Agents".

While working on his PhD, Dr. Assaraf also undertook teaching responsibilities and gained recognition on several occasions for his scientific achievements. In 1994 he was awarded Ben-Gurion and the Pazner and Jocheedson Foundation Awards for excellence in his PhD studies. In 1997 he also gained awards in recognition of his work from the British Council and Baron De Hirsch Foundations. He has published in a number of scientific journals and is a member of the American and Israeli Phytopathological Societies. Dr. Assaraf also has several patents on his name, as well as in partnership with others, for soil fumigants and an environmentally-friendly pesticide that controls plant parasitic nematodes in various crops.

With this valued knowledge and expertise, we warmly welcome Dr. Assaraf to IPI and to him assisting us in our activities in China and India.

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