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

Editorial

Dear readers,

"Over recent decades, central governments of most countries have curtailed their direct involvement in agricultural extension," states Blum *et al.* in one of two articles on extension featured in this edition of *e-ifc*. Why were these agencies involved in the first place? These days, governments and donors once more share the view which was so prevailing in the past – that agriculture is a mainstay of rural and also urban livelihoods. As the first decade of the 21st century draws to a close, it is now clear that agricultural research and rural extension are essential to worldwide food security and are back on the development agenda. In this edition, we are pleased to provide a general analysis of extension (Blum *et al.*), as well as a more specific story about the Bulgarian Extension Service during the last 20 years (Nikolova and Donchev).

Also featured in this issue is a preliminary report from Hungary on "Rootstock Efficiency in Nutrient Uptake and Utilization in a High Density Cherry Orchard Experiment". In addition, as always, we bring you updates of events, new scientific publications and more.

Finally, a message to all our veteran Potash Review readers: We recently completed the scanning of all Potash Review publications from 1956-1995. These legacy documents are now available on the IPI website, and can be searched by title, author, year and theme. We also have a free search which will search through the full text of each document in the database. No more dusty forgotten papers… now this database is available to all.

I wish you an enjoyable read and all the best for a prosperous 2011.

Hillel Magen

Director

Manual harvest of potato in the Czech Republic. Autumn 2010. Photo by IPI.

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The Role and Function of Agricultural Extension

Blum, A.[(1)], *A. Lowengart-Aycicegi*[(2)], *and H. Magen*[(3)].

This paper is based on various internal discussions at IPI during 2008-2010 supported by literary references.

A group meeting of banana growers in North Israel, discussing recent field experiment data. 2004. Photo by A. Lowengart-Aycicegi.

Towards a New Paradigm

Over the past few decades, central governments of most countries have curtailed their direct involvement in agricultural extension. In industrialized countries, advisory services[(4)] have been "privatized", and farmers, as clients, have to pay for most extension activities. In developing countries, there has also been a move to privatize, outsource or regionalize extension and to demand that farmers pay for services, which in the past were provided free-of-charge by governmental agricultural advisory services.

Under these circumstances, it is only natural that farmers who have to pay for services should have a voice when extension goals and means of delivery are discussed. Thus "*supply driven*" extension becomes "*demand driven*" or "*market driven*" advice. Agricultural advisors have not only to bring relevant knowledge and practical solutions to farmers; they must also ensure that farmers' problems are brought to researchers, who can work towards feasible and economical solutions. Agricultural extension is becoming more pluralistic, with different actors concurrently using different approaches and extension methods. Hopefully, this pluralistic approach will lead to a generation of custom-made, environmentally-friendly and economically sustainable solutions based on farmers' involvement in agricultural innovation systems.

At the same time, different environments demand different solutions. Where soils are poor and depleted, as in many parts of Africa, fertilization is an urgent need. In regions with moderate fertilizer usage, an improvement in nutrient management hand in hand with other practices is required.

In the past, private advisors could be paid only by wealthier, more prosperous farmers and by corporate farms. With the trend towards privatization, the roles of public and private (commercial) extension has had to be redefined. Umali -Deininger (1997) suggested that where the knowledge being communicated is embedded in, or closely associated with, market goods (e.g. tractors, hybrid seeds, fertilizers etc.), the delivery of relevant advice can be left to the private sector, within an appropriate regulatory framework. However, where the technology or practice being promoted is associated with a toll good (such as farm management or marketing information), the delivery of extension advice is best handled by a judicious combination of public and private entities. If a common -pool good (such as soil, water and air resources, community forests, fisheries, common pastures etc.) is involved, it is highly beneficial to connect the advisory activities closely with cooperative or voluntary action. Where market and participation failures are high, for instance where subsistence farming dominates, a public sector approach to agricultural extension is required.

In any of these scenarios, it remains the responsibility of the government to ensure that agricultural advisory services adhere to quality standards, which should be clearly stated in the contracts provided by chosen extension providers.

The Role of the Private Sector

Private sector extension existed long before governmental extension systems were heavily curtailed, leaving a vacuum in many areas.

Four groups of firms provide the majority of private extension services:

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[(2)]*Extension Service, Ministry of Agriculture and Rural Development, Western Galilei, Israel.*

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[(4)]*In this document the terms "extension" and "advisory" are used as synonyms.*

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1. Private (individual or corporate) extension firms. Private extension firms often hire the best public extension services advisors, as they are able to pay more than the State and provide better working conditions. Sometimes, a public sector authority contracts a private party to join it in a public-private partnership (PPP) consortium. In other cases the government outsources its former extension responsibilities to a private firm. And in other instances, extension agents "set up their own shop". However, the need to work hard to make the business profitable can prevent them from acquiring newly emerging know-how. Therefore, some kind of quality control or certification by the State is required.
2. Factories that process farm produce into higher value products, e.g. canned, dried or frozen foods. These factories contract farmers to follow strict production methods. In return, the factory offers extension advice and guarantees to buy the produce, often guaranteeing a minimum price. The factories employ highly trained and experienced extension agents.
3. Farm input supply firms (selling fertilizers, seeds, pesticides, feeding stuff, implements and other supplies). These agro-dealers often include pre-sale advice and sometimes ongoing extension advice as part of their services. They have the advantage that their personnel can specialize in a specific field of knowledge, compared to the field extension workers of public extension providers. In the past, advisers in official extension services often viewed input supply dealers, and the private sector generally, as competitors, who had only their narrow business interests in mind. However, where joint knowledge platforms with other stakeholders have been set up, this negative attitude has disappeared. Input dealers with ethical standards can play an important role in the building of trust between them and farmers.
4. Marketing chains often indicate what produce they prefer (e.g. organically grown vegetables) or what specified product might get a higher price. This kind of advice is less obligating than the instruction of food processing firms, but it informs farmers about up-to-date market trends.

IPI-FAI dealer training program. 2006. More than 1,000 dealers participated over the last few years. Photo by IPI.

Training Modes and Models

While subject matter specialists in advisory and related services are able to use scientific publications and contact applied research institutions in order to update their specialist knowledge, input dealers and enterprising farmers need training to access these sources. Special attention should be paid to the training of lead farmers, who are known to influence other farmers and can serve as multipliers of relevant agricultural knowledge and practices.

Farmers fill in an evaluation form at the end of farmers' day. Sichuan, China. 2002. Photo by H. Magen.

The most effective and economic means to spread specific extension messages is through campaigns, using well publicized meetings at demonstration plots and appropriate mass media. However, such campaigns should not replace regular training for developing a deeper understanding, for example, on the roles that fertilizers play in plant husbandry.

Descriptions of relatively recent training schemes for input dealers in Ghana, India and an introduction to Farmers' Field Schools are described in Appendix I.

Assessing the Impact of Agricultural Extension

Agricultural advisory services are under an obligation to demonstrate that they have made an economic and social impact on the well-being of the farmers they serve, mainly through the quantitative and qualitative enhancement in crop productivity and in farmers' net income. This impact should be environmentally and economically sustainable.

Although hundreds if not thousands of agricultural extension services and

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projects have been developed since the end of World War II, only in rare cases has a rigorous attempt been made to assess the economic return or the impact of extension efforts on farmers' productivity and income. Project completion reports cannot be counted as impact evaluation, because they do not study what happens after the external project funding has ceased and local authorities are unable to afford the cost of impact evaluation. Too many agricultural development projects that were funded by international aid agencies failed in the end, because the developing country could not afford the expenses after the donors ended their financial support.

In addition, it is extremely challenging to find two groups of farmers who are "equal" enough to set-up a controlled experiment. Models developed for experiments with genetically identical plants are not necessarily suitable for measuring human behavior. Trying to differentiate between the separate contributions of research and extension to a new agricultural practice is very problematic. Furthermore, a rise in productivity could be the outcome of many factors: Extension interventions, different levels of farmer's education, better market opportunities, availability and low prices of inputs, optimal weather etc. The nature of agricultural extension interventions makes randomization difficult. Several meta-studies have shown different types of biases in the selection of the samples (Romani, 2003).

In spite of these challenges, various economic models for assessing the impact of extension have been developed and used mainly in high income countries. However, meta-studies have shown that these impact studies were either designed to be statistically rigorous, but with limited scope, or comprehensive, but with limited coverage (Waddington *et al.*, 2010). At present, a major "International Initiative for Impact Evaluation" (acronym: 3ie) is making a major effort to develop more rigorous impact evaluation techniques. A draft report is expected to be released by the end of 2010. The recently founded Global Forum for Rural Advisory Service (GFRAS) is also working to develop a toolkit for evaluating extension systems.

Farmers' day organized by IPI in Sri Lanka. 2006. Photo by V. Nosov.

Four meta-studies on the economic rate of return of extension projects are of special interest. Birkhaeuser *et al.* (1991) identified 48 studies conducted in 17 countries assessing the effect of several aspects of extension, including knowledge diffusion, adoption of improved technology and productivity. Their analysis suggests that extension can have a significant relationship with these outcomes and, while only five studies from developing countries included estimates of the rate of return to investments, these suggest that rates of return to extension can be very high. However, the authors of the meta-study found that often there was an inadequate control for sample selection biases.

More recently, Purcell and Anderson (1997) assessed the impact of World Bank support to the development of national research and extension systems in the 1980s and 1990s. This study concludes that despite serious limitations in the systems receiving support, there have been significant positive outcomes of World Bank interventions. However, this study is also based on a review of project completion reports, rather than evaluation evidence.

Evenson (1997) found rates of return to extension greater than 50 percent for the majority of countries, but the rates varied widely.

Alston *et al.* (2000) produced the extensive review of over 1,100 estimated rates of returns for the economic returns to investments in agricultural research and development. About half (512) of these were for research and extension combined, but only 18 were from extension-only investments. The meta-analysis showed an average rate of return of 47 percent for research and extension investments, while for extension-only investments the rate of return was 80 percent. The authors found that only a few rate of return studies had used a high quality methodology.

In the past, most of the economic models also tended to ignore long-term effects of extension, such as farmers' increased technical and communication

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skills and experience in decision-making. These factors can increase farmers' negotiation power in the market and thus also their income. Economic rate of return studies do not take into account important indirect benefits to "public goods" such as improvements in health and the environment, for instance when farmers spray less than in the past. For example, as a result of training, rice farmers in Indonesia, Vietnam and Bangladesh moved from prophylactic spraying against brown rice hoppers to Integrated Pest Management (IPM) and reduced the use of pesticides by 35-92 percent. In Sri Lanka, rice farmers trained more than five years previously in a Farmer Field School (FFS; Van den Berg and Jiggins, 2007) used only a third of the amount of pesticides used by the control group. Recent results on cotton from China, India and Pakistan indicate 34-66 percent reductions in pesticide use, while cotton yields rose by 4-14 percent.

Because of the weaknesses of purely economic impact evaluations, extension systems often use more sociological impact evaluations, in which farmers' experiences, expectations, opinions and other non-economic factors are considered. Pope *et al.* (2007) suggest that for the more complex questions facing policy- and decision-makers, a myriad of other forms of evidence in the widest sense will potentially be relevant. These include qualitative research, non-trial based quantitative research and the observations of stakeholders and expert panels.

Lessons Learned from Project Failures and Successes

Unfortunately, many agricultural development projects, financed by foreign donors, failed once donor funding ended, usually because national governments did not have the budget or the political will to continue. These projects were either too expensive for a developing country or they did not fit the national development programs. Some lessons can be learned:

Field day for citrus farmers in Brazil (IPNI-IPI program, 2005). Photo by H. Magen.

- Plan and execute a project within a budget that is affordable for the host country or region to continue activities after the culmination of the project.
- Coordination with the responsible civil servants should be carried out in the initial planning stage to explore how the project will be integrated into national development plans, after the project ends.
- Coordinate with those responsible for infrastructure development; there is no sense introducing export or perishable crops if the necessary infrastructure is not in place, or in the process of being developed.
- Set up a stakeholder "platform" involving farmers' organizations, extension officers, researchers, suppliers, credit banks, environmentalists and other stakeholders, who can be involved in planning processes as well as have an opportunity to learn from each others' knowledge and experience.
- Ensure that the project fits within national policy priorities (as long as they are morally defendable).
- Train local people at an early stage, which will enable them to lead the project as part of their national development plan.

All these will provide higher probability for success.

Synthesis on the Opportunities for IPI in Agricultural Extension

- IPI is a highly specialized entity that manages the knowledge of one specific plant nutrient: Potassium (K). As such, IPI plays a vital role in the optimized use of potash fertilizers by farmers, helping them to increase their income from agriculture. Appendix 2 features two accounts of successful involvement of IPI in extension intervention.
- K-fertilization is a vital part of balanced plant nutrition; however its assessment is complicated and farmers often fail to correctly recognize and attribute the beneficial effects of potassium.
- Balanced plant nutrition contributes to poverty alleviation through optimizing sustainable crop production.
- Spreading specific extension messages can be done through special campaigns, and capacity building

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Farmer in Vietnam reporting on nutrient management in maize. 2007. Photo by IPI.

aimed at dealers, advisors and groups of farmers who learn through experiments and frequent training.

Within this context, IPI:

- with its central role in the potash knowledge and information system, functions through regional coordinators, who mediate between farmers' needs, researchers' findings and the interests of other stakeholders (e.g. extension providers);
- translates research results and field experiences into a set of "best practices";
- conducts applied research to constantly generate validated results under different soil, crop rotation, climatic and socio-economic conditions;
- cooperates with existing extension field services, mainly at the level of subject matter specialists and at training institutions, in order to serve smaller farmers;
- emphasizes in-service training of trainers and farmers and long-term capacity building within its activities, in order to help build social capital;
- publishes scientific reports for researchers and subject matter specialists in extension organizations, popular articles for extension workers and literate farmers, and flyers using pictures to convey messages for non-literate farmers, especially those attending farm days and demonstration plots;
- strives to develop partnerships with other stakeholders for developing and participating in extension initiatives using advanced technologies to disseminate the messages widely.

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IPI special web collation on Extension and Delivery of knowledge is updated regularly with relevant information. IPI's web site can be searched by language (22), or crop, or free search.

The paper "The Role and Function of Agricultural Extension" appears also at:

IPI K Centre - Extension & Delivery of Knowledge

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Appendix 1: Successful Training Models

GADD: The Ghana Agro-Dealer Development Project

One of the central objectives of GADD is to provide capacity building to 2,200 agro-dealers. So far some 600 agro-input dealers have received their Basic Training Certificate and were recognized by the Ministry of Agriculture as certified agro-dealers. The certificate is awarded to those who attend a three-day technical and business management training course. In this short course, the dealers learn about traditional and modern methods of information delivery using ICT. Course participants learn how to obtain acreage intentions of farmers prior to a cropping season, to estimate from this data the input requirements and to convey these to the respective service providers. The dealers are encouraged to obtain information on the volumes harvested. Special attention is given to the setting up of sales points for the last-mile delivery of goods. These points should also serve as a first-mile request point for information, goods and services.

As another incentive, certificate holders have access to a loan from the Unique Trust Bank, which is guaranteed by the Ghana Agro-Input Dealers' Association. As a result, agro-dealers are able to "set up their own shop" or enlarge their business. GADD is working to increase the number of agro -dealers in rural areas so that farmers do not have to travel such long distances to purchase inputs.

DAESI: Diploma in Agricultural Extension Services for Input Dealers in India

The 280,000 Indian agro-input dealers have, on average, a higher formal education than their Ghanaian peers, but none are trained in agriculture. Generally, Indian dealers also have useful information on market conditions and credit opportunities. However, these dealers have insufficient knowledge on the laws relating to handling agricultural inputs and agriculture generally, and even less about agricultural extension. Yet, agro-input dealers often have closer contact with farmers than extension advisers. With this context in mind, MANAGE - the National Institute of Agricultural Extension Management in Rajendranagar, Hyderabad - has initiated a special one-year diploma course for input dealers who had 12 years of education (many of these have a university degree, but not in agriculture).

The course methodology is based on a Distance Education mode with classroom interactions and field visits on 48 Sundays. Course participants are supplied with study materials; they use multi-media instructional devices and receive support from resource personnel.

The DAESI course covers four blocks:

1. *Agro-technical Topics:* Agro-climatic conditions; soils and soil analysis; Integrated Nutrient Management; manures and fertilizers; crop production technology for all crops grown in the district, including high-value horticultural, vegetable and floricultural crops; plant protection with an emphasis on Integrated Pest Management; farm mechanization.
2. *Extension:* Extension and communications methods (demonstrations, field trials, exposure visits and farmers' training); mass media (the role of radio, TV and print media; information technology and cyber extension).
3. *Individual Development:* Principles of business management, business ethics (creating a "win-win" relationship with farmers), financial management, and community organization. More recently, the importance of meditation for mind control and thought processes have been added.
4. *Laws Relating to Agricultural Inputs:* Laws relating to seeds, fertilizers, pesticides and other agricultural aspects, as well as Acts on consumer protection.

The organizers of the course expect that course participants will develop the technical capacity and communication skills to be able to impart appropriate technical advice to farmers. At the same time, diploma holders should be aware of their regulatory responsibilities.

The course is evaluated by conducting six bi-monthly tests, half-yearly and annual examinations with questions requiring descriptive answers and a final practical examination consisting of skill demonstration. Course participants have to maintain a record book for all practical classes. Those participants who successfully complete the course receive a Diploma

IPI's training course on fertigation for farmers in Egypt. Photo by M. Marchand.

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Farmers participating in the IPI-PAU-KVK program in Punjab. 2004. Photo by P. Imas.

in Agricultural Extension.

The DAESI program is constrained by the course fee of 20,000 Rupees (approximately US$400) - a large sum for small dealers in rural areas of India. Financial support is sought from the government, and multi-national companies who employ local dealers. A further concern has been expressed over whether it should become compulsory to have a diploma before one obtains a license to become an agro-dealer. In a national workshop held in 2005, the individual responsible for extension in the Indian Ministry of Agriculture expressed his opinion that this issue should be reviewed after training 30-40 percent of dealers. So far, 1,500 agro-input dealers (5.3 percent of the target group) have received the Diploma in Agricultural Extension. As a next step, all State Agricultural Universities are expected to offer the DAESI course and use its reference materials. This could also help to lower the course fee.

Farmer Field Schools (Van den Berg and Jiggins, 2007)

Farmer Field Schools (FFS) were first developed in 1989 in Indonesia to train farmers how to control the main pest in rice (*Nilaparvata nuglens*), using Integrated Pest Management methods. Groups of farmers meet once a week in one farmer's field to discuss their observations. Farmers are supported by professionals, but also encouraged to learn from peers and to develop their own experiments. By 2005, FFS programs had been initiated in 78 countries with a total of around four million graduates (90 percent in Bangladesh, China, India, Indonesia, Philippines and Vietnam). Over the last 15 years, the FFS approach has been adapted to other agricultural commodities, soil fertility management, aquaculture and others. The educational approach is interesting because unlike most extension practices, farmers are not "told" what to do; farmers learn from each other, under the guidance of an extension adviser.

Appendix 2: Success Stories of IPI Involvement in Extension

The Transfer of Technology by an IPI Project in India Helped Farmers to Improve Yield and Profits

(by Dr. M.S. Brar, Punjab Agricultural University (PAU), Ludhiana, India)

Although only covering two percent of the geographical area of India, Punjab state contributes more than 50 percent of the country's food grain. As a result of highly intensive agriculture with 186 percent cropping intensity, Punjab soils are now under fatigue and multiple nutrient deficiencies are emerging. Farmers in Hoshiarpur district of Punjab are growing three crops in maize-pea (green)-sunflower rotation. Soil test reports of this area show that 78 percent

Rice farmers participating in a group discussion over SSNM. Philippines. 2008. Photo by H. Magen.

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of soils are low to medium in available potassium (K). With the exception of potato, almost no K is applied to any crop. The application of negligible amounts of K is considered as one of the major constraints on higher production of crops in the area.

IPI in collaboration with Krishi Vigyan Kender, KVK (Agricultural Science Centre) of Punjab Agricultural University decided to lay out demonstration cum research trials at KVK farm Bahowal (Hoshiarpur) and in farmers' fields in different villages. The demonstration at KVK farm acted as a nodal point for showing farmers the benefits of K application on crop growth and yield. In addition, various presentations and sessions regarding the role of K to improve yield and quality were delivered by the IPI Coordinator for India in collaboration with partners. Experiments conducted in the farmers' fields acted as a catalyst for the adoption of the technology by farmers visiting the demonstration plots and seeing the results, as they were then convinced about the usefulness of K application to crops.

The results of the experimental cum demonstration plots showed that on average the sunflower yield increased from 10 q ha^{-1} (without K) to 15 q ha^{-1} with the application of 60 kg K_2O ha^{-1} (a 50 percent increase). Similarly, oil yield increased from 4.2 q ha^{-1} to 6.4 q ha^{-1} and the benefit to cost ratio was 14.7:1.0 with farmers obtaining extra net return of Rs. 6,840 per ha (US$150). The results were so encouraging that Punjab Agricultural University included the application of 60 kg K_2O ha^{-1} to sunflower in its book "Package of Practices for Crops" for the benefit of farmers.

The maize grain yield, on average, increased from 40.9 q ha^{-1} (without K) to 47.5 q ha^{-1} with the application of 60 kg K_2O ha^{-1} (a 15 percent increase). The benefit to cost ratio was 12.9:1.0 and farmers achieved an additional income of Rs. 5,940 per ha (US$130). Between maize and sunflower crops, farmers were encouraged to grow an extra crop of (green) peas. The peas are sold as green pods and farmers receive a good return in a short period. Farmers do not normally apply K to green peas. However, there was a substantial increase in the yield of fresh pods with the application of K, which not only improved the yield of fresh pods from 35.2 q ha^{-1} to 41.1 q ha^{-1} (a 17 percent increase), but also increased the length and development of the pods thus fetching a higher price for the produce and providing a higher profit to the farmers. The benefit to cost ratio was 15.3:1.0 and farmers achieved an additional income of Rs. 7,080 ha^{-1} (US$157). The project is an excellent example of how farmers can benefit from technology transfer using extension methods implemented in their fields.

An Extension Success Story from Southeast Asia in which IPI is Involved

Adapted from Palis and Gabinete, 2008. IPI has been supporting SSNM since 1997. The last phase of this project, 2009-2012, focuses on large-scale dissemination of the SSNM technique.

This is a case-study of a Filipino rice farmer, Mr. Johnny Tejeda, who took the risk of deviating from the traditional method of applying fertilizers by practicing site-specific nutrient management (SSNM), a new way of applying fertilizers. In 2007, IRRI scientists led by Dr. Roland 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 demonstration plot was 100 m². According to Johnny, while the experiment was on-going, he quietly imitated the SSNM practice in the remaining larger portion of his field of about 1.2 ha. His farm neighbor, an agricultural technician, told him that SSNM validation experiments had worked in other villages. This farm neighbor gave him the SSNM recommendations. Trusting his farm neighbor, he took the risk because of the rising prices of fertilizers, the increasing cost of living, and the opportunity to improve his rice yield.

"When I first practiced SSNM in the 2007 wet season, I was not able to sleep well for around ten 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 ten days, I was uneasy and kept moving around the rice fields in the village, comparing the growth of the rice plants. But ten 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 to take a balanced food or diet before "vitamins" or urea were supplied."

Typically, in Southeast Asia, SSNM can increase rice yields by at least 10-30 percent. More similar projects are needed, using the same model of science-based research, validation, and large-scale dissemination. ■

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The Role of Extension in Bulgaria in Increasing Agricultural Productivity - Experience over the last 20 Years

Nikolova, M.[(1)]*, and D. Donchev*[(2)]*.*

Farmers' meeting with extension officers, Troyan, Bulgaria. 2009. In recent years these types of meetings are regularly conducted throughout the country. Photo by M. Nikolova.

Agriculture and forestry are important sectors in the Bulgarian economy making a significant contribution to the country's GDP, exports and employment. The total land area of Bulgaria is 111,000 km^2, of which 50.9 percent (5.7 million ha) is devoted to agriculture. In 2009 the utilized agricultural area (UAA) was 5.3 million ha covering 45.3 percent of the country's landmass, the arable area making up 3.12 million ha. Permanent grasslands, meadows and orchards account for 34.2 percent of the UAA and permanent crops, 3.3 percent. Most of the agricultural land area is used for cereal production (over 50 percent of the arable land), and the cultivation of sunflower, oilseed rape, potatoes, vegetables (tomatoes, cucumbers, peppers, cabbages), vineyards, orchards (apples, plums, peaches, cherries, apricots) accounts for the rest.

In the days of socialist control, the big collective farms had sufficient agricultural specialists – agronomists, livestock breeders, economists and engineers. Some elements of advisory services were developed but they were not systematic. The most effective service was organized for fertilizer recommendations. At that time, the state subsidized the monitoring of soil nutrient status, and fertilizer recommendations were based on the soil analytical data. However, because of the absence of both private land ownership and a market economy, fertilizer recommendations were not well implemented.

During the transition to a market economy the collective farms were disbanded and the land restituted - a development which created significant fragmentation in land ownership. The average size of agricultural plots is now 0.62 ha and the number of registered farmers in Bulgaria is over 91,000. Approximately 97 percent of the total number of farms are small, between 0 and 4 economic units (*Note*: A European economic unit (EEU) is a measurement of the difference between gross agricultural product and the cost of production; 1 EEU = 1,200 Euro), but they cultivate only 18.2 percent of the agricultural area. At the same time, 0.4 percent of the total number of farms are large-scale (over 40 economic units), and they cultivate 67.8 percent of the total agricultural area.

The new farmers emerging after disbandment of the collective farmers lacked knowledge and experience in farming. This disadvantage, together with the accompanying economic constraints affecting all the agricultural practices, depressed production. For example, fertilizer usage dropped significantly. Compared to the years before the reforms, fertilizer usage was lower by about five times for nitrogen, 10 times for phosphorus and up to 50 times for potassium. These lower rates of fertilizer consumption were reflected in yield decreases in all the main crops. There was thus a clear need for developing a system for an agricultural advisory service for the new agricultural producers.

In the late 90s in Bulgaria, the development of a system for agricultural advisory services was started under the EU PHARE projects (The PHARE program is one of the three pre-accession instruments financed by the European Union to assist the applicant countries of Central and Eastern Europe in their preparations for joining the European Union) and in 2000, a National Agricultural Advisory Service (NAAS) was established under the Ministry of Agriculture. NAAS activities began in 2001 which marked the beginning of a professional

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In this document the terms "extension" and "advisory" are used as synonyms.

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extension service in Bulgaria. NAAS has a central department in Sofia with 27 area offices, one in every regional centre of the country in which agronomists, livestock breeders and economists are employed. A well equipped analytical laboratory for soil, plant, forage and water analyses was also set up.

NAAS's mission statement is to support state policy implementation in the agricultural sector as well as the achievement of the Ministry of Agriculture and Food priorities and goals for carrying out effective and competitive agriculture in Bulgaria by providing qualitative up-to-date and useful information and technical assistance to the farmers. The national advisory services aims to benefit the customer (the farmer) and create value on the farm.

The versatile activities of NAAS focus on various topics depending on priorities. Before EU accession, the main areas of interest were directed to the preparation of Bulgarian agriculture to EU standards:

- Common agricultural policy explication
- Grain production development
- Restoring and establishing of fruit orchards
- Balanced fertilization and soil fertility
- Quality live-stock production
- Organic farming
- Assistance to producers groups foundation
- Assistance to agricultural accounting.

In its work, NAAS applies most advisory methods and tools including specialised technical advice, knowledge and information dissemination, field trials, demonstrations, seminars, development of projects, education, training and courses. NAAS also provides the link between research and practical farming and participates in international projects involving knowledge transfer.

Fertilizer use in Bulgaria, 1990-2009.

Year	N fertilizers		P fertilizers		K fertilizers	
	kg ha^{-1} N	*mt*	*kg ha^{-1} P_2O_5*	*mt*	*kg ha^{-1} K_2O*	*mt*
1990	85.1	395,900	14.5	67,700	2.3	108,400
2000	30.9	155,400	3.4	21,400	0.5	1,100
2009	35.3	177,600	6.1	30,700	2.4	11,800

For example, the "Balanced fertilization program" was developed using the advisory methods and tools mentioned. An important precondition for its success was the training of all NAAS agronomists in plant nutrition, soil testing, and fertilizer recommendations. Later the NAAS experts organized and provided training to local agricultural producers. The Central NAAS department also published several brochures devoted to balanced fertilization and best fertilization practices, as well as specificity of N fertilization etc. Local experts regularly prepare information bulletins, calendars etc., focused on present day problems. The experts also assist farmers in taking soil samples and in providing fertilizer recommendations. Demonstrating the advantages of site specific fertilization based on soil analyses has been particularly effective especially as the samples are analyzed free-of-charge at the NAAS laboratory.

A very impressive means of implementing good fertilization practices has been achieved by carrying out demonstration trials with different fertilizers and crops. Such trials have been conducted mostly in collaboration with IPI on various crops including wheat, barley, sunflower, oilseed rape, potatoes, cherries, peaches, and grapes. Events with farmer groups have been held to present and discuss the results of these field experiments. Annually 10-15 seminars devoted to balanced fertilization have taken place. Some of these meetings with farmers were organized under the IPI umbrella whereby a number of very attractive and effective seminars were held. On these occasions, Dr. Thomas Popp, IPI Coordinator for Central and Eastern Europe, presented IPI activities in general as well as the work of IPI in Bulgaria. He also gave lectures devoted to balanced fertilization and the effect of potassium in different trials carried out across the country. IPI has also published several brochures in Bulgarian about the effect of potassium fertilization on different crops including cereals, sunflower, potatoes, tobacco, vegetables, fruit crops, and vineyards. These brochures have been disseminated free-of-charge. In particular, the IPI Research Topic No 18 "Potassium – nutrient for yield and quality" has proved to be very popular among farmers, agronomists and students. A second revised edition was published in 2010 (see on IPI website).

Special attention has also been paid to fertilization research in Bulgaria. From evidence of an inadequate amount of research on the effect of potassium on vine and fruit crops a special seminar "Balanced fertilization of fruit plants and vine" held in Plovdiv, 2003 was organized by IPI and NAAS with Bulgarian and invited scientists from Hungary and Germany working on fertilization issues. During the seminar, the research achievements in balanced fertilization for these crops were presented and discussed and the needs for future investigations were outlined.

Thanks to the NAAS extended balanced fertilization program supported by IPI, farmers have gradually been convinced of the benefits of site specific fertilization so that the demand for soil testing increased 6.5 fold during 2001-2007. After a prolonged period of low application, a tendency for significant

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increase in phosphorus and potassium application was registered. In 2009, the use in phosphate fertilizers was 3.6 times and in potash fertilizers 5.1 times greater than in 2001.

Fertilization has been optimized for the main crops, with P and K rates per unit area for wheat and maize being doubled and those for sunflower increased four-to-five times. It is known that fertilization is not the only factor affecting the yields but it is a powerful factor and a clear tendency for increasing or stabilizing yields in main crops has been observed. For the same period (2001-2007) the average yield increase for wheat was 20 percent, maize 10 percent and sunflower 29 percent.

After EU accession, NAAS priorities have been aligned to the implementation of EU Common Agricultural Policy and the Rural Development Program (RDP) for 2007-2013 in Bulgaria - the main program document relating to utilization of EU funds. According to the Bulgarian RDP, NAAS is the single beneficiary under measure 143 "Provision of farm advisory and extension services in Bulgaria and Romania". NAAS orientated its responsibilities primarily to business plans and application form preparation for new measures including the following themes: Support for young farmers, Supporting Semi-Subsistence Farms Undergoing Restructuring, Setting up Producer Groups, Agri-environmental Payments, Modernization of Agricultural Holdings, Diversification with Non-agricultural Activities; Improving the Economic Value of the Forests; and Adding Value to Agricultural and Forestry Products. NAAS experts also provide farmers with advice, information and consultations as to how to achieve the objectives of the business plans. Unfortunately in 2007 the NAAS laboratory was closed because of political reasons and no longer offers free soil analyses and recommendation services to the farmers. Some other university and institute labs carry out soil analyses but are limited in number and do not provide a systematic approach.

Experimental plot by the Extension Service, Bulgaria. Photo by M. Nikolova.

Recently the new NAAS administration has realized that there is still a need to increase producers' knowledge concerning fertilization practices in the country. The farmers still prefer to use nitrogen whereas phosphorus and especially potassium application is low. Over the last two years the unfavorable $N:P_2O_5:K_2O$ ratio of 100:17:8 has been reported. Moreover, nutrient balances are negative – the national deficiency in 2009 is about 90,000 mt for nitrogen, 105,000 mt for phosphorus and 244,000 mt for potassium. NAAS and the other consultants (universities, institutes, and private sector) therefore need to put more effort into improving fertilization practices. A valued contribution in this respect is the International Plant Nutrition Institute (IPNI) project for Bulgaria titled "Best management practices for sustainable crop nutrition in Bulgaria" of which the main project goals are:

- to develop a nutrient management software with the objective of advising farmers;
- to train and teach farmers and students good fertilization practices;
- to contribute to improving fertilization practice in the country.

An important development for the successful implementation of the project is the new change in policy in guidance from the Ministry of Agriculture in providing practical support for farmers. The NAAS analytical laboratory is also in the process of being re-established. NAAS, in cooperation with national universities and institutes, will once again be able to provide a program devoted to balanced fertilization. ■

The paper "The Role of Extension in Bulgaria in Increasing Agricultural Productivity - Experience over the last 20 Years" appears also at:

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Rootstock Efficiency in Nutrient Uptake and Utilization in a High Density Cherry Orchard Experiment: A preliminary report from the results of three years findings of the use of the cultivar 'Petrus' on four rootstocks with special reference to potassium

Hrotkó, K.[(1)], *L. Magyar*[(2)], and *M. Gyeviki*[(2)].

'Rita' trees on Gisela 6 rootstock. In background 'Petrus' on vigorous P. mahaleb. Hungary. Photo by K. Hrotkó.

Introduction

Maintaining optimal potassium (K) supply is important in cherry orchards (Hanson and Proebsting, 1996), because this nutrient plays an important role in carbohydrate transport. The cherry fruit accumulates relatively large amounts of potassium and it is for this reason that inadequate supply in cherry orchard soils may lead both to low yield and quality of fruit. The current trend in increased planting of high density orchards (Hrotkó *et al.*, 2007; Musacchi 2010), emphasizes the importance of maintaining optimal nutrition.

In high density orchards the young trees planted are heterografts. These are composite trees which consist of two different parts, in which the scion of one cultivar is grafted to the rootstock of another. The rootstock, which forms the root system of the tree, is responsible for the uptake of mineral nutrients from the soil. From the literature, rootstocks may be selective in nutrient uptake and transport, whereas the scion may influence the xylem flux, which results in different concentration of nutrients reaching the leaves and fruits. For example, Ystaas and Frøynes (1995, 1998) found that the leaves of trees on *Colt* rootstock had lower nitrogen (N) and K, and significantly higher calcium (Ca) and magnesium (Mg) contents than those of trees on control *Mazzard* rootstock. Also the leaf phosphorus (P) content in seven out of nine rootstocks (*Colt*, *Camil*, *Inmil*, *Weiroot 10*, *Gisela 1*, *Gisela 5*, and *Gisela 10*) was significantly lower than those from trees on control *Mazzard* rootstock. Hrotkó *et al.* (1997) found higher N, P and K contents in leaves of trees on moderately vigorous *M x M 14, M x M 97* rootstocks, compared to vigorous *Mahaleb SL 64* and *Colt*. Ca and Mg leaf contents were also higher in trees on vigorous rootstocks. Data from Roversi *et al.* (2008) also confirms the importance of rootstock in determining leaf mineral composition of sweet cherry trees. Large differences in leaf mineral composition of sweet cherry trees were also reported by Seker *et al.* (2008). In the region in which the present study was carried out, trees on *P. mahaleb* and *Gisela 6* rootstocks proved to have high content in N, P, K, Mg and Iron (Fe).

In order to predict fertilizer requirements for high density sweet cherry orchards in which new hetrographs are being grown, several aspects have to be considered:

- possible variability in mineral composition of leaves and fruits of cultivars (Roversi *et al.*, 2008);
- rootstock differences in mineral uptake and mineral composition of wood, leaf and fruit;
- data on nutrient quantities taken up and incorporated by the tree are not available; tree mass, and amounts of pruning wood are different compared to traditional orchards;
- the fertilizer need of grass in the alleyway as well as that of the trees must be taken into account.

Our investigation aimed to study the mineral composition of leaf, fruit, root and wood of sweet cherry trees budded on different rootstocks in order to establish their mineral uptake, distribution and utilization in high density orchards in Hungary. As well as providing information for possible

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different mineral nutrient features of these rootstocks, our results may also contribute to improving fertilizer recommendations specifically for sweet cherry orchards. In this publication we give an overview of the results of experiments carried out during 2007-2009 using different rootstocks and cultivars and provide a preliminary report of the findings of one cultivar 'Petrus' grafted on four different rootstocks. We acknowledge, with thanks, the support of the International Potash Institute (IPI).

Materials and methods

The experimental orchard is planted at Soroksar Station, the experimental farm of the Faculty of Horticultural Science, Corvinus University of Budapest. The farm is located southeast of Budapest. The soil is calcareous and sandy with a lime content around 2.5 percent and a pH of 7.7. Soil compactness index (K_A) is 24 (low). The climate is typical of the central Hungarian plain, meteorological characteristics on average for the fourteen years (1991-2004) were as follows: Yearly temperature is 11.3°C, total sunshine is 2,079 hours in a year, and rainfall is 560 mm year^{-1}. Trees were planted in the orchard in spring 2004.

The trees were planted at a spacing of 4 x 2 m, i.e. a density of 1,250 trees ha^{-1} (Photo 1). Each experimental plot consisted of three trees. Each plot was from different rootstock/scion combination, and replicated six times. The setup was randomized. The trees are trained to Hungarian Cherry Spindle (Hrotkó *et al.*, 2007; Photo 1); in the alleyway naturally grown grass is managed by mowing. Drip irrigation was installed in the orchard providing 60-120 mm water during fruit growing until ripening, the quantity varying depending on the rainfall.

In autumn 2007 (September) soil samples at nine points within the orchard were taken and measurements made according to Hungarian guidelines (MSZ – 08 0202-77). The following parameters were measured: pH (in KCl), soil compactness index (K_A), organic humus content, KCl-soluble nitrate and ammonium, Al-soluble P, K, and micronutrients. From the literature, P and K contents at upper soil depth (0-20 cm and 20-40 cm) were higher than optimum, while Mg content was around optimum (Szűcs, 2003). The decreasing P and K levels at different soil depth may be attributed to the slow movement of these nutrients in this soil. Even the deepest soil layer (40-60 cm) contained optimal nutrient levels of P, K and Mg, according to Szűcs (2003; Table 1). From these data it can be concluded that soil fertility conditions were optimal for cherry trees.

Table 1. Soil characteristics and nutrient level measured in the research plot.

Parameter	Value				
Soil depth (cm)	0-20	20-40	40-60	Mean	Optimum*
pH (KCl)	7.68	7.74	7.77	7.73	
Compactness index (K_A)	24	24	24	24	
Total salt content (%)	<0.02	<0.02	<0.02	<0.02	<0.1
$CaCO_3$ (%)	2.21	2.62	2.80	2.54	>1
Organic humus (%)	0.94	0.88	0.81	0.87	0.71-2.0
NO_2+NO_3-N (mg kg^{-1})	2.80	5.29	4.12	4.07	
P_2O_5 (mg kg^{-1})	424	339	309	357	100
K_2O (mg kg^{-1})	206	137	99	147	100
Mg (mg kg^{-1})	70	64	66	67	60

*Szűcs, 2003. *Source*: Soroksar, 2007.

Photo 1. *View of the sweet cherry orchard trained to Hungarian Cherry Spindle. 2008. Photo by K. Hrotkó.*

Leaf samples were collected from six trees from each rootstock at the end of the months of May, June, July and August, the samples being taken from the middle of long shoots (50-70 cm) from four sides of the tree.

Leaf N, P, K, Ca, Mg and Fe contents were measured using ground dry leaf samples. N, P and K were determined after digesting the dried samples (0.5 g) with 5 cm³ concentrated sulphuric acid (H_2SO_4) at 150°C. After cooling to room temperature, 5 cm³ 30% solution of hydrogen peroxide (H_2O_2) was added and boiled until clearing. For Ca, Mg, Fe, the ground dry leaf samples were digested at 105°C with 10 ml concentrated nitric acid (HNO_3) plus

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4 ml 30% solution of H_2O_2, which was boiled until clearing. The N content of the digestion solution was measured using a Tecator spectrophotometer with FIAstar flow injection system. The contents of the other mineral nutrient elements in the two digestion solutions were measured using ICP atomic emission spectroscopy (ICP Thermo Jarrell Ash ICAP 61E equipment).

Cultivars and rootstocks involved in the trial

During 2007-2009, thirty-two types of cultivar/rootstock combinations were tested (Table 2). 'Petrus' was tested on all eleven rootstocks, while the cultivars 'Rita', 'Vera' and 'Carmen' were tested only on seven of the rootstocks. Rootstock SL64 was tested only on 'Petrus'.

Some information about the cultivars and rootstocks is given below:

Cultivars (four):

1. 'Petrus'®; patented new Hungarian cultivar, ripens early (second cherry week), self fertile.
2. 'Rita'®; patented new Hungarian cultivar, ripens very early (first cherry week), needs pollinator.
3. 'Vera'®; patented new Hungarian cultivar, ripens medium to early (third cherry week), needs pollinator.
4. 'Carmen'®; patented new Hungarian cultivar, ripens medium to early (third-to-fourth cherry week), needs pollinator.

Rootstocks (eight):

1. Mazzard (*Prunus avium* L.); seedlings of selected virus-free seed tree clone C 2493.
2. SL 64 (*Prunus mahaleb* L.); selected clonal rootstock from France, widespread sweet cherry rootstock used all over the world. Vigorous, very productive, performs well on sandy soils.
3. Cemany (*Prunus mahaleb* L.); seedlings of selected seed tree.
4. Érdi V. (*Prunus mahaleb* L.); seedlings of selected seed tree.
5. Bogdány (*Prunus mahaleb* L.); clonal rootstock selected in Hungary, vigorous, very productive, more hardy than SL 64, performs well on light sandy soil.
6. Magyar (*Prunus mahaleb* L.); clonal rootstock selected in Hungary, moderate vigorous, very productive, more hardy than SL 64, performs well on light sandy soil.
7. Gisela 6 (*Prunus cerasus* x *P. canescens*, Gi 148/1); clonal rootstock from Germany, semi-dwarf, precocious, requires fertile soil and irrigation.
8. Prob (*Prunus fruticosa* Pall. *forma aucta* Borb.); clonal rootstock from Hungary, dwarfing, precocious, early senescence of trees is typical on this rootstock.

Table 2. Scion/rootstock combinations involved in the investigations.

Cultivar	'Petrus'			'Rita'		'Vera'	'Carmen'
Year	2007	2008	2009	2008	2009	2009	2009
Rootstock							
Gisela 6	<u>X</u>	<u>X</u>	<u>X</u>	X	X	X	X
Érdi V.			X	X	X	X	X
Cemany			X		X	X	X
Korponay			X		X	X	X
Egervár			X		X	X	X
SM 11/4			X		X	X	X
Mazzard	X		X	X	X	X	X
Prob	<u>X</u>	<u>X</u>	<u>X</u>				
Magyar	<u>X</u>	<u>X</u>	<u>X</u>				
Bogdány	<u>X</u>	<u>X</u>	<u>X</u>				
SL 64	X						

Note: <u>X</u> represents combinations from which leaf samples were taken.

The investigations were carried out in 2007 on leaf samples of 'Petrus'/Gisela 6, Prob, Magyar and Bogdány taken from May to August in every month. These were extended in 2008 with 'Rita' on three rootstock combinations (Table 2) and in 2009 with additional four rootstock combinations. In 2009, samples in all combinations were taken in August only, from trees of four cultivars (Petrus, Rita, Vera and Carmen) on 10 (for 'Petrus') and seven (for Rita, Vera and Carmen) rootstocks (Table 2). In this overview we have restricted the presentation of data to selected scion – rootstock combinations and years. Results of leaf analysis are presented for the cultivar 'Petrus' only (Table 2, Fig. 1 and 2).

Applied mineral nutrition

The fertilizing program applied in the orchard and the nutrient supply capacity of soil was uniform during the trial, matched with expected crop (Szűcs 1997, 2003). The following fertilizer quantities were applied in spring 2008 and 2009: N - 30 kg ha^{-1}, P_2O_5 - 10 kg ha^{-1} and K_2O - 50 kg ha^{-1}. The very low amounts of nutrients used were because the soil has a relative high nutrient status.

Results and discussions

Our results confirmed the literature data that there are significant differences in leaf mineral composition between trees on different rootstocks, however these differences are inconsistent and may alter depending on sampling date, and on year of growth. Furthermore, similar large differences are found between cultivars budded on the same rootstocks.

Changes in leaf mineral content during the season

Seasonal changes in leaf mineral contents on all rootstocks showed typical nutrient patterns as reported in the literature. Highest N contents were found in May, which gradually decreased towards the end of the growing season (Fig. 1) as also reported by Hanson & Proebsting (1996). Trees on dwarf *Prunus fruticosa* Prob showed the lowest leaf N-content, while higher N contents were present in leaves of

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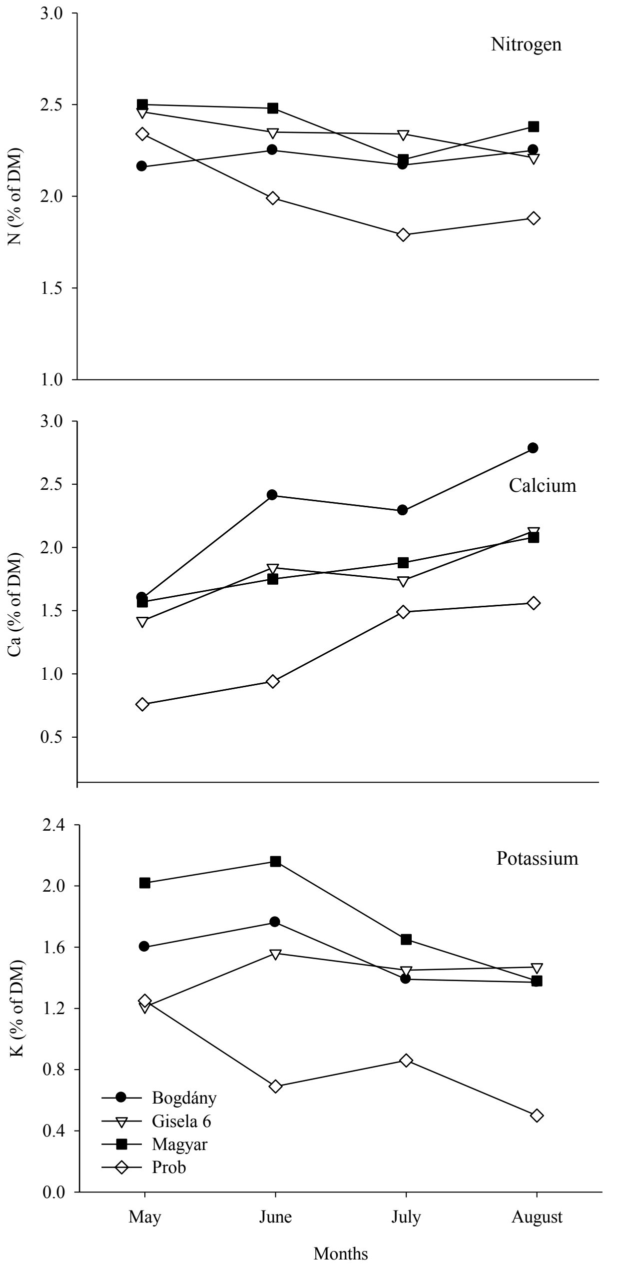

Fig. 1. N, K and Ca concentrations (% of DM) in leaves of 'Petrus' x four rootstocks in 2008 from May to August.

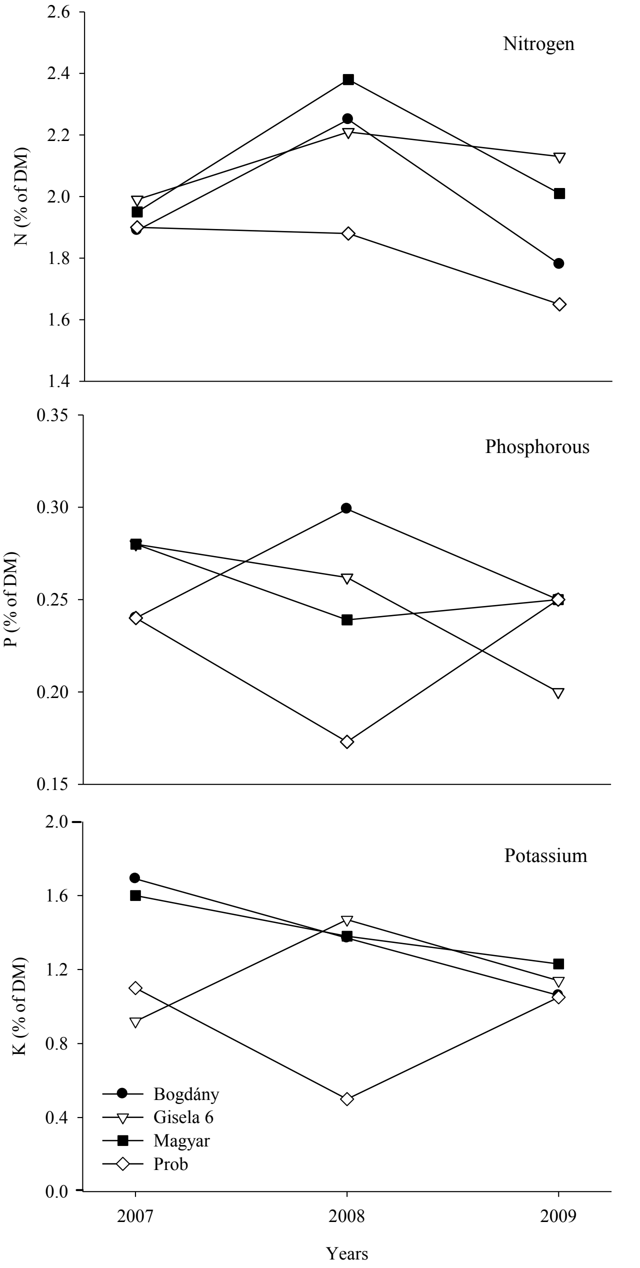

Fig. 2. N, P and K concentrations (% of DM) in leaves of 'Petrus' x four rootstocks in 2007-2009, leaves sampled in August of each year.

trees on vigorous *Prunus mahaleb* rootstocks. P contents were fairly constant from May to August. The leaf K content decreased, while Ca content increased during the growing season (Fig. 1) as might be expected because of the high mobility of K (like N) and the virtual immobility of Ca within plants. These data are important in terms of fertilizer practice because recommendations based on leaf analysis are made at the end of August when K leaf contents are at their lowest.

Effect of rootstocks on leaf mineral composition

Rootstocks might be expected to play an important role in determining leaf mineral content of grafted trees because to a large extent they control the nutrient uptake of the tree. However, in comparing leaf mineral composition of the same cultivar (Petrus) with 4 different rootstocks (all growing on the same soil), there was a lack of consistency between rootstocks and between years of sampling (Fig. 2). In the experiment as a whole, three conspicuous rootstocks, or rootstock groups showed more or less consistent performance. The leaves of trees on dwarf *Prunus fruticosa* Prob regularly

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Table 3. Leaf mass production in the 'Petrus' orchard (kg tree^{-1}; with 1,250 tree ha^{-1}) in 2008.

Rootstock	Fresh leaf mass	Dry leaf mass	Fresh leaf mass	Dry leaf mass
	--------*kg tree^{-1}*--------		--------*kg ha^{-1}*--------	
Gisela 6	2.71	0.70	3,387.5	875.0
Magyar	8.15	2.11	10,187.5	2,637.5
Bogdány	15.69	3.84	19,612.5	4,800.0

Table 4. Nutrients (kg ha^{-1}) used by trees to produce leaf mass (August samples) of 'Petrus' cherry orchards on different rootstocks at 1,250 trees ha^{-1} density in 2008.

Nutrient	Rootstock		
	Bogdány	Magyar	Gisela 6
	-----------*kg ha^{-1}*--------------		
Nitrogen	108	62.8	19.3
Phosphorus	14.3	6.4	2.3
Potassium	65.8	36.4	12.9

show the lowest mineral contents (N, P, and K), whereas those of trees on *Prunus mahaleb* rootstocks usually have mineral contents typical of well supplied trees, although large differences may occur from one year to another. Leaf samples of trees on Gisela 6 rootstock regularly contain the highest mineral levels (N, P, K), except for K (Fig. 2) in the first year 2007. We suppose that these trees had not developed their full root capacity at this stage. These results confirm Seker (2008), who also found higher mineral content of sweet cherry leaves on Gisela 6 in Turkey. It would appear that this rootstock is more efficient in mineral uptake and utilization and is similar to some *mahaleb* rootstocks.

Our results confirm the effect of rootstocks on leaf mineral content but further factors, including the degree of vegetative growth and crop load of the current year may modify mineral nutrient utilization and so too leaf mineral content.

In 2009, four trees on different rootstocks 'Petrus' (on Gisela 6, Magyar and Bogdány) and 'Rita' (on Gisela 6, Mazzard and Érdi V) received a double dose of fertilizer in spring. From the leaf samples collected in August from these trees only, Gisela 6 showed significantly higher nitrogen content which again confirms the higher uptake efficiency of this rootstock.

Nutrient use by trees on different rootstocks

The fertilizing program has a much larger impact on the rootstock usage in intensive sweet orchards when the nutrient use in biomass production is considered. Here we present only the leaf nutrient use for leaf mass production calculated for 2008.

Calculating the leaf mass produced on trees on different rootstocks showed differences much larger than those known from the literature when comparing the vigor by trunk cross-sectional area. The dry weight of leaf mass produced on vigorous Bogdány trees is more than five times larger than that of trees on dwarf Gisela 6 rootstock (Table 3).

Since the differences between rootstocks in leaf nutrient content are much smaller than those in the leaf mass production, nutrient use per hectare follows the trend of leaf mass production (Table 4). Note that this calculation does not consider the nutrient quantities taken up and incorporated by the tree (the tree mass, and pruning wood), which differs in trees depending on rootstock.

Of the K taken up by trees, large differences occur between rootstocks in distribution between leaves and fruits (Table 5). K use efficiency, as described in terms of the ratio between the yields produced (kg ha^{-1}) and the K used in leaves and fruit flesh (kg ha^{-1}), is also highly dependent on rootstock. Petrus trees on dwarf Gisela 6 produced 127 kg fresh fruit with 1 kg K taken up by leaves and fruits, whereas the comparative figure for trees on Bogdány were 43.5 kg. In this respect, an orchard planted with trees on Gisela 6 is three times more efficient. Since leaf analysis data are from the orchard in fifth leaf, this ratio is valid at the stage of development just as fruit bearing is beginning to take place.

We would like to emphasize that orchard efficiency also depends on economic considerations. Trees on dwarfing rootstocks like Gisela 6 should be planted at four-to-five times higher density (Lugli and Musacchi 2010) in order to achieve the same bearing surface, which implies a similar leaf mass per hectare, but less wood and root mass compared to vigorous rootstocks. On the other hand, the yield is relatively low with no more than 10-15 mt ha^{-1} in contrast to larger crops on vigorous rootstocks with good fruit size. Furthermore, under our site conditions, the general performance of these trees on dwarfing rootstocks is unsatisfactory. In our conditions the nutrient requirements of orchards on vigorous rootstocks, which tend to waste nutrients, should be considered.

Nevertheless the data achieved in our research project should provide a useful basis for establishing fertilizer programs for high density sweet cherry orchards.

Table 5. K use efficiency of 'Petrus' trees on different rootstocks at 1,250 trees ha^{-1} density in 2008.

Rootstock	K use in leaves	K use in fruit flesh	K use Σ in leaves and fruit flesh	Yield	Efficiency: Produced yield
	-------------------------*kg ha^{-1}*-------------------------				*kg kg^{-1}K used*
Bogdány	65.80	6.42	72.22	3,137.5	43.45
Magyar	36.40	7.34	43.74	3,400.0	77.74
Gisela 6	12.90	5.62	18.52	2,350.0	126.91

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Conclusions

Nowadays planting of high density orchards is becoming more common which emphasizes the importance of optimal nutrition. The cherry fruit accumulates relatively large amounts of K, and for this reason lack or low level of K in soils of cherry orchards may lead to low crop and low quality fruit. For high density orchards different rootstocks are preferred, the trees used being heterografts, or composite trees consisting of two different species. From the literature, rootstocks may be selective in nutrient uptake and transport, so that rootstock usage should be considered when planning fertilizing programs.

Our results confirm literature reports that there are significant differences in leaf mineral nutrient content between trees on different rootstocks. However these differences are inconsistent, with differences at specific sampling dates and variations from year to year. Furthermore, similarly large differences are found between cultivars budded on the same rootstocks. However, our results confirm the effect of rootstocks on leaf mineral content, although additional factors, such as vegetative growth and crop load of the current year, may modify mineral utilization and so too leaf mineral content.

The fertilizing program has a much larger impact on the rootstock usage in intensive sweet orchards when the nutrient use of biomass production is considered. Calculating the leaf mass produced on trees on different rootstocks showed differences, much larger than those, known from comparisons of vigor by trunk cross-sectional area. In this respect an orchard planted with trees on Gisela 6 is more efficient in nutrient utilization. However, under our site conditions, the general performance of trees and fruit size on dwarfing rootstocks is unsatisfactory.

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The paper "Rootstock Efficiency in Nutrient Uptake and Utilization in a High Density Cherry Orchard Experiment: A preliminary report from the results of three years findings of the use of the cultivar 'Petrus' on four rootstocks with special reference to potassium" appears also at:

Regional Activities/Central Europe

IPI Events

Recipients of the 2010 IPI-FAI award for "Promoting Balanced and Integrated Fertiliser Use with Emphasis on Potassium' were Dr. S.S. Yadav (second from left), Mrs. Abha Tikkoo (center) and Mr. Sultan Singh (second from right), all from CCS HAU Regional Research Station, Rewari, Haryana. Dr. S. S. Yadav and his team have done good work promoting K in southern Haryana under CCS HAU-IPI Coordinated Research Project. Also in the picture are Mr. E. Sokolowski (left), IPI Coordinator India, Dr. S.K. Bansal (right), Director PRII and Mr. H. Magen (third from right), Director IPI. Photo by IPI.

December 2010

Presentation of the Annual IPI-FAI Award for "Promoting Balanced and Integrated Fertiliser Use with Emphasis on Potassium", New Delhi, India. The Annual IPI-FAI Award is given to promote best extension of nutrient management (see photo above). ■

Autumn 2011

International symposium in Sri Lanka. The first circular will be made available in February 2011 on the IPI website. For more details please contact Dr. Baladzhoti Tirugnanasotkhi, IPI Coordinator East India, Bangladesh and Sri Lanka. ■

Spring 2012

IPI is preparing for an international symposium in South West China, with the tentative title "Potassium in Soil and Plant Systems".

More details will be available soon on the IPI website. ■

Other Events

February 2011

International symposium on Sensing in Agriculture in Memory of Dahlia Greidinger, 21-24 February 2011, Faculty of Civil and Environmental Engineering, Technion, Israel Institute of Technology, Haifa, Israel. The aim of this symposium is to review research and development in the fields of remote and direct sensing systems and their future operational support in assuring sustainable agricultural production.

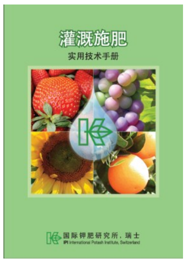
For more details see symposium website. ■

March 2011

The 9th New Ag International Conference & Exhibition, Semiramis InterContinental, Cairo, Egypt, 15-17 March 2011.

For more details see conference website. ■

Publications

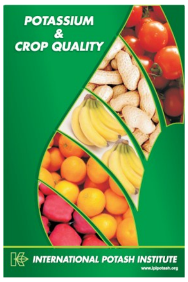


Technical Aspects of Fertigation. Edited by P. Imas, Tian Youguo and H. Magen. 2010. 8 p. Chinese. DOI: 10.3235/978-3-905887-04-4. Joint publication by IPI, National Agro-Tech Extension and Service Centre (NATESC) and the Soil Science Society of China (SSSC). This brochure, designed for farmers and extension officers, provides a quick reference to the use of fertigation at field level. It contains practical tables, figures and color pictures, demonstrating how to apply fertigation in the field. Download from IPI website, or order a copy from Dr. Tian Youguo, Senior Agronomist, National Agro-Tech Extension and Service Centre (NATESC), Ministry of Agriculture, P.R. China, 100026. ■

Balanced Fertilization: Potash for Higher Crop Yields and Better Quality. Edited by P. Imas and Tian Youguo. 2010. 8 p. Chinese.

DOI 10.3235/978-3-905887-03-7. In Chinese. Joint publication by IPI, National Agro-Tech Extension and Service Centre (NATESC) and the Soil Science Society of China (SSSC). This brochure, designed for farmers and extension officers, provides a quick reference for balanced fertilization with potash fertilizers and its benefits. It contains simple tables and color pictures, demonstrating the role of K in crop production. Download from IPI website, or order a copy from Dr. Tian Youguo, Senior Agronomist, National Agro-Tech Extension and Service Centre (NATESC), Ministry of Agriculture, P.R. China, 100026. ■

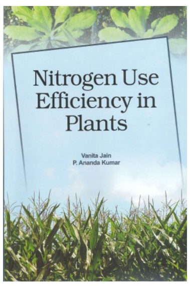
Publications



Potassium & Crop Quality. Compiled by M.S. Brar and P. Imas. 2010. 8 p. English and Hindi. This brochure, designed for farmers and extension officers, provides a quick reference for quality aspects of various crops as affected by potassium fertilization. Download from IPI website, in English or Hindi or order a copy from Dr. M.S. Brar. ■

Potassium Fertilization. Edited by Dr. Abdulrahman Al Moshileh. 2010. 6 p. Arabic. This leaflet describes with color photos the role of potassium fertilizers in crop production. Download from IPI website, or order a copy from Dr. A. Al. Moshileh, Qassim University, P.O.B. 6622, Buraydah 51452, Saudi Arabia,
Phone: 00505136402,
Fax: 0096663801360 ■

Other Publications



Nitrogen Use Efficiency in Plants. Edited by V. Jain and P.A. Kumar. 2011. New India Publishing Agency, New Delhi-110 088. ISBN 9789380235738. Chapter 6 of this book is on "Interactive Effects of Potassium and Nitrogen on Physiological Use Efficiency of Nitrogen and Crop Yield" by S. Umar, Anjana and M. Iqbal. ■

Comparação de técnicas analíticas para a extração de potássio de amostras de tecido vegetal com água e soluções ácidas concentrada e diluída. A.C.C. Bernardi, Sílvia Harumi Oka; Gilberto B. de Souza. Eclet. Quím. vol.35 no.2 São Paulo 2010. DOI: 10.1590/S0100-46702010000200005. Portuguese. This paper compares three forms of extraction of potassium (nitro-perchloric decomposition, extraction with water and extraction with diluted solution of HCl) of plant tissue samples of Tanzania grass (*Panicum maximum* cv. Tanzania) and alfalfa (*Medicago sativa* cv. Crioula). Download the full paper. ■

in the Literature

Effects of Three Commercial Rootstocks on Mineral Nutrition, Fruit Yield, and Quality of Salinized Tomato. D. Savvas, A. Savva, G. Ntatsi, A. Ropokis, I. Karapanos, A. Krumbein, and C. Olympios. Journal of Plant Nutrition and Soil Science. DOI: 10.1002/jpln.201000099.

Abstract:

Tomato (*Solanum lycopersicum* Mill. cv. Belladona F_1) plants were either self-rooted, self-grafted, or grafted onto the commercial rootstocks "Beaufort", "He-Man", and "Resistar" and grown in a recirculating hydroponic system. Three nutrient solutions differing in NaCl-salinity level (2.5, 5.0, and 7.5 dS m^{-1}, corresponding to 0.3, 22, and 45 mM NaCl) were combined with the five grafting treatments in a two-factorial (3 × 5) experimental design. At the control NaCl level (0.3 mM), fruit yield was not influenced by any of the grafting treatments. However, at low (22 mM NaCl) and moderate (45 mM NaCl) salinity levels, the nongrafted and the self-grafted plants gave significantly lower yields than the plants grafted onto He-Man. The plants grafted onto the other two rootstocks gave higher yields only in comparison with the nongrafted plants, and the differences were significant only at low (Beaufort) or moderate (Resistar) salinity. Yield differences between grafting treatments at low and moderate salinity arose from differences in fruit number per plant, while mean fruit weight was not influenced by grafting or the rootstock. NaCl salinity had no effect on the yield of plants grafted onto He-Man but restricted the yield in all other grafting treatments due to reduction of the mean fruit weight. With respect to fruit quality, salinity enhanced the titratable acidity, the total soluble solids, and the ascorbic acid concentrations, while grafting and rootstocks had no effect on any quality characteristics. The leaf Na concentrations were significantly lower in plants grafted onto the three commercial rootstocks, while those of Cl were increased by grafting onto He-Man but not altered by grafting onto Beaufort or Resistar in comparison with self-grafted or nongrafted plants. Grafting onto the three tested commercial rootstocks significantly reduced the leaf Mg concentrations, resulting in clear Mg-deficiency symptoms 19 weeks after planting. ■

Effect of Split Application of Potassium on Yield and Yield Component of Upland Cotton. Khalequzzaman, M.S. Mandol, M.F. Uddin, N.U. Ahmed, and M.G.G. Mortuza. Bangladesh J. Agric. And Environ. 6(1):59-66. June 2010.

Abstract:

Field trials of split application of potassium on cotton (*Gossypium hirsutum* L) were set up in Randomized Complete Block Design with three replications at the Cotton Research Farm, Sreepur and Jagaishpur during the year of 2007-08. There were five treatments viz.T_1=175 kg MoP/ha as basal (Control) T_2=50% MoP as basal + 50% MoP at 20 DAS, T_3=33% MoP as basal + 33% MoP as 20 DAS + 33% MoP at 40 DAS, T_4=25% MoP as basal + 25% MoP at 20 DAS +25% MoP at 40 DAS + 25% MoP at 60 DAS and T_5= No basal + 25% MoP at 20 DAS +

K in the Literature

25% MoP at 40 DAS + 25% MoP at 60 DAS + 25% MoP 80 DAS. Among the treatments, T_5 produced significantly the highest number of sympodia/plant, number of boll/plant, seed index and seed cotton yield (2.568 t/ha) followed by T_4 (2.267 t/ha) and T_3 (2.194 t/ha). Plant height, monopodia/plant, boll weight and GOT were found not significant. Location had also significant effect on plant height, number of monopodia/plant, number of sympodia/plant and boll weight. But yield performance was similar in both locations. However, interactions between location and treatment were not significant for any studied parameters. ■

Last Mile Delivery of Farm Technology: Approach and Suggested Model for Public Private Partnership. B.C. Marwaha. Indian J. Fert. 6(10):24-31.

Abstract:

Agriculture in India, having seen rapid strides in 80's, is at a cross road, with stagnating crop yields despite increased use of fertilisers and increasing cost of cultivation. Besides several factors responsible for such a situation, one major reason seems to be lack of information and effective communication – the last mile delivery of available farm technology, in a location specific manner, and poor use efficiency of most of the agri-inputs. This calls for coveted improvement in the quality of technical information and its last mile delivery. This paper describes various aspects of last mile delivery and approaches to overcome the situation, especially thorough Public Private Partnership (PPP). A suitable working model of PPP with targeted and result oriented approach is also suggested. ■

Significance of Nutrient Ratios in NPK Fertilisation in Rice-Wheat Cropping System in Indo-Gangetic Plains of India. B. Singh, and Y. Singh. Indian J. Fert. 6(10):44-50.

Abstract:

Recommendations for amount of fertilizer N, P and K to obtain optimum yields of rice and wheat in different states in the Indo-Gangetic plain show hardly any similarity in terms of ratios of applied $N:P_2O_5:K_2O$. Even when nutrient needs are based on crop removal and fertilizer use efficiency considerations, nutrient ratios do not have any relevance. In fact, there is hardly any relationship between nutrient ratios and food production or the pattern of NPK removal by crops. The deviation from the commonly recognized ratio of $N:P_2O_5:K_2O$ as 4:2:1 in administration circles and bias towards applying urea as compared to P and K to both rice and wheat is conspicuously visible in the ratios observed in different parts of the Indo-Gangetic plains. The data generated from long-term fertility experiments revealed that responses to N, P and K or partial factor productivity values for N, P and K were not found to be related in any manner with the $N:P_2O_5:K_2O$ ratios. In this paper relevance of $N:P_2O_5:K_2O$ ratios in fertilizer recommendations has been critically analysed in the context of fertilizer use on a field to region scale for achieving balanced supply of NPK as well as sustainable high yield levels of rice and wheat. ■

Read on:

- **Effect of zinc nutrition on growth, yield, and quality of forage sorghum in respect with increasing potassium application rates.** Moinuddin and P. Imas. 2010. Journal of Plant Nutrition, 33:2062–2081. ■
- **Phosphorus and potassium nutrition of cotton: interaction with sodium.** Rochester, I.J. 2010. Crop & Pasture Science, 61:825–834. ■
- **The top 100 questions of importance to the future of global agriculture.** Pretty *et al.*, 2010. International Journal of Agricultural Sustainability. 8(4):219-236. ■
- **Metabolite and mineral analyses of cotton near-isogenic lines introgressed with QTLs for productivity and drought-related traits.** A. Levi, A. Paterson, I. Cakmak and S. Saranga. 2010. Physiologia Plantarum. DOI: 10.1111/j.1399-3054.2010.01438.x. ■

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

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

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Potash Review

We call it Legacy, not History.

Between 1956 and 1995, for almost 40 years, IPI published the **Potash Review**, a collection of themed scientific papers, with many of the papers dealing with potash use in international agriculture.

These legacy documents are now available here on the IPI website, and can be searched by title, author, year and theme. We also have a free search which will search through the full text of each document in the database.

Prof. (Emer.) Uzi Kafkafi, from the Robert H. Smith Inst. of Plant Sciences and Genetics in Agriculture, The Hebrew University of Jerusalem, Faculty of Agriculture says that *"A new transformation of the practical reports, published in* ***Potash Review*** *for over 40 years, is once again bringing to life the basic agronomical knowledge accumulated in almost a century of*

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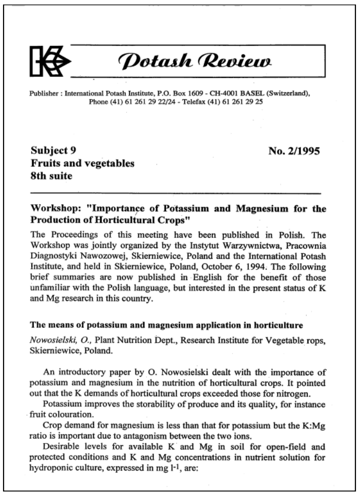
*advanced agricultural research. These reports are now easily accessible and the advanced search technology provides access to the whole **Potash Review** library. Basic information, needed by agronomists and growers, can now be retrieved quickly and accurately with the proper references. In this new format **Potash Review** can replace old plant nutrition books that are not easily accessible these days. In present, modern times, where most agriculture research centres are concentrating on genetic research, such basic agronomic knowledge is neglected*


Potash Review

Publisher : International Potash Institute, P.O. Box 1609 - CH-4001 BASEL (Switzerland), Phone (41) 61 261 29 22/24 - Telefax (41) 61 261 29 25

Subject 9 **No. 2/1995**
Fruits and vegetables
8th suite

Workshop: "Importance of Potassium and Magnesium for the Production of Horticultural Crops"

The Proceedings of this meeting have been published in Polish. The Workshop was jointly organized by the Instytut Warzywnictwa, Pracownia Diagnostyki Nawozowej, Skierniewice, Poland and the International Potash Institute, and held in Skierniewice, Poland, October 6, 1994. The following brief summaries are now published in English for the benefit of those unfamiliar with the Polish language, but interested in the present status of K and Mg research in this country.

The means of potassium and magnesium application in horticulture

Nowosielski, O., Plant Nutrition Dept., Research Institute for Vegetable rops, Skierniewice, Poland.

An introductory paper by O. Nowosielski dealt with the importance of potassium and magnesium in the nutrition of horticultural crops. It pointed out that the K demands of horticultural crops exceeded those for nitrogen.

Potassium improves the storability of produce and its quality, for instance fruit colouration.

Crop demand for magnesium is less than that for potassium but the K:Mg ratio is important due to antagonism between the two ions.

Desirable levels for available K and Mg in soil for open-field and protected conditions and K and Mg concentrations in nutrient solution for hydroponic culture, expressed in mg l^{-1}, are:

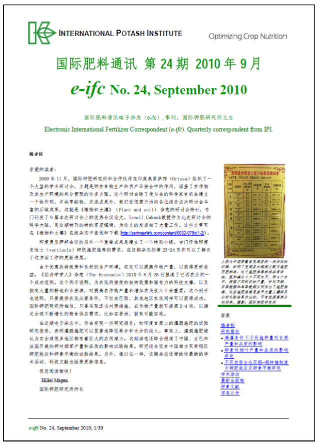
and the current generation of students has no real contact with the old accumulated wisdom. IPI deserves deep appreciation for the resurrection of this real basic knowledge in fertilizers and plant nutrition that otherwise would have been lost forever.”

This work was possible also with the support of **The Library Authority, Library of Agricultural, Food, and the Environmental Quality Sciences, The Hebrew University of Jerusalem, Rehovot, Israel.** We thank them for their support. ■

e-ifc Chinese Edition

At the time of publishing the *e-ifc* No. 24 edition (September 2010), IPI began translating the complete *e-ifc* to Chinese. This task has been undertaken by a team of dedicated scientists in China.

From January 2011, we will begin to post the [*e-ifc* Chinese edition] on the IPI website as well as various Chinese academic websites.


INTERNATIONAL POTASH INSTITUTE Optimizing Crop Nutrition

国际肥料通讯 第 24 期 2010 年 9 月

e-ifc No. 24, September 2010

国际肥料通讯电子杂志（e-ifc）,季刊，国际钾肥研究所主办

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

编者按

亲爱的读者：

2009 年 11 月，国际钾肥研究所和合作伙伴在印度奥里萨邦（Orissa）组织了一个大型的学术研讨会，主题是钾在食物生产和农产品安全中的作用，涵盖了农作物及其生产环境的养分管理的许多方面。这个研讨会除了使与会的科学家有机会建立一个协作网，并共享经验，交流成果外，我们还很高兴地向各位报告这次研讨会丰富的后续成果，这就是《植物和土壤》（Plant and soil）杂志的研讨会特刊，专门刊发了 9 篇本次研讨会上的优秀会议论文。Ismail Cakmak教授作为此次研讨会的科学大脑，是这期特刊的特约客座编辑，为论文的发表做了大量工作。这些文章可在《植物和土壤》在线杂志中查阅和下载（http://springerlink.com/content/0032-079x/1-2/）。

“The opportunity to provide the contents of the *e-ifc* in another important language, to many other potential readers is exciting and greatly adds to our existing activities in China” says Mr. Eldad Sokolowski, IPI Coordinator China.

Dr. Tian Youguo, Chief Editor of the *e-ifc* Chinese edition, says that although the substantial amount of work involved in turning the four annual issues into a Chinese newsletter is challenging, this new development for *e-ifc* provides an opportunity to bring this important publication to many Chinese scholars and to share agricultural research findings from different countries and experiences.

The people behind the *e-ifc* Chinese edition are:

Dr. Tian Youguo, National Agro-tech Extension and Service Center (NATESC), MOA, Beijing; Dr. Jia Xiaohong, Soil And Fertilizer Extension Service, Beijing Municipal city; Ms. Zeng Xiaoduo, Guangdong Institute of Eco-environment and Soil Sciences, Guangdong; Dr. Duan Yinghua, Institute of Soil and Fertilizer, Chinese Academy of Agricultural Sciences, Beijing; Dr. Tan Qilin, College of Resources and Environment, Huazhong Agricultural University, Wuhan; and Mr. Zheng Lei, National Agro-tech Extension and Service Center (NATESC), MOA, Beijing. ■

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