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IPNI
INTERNATIONAL
PLANT NUTRITION
INSTITUTE

Agronomic Research

Progress on NE Wheat, Maize, Rice and Soybean

Crop yield response reflects soil fertility after fertilization. The scientific basis for Nutrient Expert (NE) is from agronomic database compiled from numerous fertilizer field experiments, soil indigenous supply, and relationship between yield response and agronomic efficiency. The Nutrient Expert also considers crop rotation system and site-related information. The NE method can improve the yield and fertilizer use efficiency, and is regarded as an alternate fertilizer recommendation method when soil testing is not available or not timely.

In 2014, field validation and large scale demonstration for NE Wheat and Maize was conducted in 60 farmers' field in Heilongjiang, Jilin, Hebei, Henan, Shandong, Shanxi, and Ningxia. The NE training for large farmer holders and fertilizer dealers were conducted in Hebei, Henan and Shandong. Through agronomic analysis from large database, field validation and consulting and discussion meeting, beta-version for Nutrient Expert for rice and soybean has been developed. Field validation was also conducted for NE Rice and Soybean including 60 trials for single season rice, early rice, middle rice, and late rice, and 33 trials for soybean in Northeast China. Results from field validation indicated that Nutrient Expert increased yield by 21.0-7.8% for maize, 2.0-11.2% for wheat, 3.4-25.0% for rice and 9.2% for soybean. Farmer's profitability was also increased and nutrient use efficiency was improved greatly as compared with soil testing and farmers' practice.

From 2012-2014, 8 papers have been published related to Nutrient Expert based nutrient management principles and field validation, including 5 papers in *Field Crops Research*, 2 articles in *Better Crops with Plant Food*, 1 paper in *Journal of Plant Nutrition and Fertilizer*. In addition, a Special Issue on Nutrient Expert for wheat and maize has been produced in *Better Crops China* which included 10 articles on field validation of NE for wheat and maize conducted in Northern China.

Fig.2 Field Validation on Nutrient Expert Rice

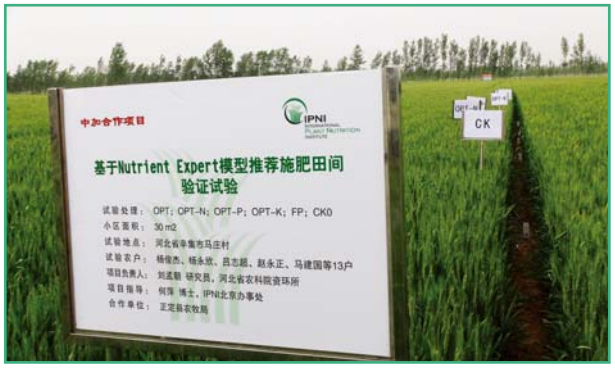


Fig.1 Long-term Field Validation on Nutrient Expert Wheat in Hebei Province

Fig.3 The Interface of Nutrient Expert Rice

Research on 4R Potassium Management Practices for Crops

In 2014 field trials were conducted to study on the effects of source, rate and timing of potassium application on yield and quality of two crops, i.e. sunflower (Gansu province and Inner Mongolia Autonomous Region (IMAR)), processing tomato (Xinjiang Autonomous Region). Following results were obtained:

Potassium application significantly increased total dry matter, seed yield, head diameter, 1000-seed weight, kernel rate, and oil content. In Gansu province, 16 of 20 sites, and all 20 sites in the Inner Mongolia Autonomous Region (IMAR), showed positive seed yield response to K with respective averages over K omission plots of 13.5% and 11.2%. Potassium application did not affect seed quality indices of oil sunflower in Gansu, while it significantly decreased content of saturated fatty acids, and increased contents of unsaturated fatty acid of edible sunflower seeds in IMAR.

The mean agronomic efficiency (AE) of K was 4.9 kg seed/kg K_2O in Gansu and 3.4 kg seed/kg K_2O in IMAR.

In Gansu, average indigenous K supply was 309 kg/ha, and average productivity was 3,799 kg/ha. In IMAR, average indigenous K supply was 176 kg/ha, and average productivity was 3,050 kg/ha. The average N, P and K required for producing 100 kg of oil sunflower seed was 4.1 kg N, 2.2 kg P_2O_5 and 10.2 kg K_2O. Similarly, the requirement for producing 100 kg of edible sunflower seeds was 3.6 kg N, 0.6 kg P_2O_5 and 7.7 kg K_2O.

There was a significant relationship between total plant accumulated K and seed yield. Also significantly positive linear relationships existed between K accumulation of seeds and seed yields. These relationships can be a reference for fertilizer K recommendation at a target yield for oil and edible sunflower.

No significant differences for seed yield, total K uptake, disk diameter, 1000-seed weight and kernel rate between sources and times of K application. Source and timing of K application did not significantly affect seed quality indices of oil sunflower in Gansu, while K_2SO_4 produced higher oil content and saturated fatty acid, and less unsaturated fatty acid than KCl for edible sunflower in IMAR.

Fig.4 On-farm Trials of K Response in Sunflower in IMAR (above) and Gansu (below)

Fig.5 Experiment on Source and Ttiming of K Application in IMAR (above) and Gansu (below)

An experiment on the interaction between K rate and water regime conducted for edible sunflower in IMAR found that drip irrigation produced the highest total dry matter, seed yield, disk diameter, 1000-seed weight, kernel rate, and total uptake of K and Cl^-. This treatment was followed by rainfed plastic mulch practices and then rainfed without mulch. The average AE for K was 4.3, 3.0 and 1.0 kg seeds/kg K_2O for sunflower with drip irrigation, rainfed plastic mulch, and rainfed without mulch, respectively. Agronomic efficiency for K decreased with an increase in K rate. The better the water supply the higher the content of saturated fatty acid, and in contrast, the lower the content of unsaturated fatty acid. Potassium rate did not influence seed quality indices except fiber content which decreased as K rate increased.

Split application of KCl alone or combined with K_2SO_4 produced more fruit yield than with all the KCl applied basally in the fall. Application of 50% of the K recommendation as KCl after flowering resulted in more agronomic efficiency (AE), more profit and higher value-to-cost ratio (VCR) than the treatment with 50% of the K recommendation as K_2SO_4 after flowering. Application 50% of the K as K_2SO_4 at flowering and fruiting stage resulted in higher total acid, color difference and lycopene content than application of KCl alone.

Later application of K fertilizer increased K accumulation by tomato plants. Application of 50% of the K as KCl basally in fall plus the remaining K as K_2SO_4 at flowering and fruiting stages resulted in more plant K accumulation than treatments providing 100% of the K basally in the fall as KCl. Combined application of KCl and K_2SO_4 decreased Cl^- contents in plant tissues and total plant accumulation of Cl^-, resulting in a more negative Cl^- balance in tomato fields compared with application of KCl alone. When only KCl was applied, basal application of 100% of the K had lower Cl^- content at the surface (0 to 20 cm), but higher Cl^- level at depth (40 to 80 cm) than treatments providing 50% or 100% of the K at later stages. The more KCl applied in later stages the higher the Cl^- levels were in the soil surface layer. Combined application of KCl and K_2SO_4 resulted in lower Cl^- at the surface (0 to 40 cm) than treatments with KCl alone.

The best K management practice in drip-irrigated processing tomato production in Xinjiang province was to apply 50% of the K requirement as KCl basally in the fall combined with the remaining K as K_2SO_4 at flowering and fruiting stages.

Ecological Intensification Nutrient Management for Maize

2014 is the sixth year of Ecological Intensification (EI) experiment initiated in 2009. The experimental sites for EI treatments are in Gongzhuling, Jilin province and Dahe Experimental Station, Hebei province, representing mono-cropping spring maize, and double cropping summer maize rotated with winter wheat, of which are two of 15 sites of IPNI Global Maize Project. It aims to maximize grain yield and eliminate negative effects to environment as well through ecological intensification nutrient management

Fig.6 Trial on Interactions of Water and K Rates in Sunflower of IMAR

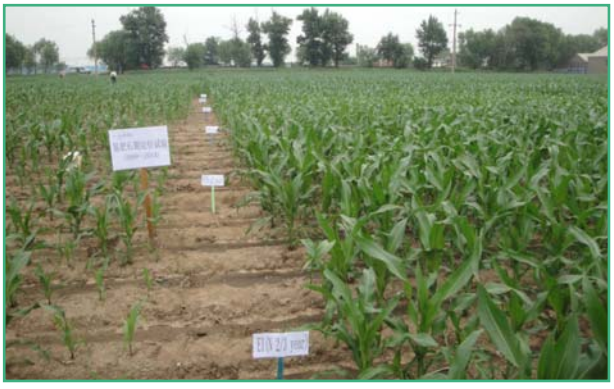


Fig.7 Ecological Intensification Nutrient Management for Maize in Jilin Province

combined with other best field management practices. The scientific concepts were highly proved that the importance of regional research to global nutrient management of IPNI. The results of field trials indicated that Ecological Intensification (EI) management with 24-28% less nitrogen (N) fertilizer input and 48-64% less P input ensured 6.7-25.9% more grain yield and 10.8-32.3% more economic benefit, and significantly improved the N use efficiency and alleviated the risk of over-use N and P fertilizer to environment.

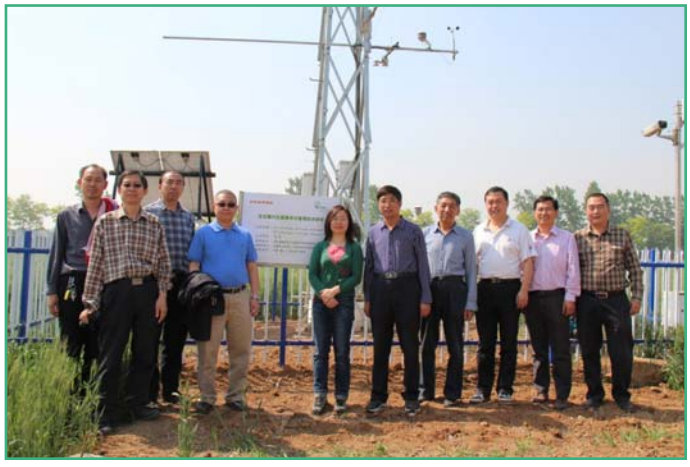


Fig.8 Ecological Intensification Nutrient Management for Maize in Hebei Province

948 Project Passed Final Evaluation from MOA

On June 6, the 948 Project (Project on introduction of new technology from abroad) entitled "Nutrient Expert based fertilizer recommendation for wheat and maize" supported by Ministry of Agriculture (MOA), China, passed final evaluation organized by MOA. Dr. Ping He, as the chief project investigator, presented the progress of the project to the evaluation committee. The projected imported and absorbed the SSNM nutrient management principles and developed Nutrient Expert Decision Support Tool based on China's agricultural situation and nutrient uptake parameters in China's main wheat and maize production areas. Field experiments indicated that NE can maintain high grain yield with 31-41% less N and 12-31% less P fertilizer, and increased 57 yuan more profit per mu than farmer's practice. Four scientific papers have been published in *Field Crops Research* and two PhD students involved in this project.

Fertilizer Economic Analysis from N, P and K Application for Crops

Maize yield responses and profitability to N, P and K fertilization were highly variable across different provinces in China. Average yield responses to fertilizer N, P and K were 1.9, 0.95 and 0.97 t/ha across seven provinces. The VCRs for fertilizer N, P and K ranged between 0.5 to 12.1, 0.1 to 43.7, and 0 to 18.6, respectively. Omission of N, P and/or K resulted in losses of both yield and profitability. Economic returns from N and P fertilization increased with increase in yield responses and fertilizer prices, but those from K fertilization decreased with increase in K prices. All of the VCRs were higher than 2.0 when yield responses were over the 25th percentile for N and P fertilizers, and those for NEs were much higher than FP. Although profitability in the FP treatment with less K input was higher than in NE treatment under K application, the optimized Nutrient Expert®-based fertilizer recommendation proved to be a successful nutrient decision support tool leading to higher grain yield and profitability. Details please reference the full paper with citation by He et al. in *Journal of Plant Nutrition and Fertilizer*, 2014, 20(6): 1387-1394, and *Better Crops with Plant Food*, 2014, 98 (1): 26-29.

Potato tuber yield responses and profitability to N, P and K fertilization during 2002 to 2011 were evaluated and indicated that yield response to N, P and K, on average, was 5657, 3967 and 5341 kg/ha and 95%, 75% and 81% of trials showed significant ($p<0.05$) response, indicating that nitrogen was the first limiting factor followed by potassium and then phosphorus in potato production. The mean agronomic efficiency of N (AE_N), P (AE_P) and K (AE_K) was 37.6 kg/kg N, 45.0 kg/kg P_2O_5 and 44.9 kg/kg K_2O, respectively. Economic analysis indicated that application of N, P and K fertilizer resulted in an average of 5218, 3683, and 4141 yuan/ha income and the mean value cost ratio (VCR) of N, P and K was 9.3, 12.7and 8.8, respectively. Estimation of VCR based on various prices of fertilizer and tuber indicated that VCRs for N, P and K fertilizer application increase with the increase of yield response even though fertilizer rate increases. At present or in the future appropriate application of N, P or K fertilizer on potato in China northwest region can be profitable in more than 75% scenarios and how much income will be obtained depends on yield response, fertilizer rate, price of fertilizer and potato tuber. (More information see: *Soil and Fertilizer Sciences in China*, 2014, 4: 42-47)

Soil Available K Changes from 1990-2012

Potassium (K) fertilizers are non-renewable resources and cannot be synthesized from other chemicals. Understanding soil K status in China is crucial for the efficient use of K resources, and the resulting food security and resource sustainability. We analyzed temporal and spatial changes in soil K from 58,559 soil samples, and yield responses from 2,055 field experiments compiled from the International Plant Nutrition Institute (IPNI) China Program database from 1990 to 2012. The results indicated that on average soil available K increased from 79.8 mg/L in the 1990s, to 93.4 mg/L in the 2000s, with the increase for cash crops faster than that for grain crops. In fact the average increase in soil available K over time was attributed to increases in soil K for cash crop fields with high K fertilizer application (1.4 to 2.6 times more than for grain crops). The study found great variation in soil available K across different regions and over time in China. Soil available K varied over space with values of 76.8, 99.8, 118.0, 83.9 and 81.3 mg/L for Northeast (NE), North Central (NC), Northwest (NW), Southeast (SE) and Southwest (SW), respectively. While no difference in soil available K over the time period of the study was observed in NE China, the values increased by 34.8%, 17.9% and 30.2% for NC, SE and SW respectively, and decreased by 75.9% for NW China between the 1990s and 2000s. Great temporal and spatial variation existed for relative yield as well, which followed similar trends to soil available K. Potassium fertilizer application continued to be recommended for grain crops due to the low soil available K falling short of critical values, and cash crops where a larger yield response to K fertilizer has been recorded. This great variation observed in soil available K across the different regions in China demonstrated the urgent need for site-specific K nutrient management. Detail information please refer to He et al. published in *Field Crops Research* (2015. DOI 10.1016/j.fcr.2015.01.003).

Long-term Fertilizer K Application on Crop Yield and K Balance

The effects of 20 years of K fertilization on grain yields, plant K uptake and efficiencies, and the K balance were examined in a Haplic Phaeozem soil under a rain-fed mono-cropped spring maize system in the province of Jilin, Northeast China. The zero K application maintained an average grain yield of 7 t/ha per year, but the year-to-year variation was large. Application of K significantly increased the average grain yields by 15.1 and 13.8% in the 113 and 225 kg K_2O/ha treatments, respectively, over the experimental period. In the top 100 cm of the soil profile, excessive or non-synchronized K application significantly increased the leaching of exchangeable K in comparison with the control, but K application had little effect on soil non-exchangeable K and total K. K fertilizer, therefore, plays an important role in increasing grain yields in China, but the K

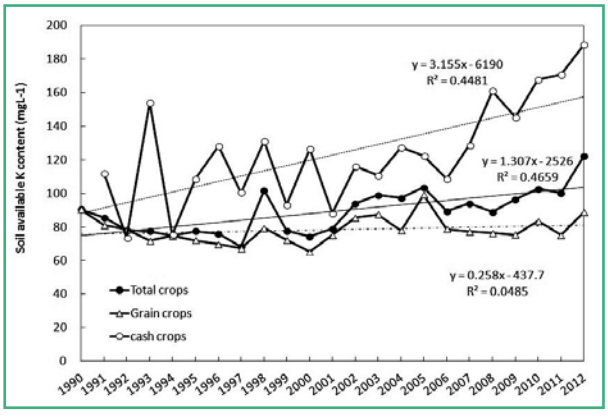


Fig.9 Soil Available K Changes During 1990-2012 in China

Fig.10 Long-term Fertilizer K Application on Crop Yield and K Balance

application rate can be reduced if farmers return stover to the soil and make full use of K below the soil surface. (Details see: *Field Crops Research*, 2014, 163:1-9).

The NP and NPS treatments decreased soil available K and slowly available K below the initial levels, K fertilization and/or straw return increased available K and slowly available K in the top 30 cm soil over the NP treatment. Compared with the NP treatment, K fertilization and/or straw return increased crop yields in most cases, and the effect of K inputs on yield increase was greater for maize than wheat. Additionally, increased straw return enhanced soil organic carbon (SOC) beyond the NP treatment, and SOC decreased with depths between 0 and 40 cm soil; however, fertilization did not change SOC below 40 cm. (Details see: *Field Crops Research*, 2014, 169: 116-122).

Adequate Supplying Phosphate Fertilizer is Crucial to Maize Production in Highly Weathered Soils in Yunnan, China

Due to continuous application of phosphate (P) fertilizers to crop lands for decades, it is usually considered that phosphorus (P) accumulation in the soil has become a problem imposing risk to the environment. In order to demon strate the neessany of P application in the highly weathered lateritic soils (red soils in the Chinese classification system), a field experiment was conducted to examine the response of maize to different P rates in Yunnan province. Results showed that maize growth was very responsive to addition of P fertilizer. Maize yield significantly increased with an increase in P rates. Addition of P fertilizer at 60 kg P_2O_5 /ha increased maize yield by 2.7 t/ha (41.6%) compared to the CK (P omission) treatment with a maize yield of 6.4 t/ha. Further increase in P rates to 120 and 180 kg/ha continued to increase maize yield by 3.0 t/ha (46.8%) and 3.4 t/ha (53.7%) compared to the CK treatment. The results imply that even after many years P application, it still needs adequate supply of P to achieve high maize yield in the lateritic soils under maize - maize cropping system.

Expanding Cash Crops Drove Fast Increase in Fertilizer Consumption in Recent Years in China

Before 1999, fertilizer consumption in China was well correlated with grain production. Since then, fertilizer consumption has remained its fast growing momentum while grain production started to decrease till its trough in 2004 and then gradually increased thereafter. For a while, people wondered why and some have attributed this phenomenon to over-fertilization that leads to serious nutrient losses and low nutrient use efficiency. A thorough analysis indicates that during this period the

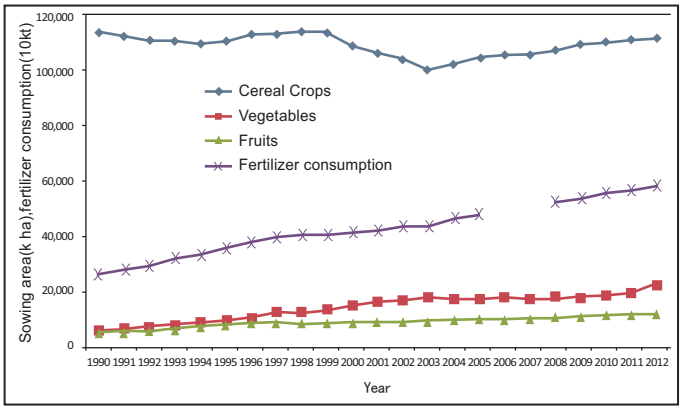


Fig.11 Sowing Areas for Grain Crops, Vegetables, Fruits and Fertilizer Consumption in China from 1990 to 2012

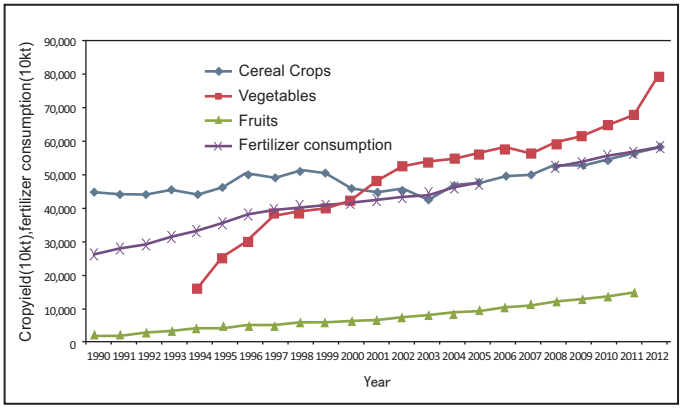


Fig.12 Total Yields of Grain Crops, Vegetables, Fruits and Fertilizer Consumption in China from 1990 to 2012

rapid increased fertilizer consumption is mainly due to fast expanding cash crops, particularly for vegetables and fruits. The growing areas had increased by 85% for vegetables and 42% for fruits during this period. The total vegetable yields in 2012, on the other hand, increased by four folds compared to 1990 and by one fold compared to 1999. Even more, The total fruit yields in 2012 increased by seven folds compared to 1990 and by two folds compared to 1999. Thus, the higher the growing areas for cash crops, the higher fertilizer consumption for the region. For example, the growing area ratio of cash crop/grain crop is 0.6 for Sichuan province and 1.3 for Guangdong province and results in fertilizer consumption of 240 kg nutrient/ha for Sichuan province and 415 kg nutrient/ha for Guangdong.

Potassium Deficiency in Rice Induced Early Heading

In a long-term field experiment with rice-wheat rotations conducted in Guanghan city, Sichuan province of China, it is of interest to observe that the K omission plot has headed about one week earlier (Fig.13 right plot with more headed rice) than the other treatments since 2008, three years after initiation of the experiment. The rice grain yield was reduced by 8-16% compared to the optimal treatment (OPT). In the dry winter season, however, wheat yield was reduced by 9-37% by omitting K but no early heading has been observed since three years after beginning of the experiment. The results indicate that K deficiency becomes more severe under dry and cold winter season than in the warm and moisture summer season, and different crops respond to K deficiency differently. Thus, under the rice-wheat rotation system heavier dose of K fertilizer to winter wheat should be considered.

Increased Times of N Splitting at Vegetative Growth Period can Advance Banana Blossom

In a field experiment to test effects of different rates and timings of controlled release urea (CRU) against regular urea (RU) on banana growth, it

Fig.13 The Plot with Omission of K (right plot - OPT-K) Induced early Heading of Rice

Fig.14 Banana Plants without Budding in the N Omitting plot (above) and with Budding in the N Treated Plot (below)

was observed that the CRU applied in three splits achieved the fast banana growth rate and the highest budding rate (81.5%) among all the treatments. The budding rate was 11.1% for N omitting plot, 62.9% for two splits of RU and 74.1% for three splits of RU applied during the vegetative period. The budding rate for the rest treatments was less than 71.0%. The results imply that banana blossom can be advanced with increased splitting of N at vegetative growth period. Alternatively, using trip fertigation that provides nutrients even more often to banana may also achieve the same effect.

Controlled Release Urea with Plastic Mulch significantly Reduces Nutrient Losses from Sloping Lands

In order to understand effects of nitrogen sources and plastic mulching on fluxes and pathways of soil nutrient losses, a randomized block experiment design was employed with two factors and four nitrogen (N) sources and simulated runoff observation method. The results showed that N, P and K losses through underground runoff accounted for 71.3%, 6.4% and 8.9% of the nutrients in the total runoff, indicating that surface runoff was the main path for P and K losses and underground runoff was the main path for N loss. Compared to the no mulching treatment, the treatment of controlled-release urea under plastic mulching effectively reduced N loss by 40.4% from the underground runoff and by 29.3% from the surface runoff. The total N losses in runoff from no mulching treatments were in the sequence of

Fig.15 Fertilization Plus Plastic Mulching is Adopted by Farmers on sloping Lands

nitrate-N > amide-N>ammonium-N >controlled-release N. Under plastic mulching, total N lost through runoff was observed in the sequence of ammonium-N>amide-N> nitrate-N> controlled-release N. The minimum N loss was in the controlled-release N treatment with plastic mulching, 59.6% less than the ammonium-N treatment. In order to effectively control nutrient losses through water runoff and soil erosion from the purple hilly area in Sichuan province, it is best to use controlled-release N with plastic mulching if applicable.

Combinations of Control Release Urea (CRU) with Regular Urea (RU) Increased N use Efficiency of Plastic Mulched Maize in Inner Mongolia

In 2014, an experiment was arranged in plastic mulched rainfed maize in Chifeng city of Inner Mongolia. Results indicated that in Chifeng city various ratio of CRU (30%-75%) combined with RU (25%-70%) produced 3.2%-4.8% more grain yield, 1.8-2.7 kg/kg more agronomic efficiency (AE), 1.4-6.5 more percentage point N recovery efficiency (RE) when 100% of recommended N was applied, and produced 2.0%-4.5% more grain yield, 1.4-3.2 kg/kg more AE, 4.1-5.3 percentage point more RE when 80% of recommended N was used. the combination of 60% CRU plus 40% RU was the best treatment that was further verified by a field trial in Wulanhaote city where this combination of CRU and RU produced 4.0% and 4.9% more grain yield, 2.7 and 4.0 kg/kg of AE, 8.5 and 3.9 percentage point of RE compared with treatment with application of 100% urea when 100% and 80% recommended N was applied, respectively. Therefore, appropriate ratio of CRU and RU could increase maize yield and N use efficiency.

Study on the Spatial Variation of Farmland Soil Fertility in Minhou County of Fujian Province

Since the second national soil survey in 1980s, the land use, cropping system, farming practices and fertilization levels have changed significantly in Fujian province, and all of these changes would affect the variety of soil nutrient status. Therefore, it is needed to study the soil nutrient spatial variation in a relative larger scale for making better fertilization recommend. The soil and Fertilizer Institute of Fujian Academy of Agricultural Science studied the soil nutrient spatial variation in Minhou county in recent year, this county located in the center of Fujian province with annual rain fall over 1500 mm.

The soil investigation result indicated that the difference of soil nutrient spatial variation is significant. Both texture factors and stochastic factors affected the soil variation in the county. The authors analyzed the regulation of soil nutrient spatial distribution and made a distribution map. According to the analysis, the investigated area showed soil available N deficient in relative small part and available K deficient in most part, while soil available P was rich in most part of the area. Compare with the data of 1980s, soil available P is accumulated in this area.

Fig.16 Yi Duo Bao Test of Rice in Honghu, Hubei Province

Study on the Effect of Control Release Urea in Rice and Cotton

In 2014, we conducted the field experiments of application the control release urea (CRU) for rice and cotton in Shanghai city, Hubei and Zhejiang provinces. Totally we conducted 2 cotton field experiments and 1 rice field experiment in Honghu and Qianjiang counties of Hubei province; 1 direct seeding rice field experiment

in Fengxi district of Shanghai city; 1 direct seeding rice field experiment in Jinhua county of Zhejiang province. Results showed that CRU increased crop yields and reduced labor cost about 15-30 days/ha compared with regular urea (RU) in each season when same rate of N was applied. At the same time, the N use efficiency and agronomy efficiency were significantly increased. For example, the 2 field experimental results from Hubei province showed that CRU in cotton produced 3,648 kg/ha and 3,990 kg/ha of seed cotton, significantly increased yield by 9.7% and 17.4%, net benefit by US$ 435/ha and US$ 697/ha over RU. Results of rice showed that CRU produced 10,709 kg/ha, increased yield by 19% and net benefit by US$ 484/ha over RU.

Yield Response and Economic Analysis of Rice and Rapeseed to Fertilizers use in SE China

In 2014, based on the results from 46 rice field trials and 93 rapeseed field trials, demonstrations and investigations from 8 provinces which supported by IPNI China Program in Southeast region of China and the statistical data from the Year Book of Chinese agricultural Statistics during 2001-2010, IPNI Wuhan Office of China Program investigated the changes of rice and rapeseed yields and prices, commercial fertilizer prices and the net benefits of rice and rapeseed planting. The results indicated that the yields of rice and rapeseed increased by 9.2% to 31.0%, product prices increased by 80.0% to 90.9%, NPK commercial fertilizer prices increased by 48.1% to 236.8%, while net benefit increased by 42.0% to 412.3% within 10 years. The authors also estimated the changes of net benefits from rice and rapeseed planting with the changes of products and fertilizer prices, the results showed that product (here are rice and rapeseed) price is the most important factor that affecting crop planting net economic benefit, while commercial fertilizer price shows much less (1/3 to 1/4) effect on crop planting net economic benefit compared with product price. Therefore, the authors suggest that we pay more attention on product price, rational and scientific fertilization and increase of nutrient efficiency in agriculture, not necessary to about care the fertilizer price changes in near future.

The Spatial Distribution of Soil Micronutrient in Bamboo Production Regions of Jiangxi

Soil micronutrient contents is affected and varied by many factors such as soil water content, temperature, pH, its content and availability is important for agricultural production. Bamboo planting needs large amount of nutrient elements include some micronutrients such as Cu, Zn, Fe and Mn. To increase bamboo yield and quality, make better nutrient management recommendation, the College of Forest Science of Jiang Agricultural University investigated the soil available Cu, Zn, Fe and Mn contents in the main bamboo planting forests in Jiangxi province in recent years. Bamboo in Jiangxi province mainly planted in northwest part and south part with warm climate (annual average temperature 18.2℃, rain fall 1625 mm), and the acid (pH 4.1-5.5) and slope (8-16 degree) land soil between altitude 200-800 m.

The investigation results from 8 bamboo plantation forests in 6 counties showed that the differences of soil available Cu, Zn, Fe and Mn contents were significant in different regions. The average contents of top soil 0-10 cm,10-30 cm and 30-50 cm were 0.7 mg/kg, 0.5 mg/kg and 0.4 mg/kg for available Cu; 2.0 mg/kg, 1.34 mg/kg and 0.86 mg/kg for available Zn; 19.4 mg/kg, 15.9 mg/kg and 13.6 mg/kg for available Fe; and 16.4mg/kg, 12.1 mg/kg and 9.2 mg/kg for available Mn, respectively. Soil organic content showed positive relationship with soil available Fe content and negative relationship with Cu content.

ACADEMIC EXCHANGES

National Symposium on the Third Chemical Fertilizer Research and Application

On May 16, the third National Symposium on Chemical Fertilizer Research and its application was held in Wuhan. International Plant Nutrition Institute China Program, and the Committee of Chemical Fertilizer Research, Chinese Society of Plant Nutrition and Fertilizer Sciences jointly organized this symposium. About 170 participants including researchers and students from 39 research institutions, representatives from fertilizer industry, and technicians from provincial agricultural extension centers. As the Director of Chemical Fertilizer Research Science Committee, Chinese Society of Plant Nutrition and Fertilizer Sciences, and the Director of IPNI China Program, Dr. Ping He gave an opening remark, and introduced the committee members and presented the certificates to the committee members. During the seminar session, there were four parts including 18 presentations with focuses on progresses of research and application of chemical Fertilizers, high efficient fertilization and nutrient management, plant nutrition physiology and nutrient cycling, potassium nutrition and potash fertilization. Dr. Ping He made a presentation on Nutrient Expert Based Fertilizer Recommendation. Dr. Shihua

Tu, Dr. Fang Chen and Dr. Shutian Li presented the Summary of Potassium use in Southwest and South region, Global Potassium Resources and Future Demand and 4R Potassium Nutrient Management for Main Crops in Northwest China. Posters related to 4R Nutrient Management, Nutrient Expert based fertilizer recommendation, and ecological intensification of Nutrient Management for Maize from IPNI Beijing Office also attracted great attention from participants. This symposium provides a very good opportunity for scientists and fertilizer industry to sit together and exchange ideas. It is also an opportunity to increase recognition of IPNI in both science world and fertilizer industry in China. The symposium was partly sponsored by Canpotex limited.

IPNI Annual Staff Meeting

From June 20 to 29, 2014, IPNI Staff meeting was held in Santiago, Chile and Buenus Aires, Argentina. IPNI regional Directors and Deputy Directors participated this meeting as routinely. The objectives of this meeting were to update regional programs and working groups, and discuss next year plan. IPNI China Program staff participated in six working groups including Ecological Intensification for Global Maize, Soybean Nutrient Management, 4R Nutrient Management, Fertilizer BMPs and Nutrient Cycling, Nutrient and Environment, and Precision Nutrient Management. During the staff meeting, IPNI staff visited potash mine in Chile and interacted with the staff from the Chilean fertilizer group SQM, the member company of IPNI.

IPNI China Program Annual Meeting

On May 15, IPNI annual meeting for North China was held in Wuhan. About 40 cooperators from Northeast, North Central and Northwest participated the meeting and made progress presentation on research projects including 4R potassium nutrient management and nutrient expert based fertilizer recommendation in 2013. Discussion was conducted on research progress and future plan in 2014. IPNI Beijing Office staff including Dr. Ping He, Dr. Shutian Li, Dr. Guifang Sun and some CAAS staff organized and participated the meeting.

IFA Round-table Meeting

On September 29, 2014 Dr.Shutian Li participated in a round table meeting organized by China Petroleum and Chemical Industry Federation (CPCIF) and IFA. Dr. Li gave a 5-8 minutes speech stating on issues of fertilizer use in China, the current nutrient management practice by IPNI including 4R nutrient stewardship and Nutrient Expert and a few suggestions on cooperative actions between government, industry, research institutions and extension agencies. The participants included Charlotte Hebebrand, Director General of IFA, leaders from CPCIF and officials from Ministry of Agriculture, National Development and Reform Commission, Ministry of Finance, Ministry of Industry and Information Technology and leaders from large fertilizer industry like Sinofert, Yuntaihua of Yunnan,Yihua of Hubei,SDIC Xinjiang Luobupo Potash Co. Ltd., Wongfu of Guizhou.

IPNI China Program IT Training

On October 12-14, IPNI China program IT training was held in Xi'an. IPNI Vice President, Mr. Steve Couch, and IPNI IT Manager, Mr. Brian Green updated China Program servers, gave the training courses on IPNI websites, IPNI database, email system, etc. IPNI China Program staff from Beijing Office, Chengdu Office and Wuhan Office attended this meeting.

Platform construction

CAAS-IPNI Joint Lab on Plant Nutrition Innovation Research

In 2014, CAAS-IPNI Joint Lab has been going well under the great support and leadership from MOA, CAAS and IPNI. Great progress has been made in agronomic research, personnel training, scientific exchange and technology transfer. In agronomic research, the work continued on fertilization recommendation method based on the yield response and agronomy efficiency, and the 4R crop nutrient management research, and translation of the Chinese version 4R nutrient management. At the same time, according to the result of agronomy research, a series of publications, printing technical brochures and CD have been distributed free of charge to the project partners, fertilizer enterprises and agricultural technology personnel at all levels. In 2014, academic exchanges have been carried out with many countries and organizations. Dr. Jingyi Yang from AAFC was invited to the joint lab in July and discussed the cooperation on crop model used in carbon and nitrogen cycle for a Ph.D student program. In October 2014, Dr. Tom Brussulma, IPNI southeast Director from Canada, visited the joint lab and made presentation on 4R nutrient management. The above joint laboratory research and exchange activities were jointly funded by Chinese academy of agricultural sciences and IPNI.

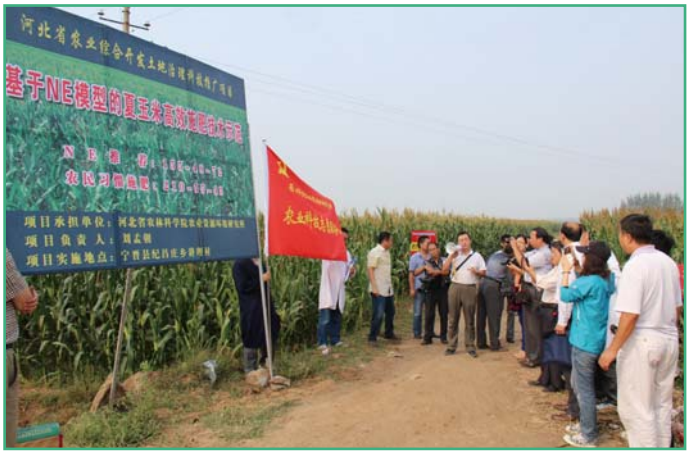
Technology Transfer and Training Activities

NE Training

On May 30, 2014, Dr. Ping He attended the conference of introduction of foreign new technology held in Hebei province. Dr. Ping He introduced Nutrient Expert System based on yield response and agronomic efficiency, and signed the "blue sky project" cooperation agreement with the Hebei Academy of Agricultural Sciences through application of Nutrient Expert System to reduce the environmental pollution. In June, IPNI China and Xinjiang Academy of Agricultural Sciences' signed a cooperation agreement about NE system.

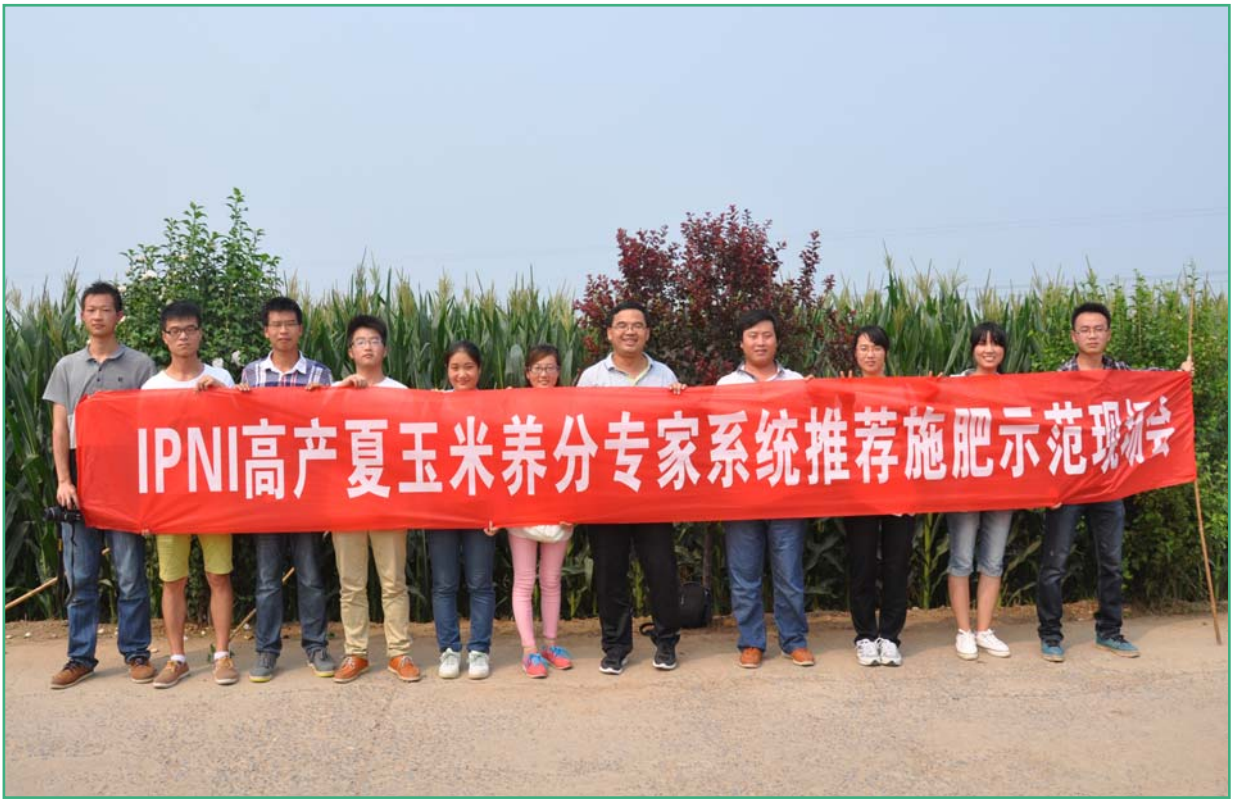
On June 6, Dr. Ping He was invited by Department of International Cooperation, CAAS, to make a presentation at Workshop of Experience Sharing between CAAS and African Regional Agricultural Research Institutes. Dr. Ping He presented the Nutrient Expert based fertilizer recommendation as a topic on sustainable and efficient fertilization. The participants from Africa have so much interest and asked so many questions on how to develop and deliver this new technique to farmers in both China and Africa.

On August 26 and September 13-14, a training program for large farmers was held in Zhengzhou of Henan



province and Ningjin county of Hebei province. Dr. Jinyun Jin, representing IPNI China Program, gave the presentation on Nutrient Expert based fertilizer recommendation for maize and wheat in China and demonstrated how to use the Nutrient Expert software to participants. 220 copies of Nutrient Expert use manual for wheat and maize have been delivered. Great interest from the participants and so many questions were put forwarded and discussed. Nutrient Expert field demonstration was also visited by the participants in Xunxian, Henna province and Ningjin county, Hebei province. The activities were organized by Agricultural Committee of Henan province, and Henan Agricultural University, and Heibei Academy of Agricultural Sciences. Over 200 large farmers and local extensions participated these two activities.

On September 9, Dr. Ping He made presentation on Nutrient Expert based fertilizer recommendation to the staff of the Soil and Fertilizer Institute, Shandong Academy of Agricultural Sciences. Many interesting questions came from the participants on how to use the software and technology transfer. In the morning of September 10, field visited on large-scale field demonstration of NE maize was conducted in Pingyuan County. About 100 farmers and local technicians were involved in the field visit. Afterwards, a training program on Nutrient Expert was conducted in the meeting room. Dr. Ping He introduced the principles of Nutrient Expert based fertilizer recommendation and demonstrated how to use the NE software.



Two Ph.D Students Participated Nutrient Expert Project

Ms Limin Chuan, whose Ph.D thesis entitled "Nutrient Expert based fertilizer recommendation for wheat" received one of the ten excellent Ph.D thesis award from 250 Ph.D graduates of CAAS in 2013. The other Ph.D student, Mr Xinpeng Xu, whose Ph.D study on Nutrient Expert for maize was selected to be involved in the incubation plan for the excellent Ph.D candidate. Five papers on NE nutrient management principles and field validation have been published in *Field Crops Research* since 2013.

4R Training

On May 16, 2014, a Workshop on the 3rd National Chemical Fertilizer Research and Application was held in Wuhan. This meeting was sponsored and organized by Chemical Fertilizer Speciality Committee of Chinese Society of Plant Nutrition and Fertilizer Sciences and IPNI. Dr. Shutian Li participated in the workshop and gave a presentation on research progress of 4R K management in main crops, showing the right source, right rate and timing of K application in potato and cotton.

On December 5, Dr. Shutian Li was invited to attend a training activity sponsored and organized by Shaanxi Soil and Fertilizer Station, Shaanxi Agricultural Protection Station, Shaanxi Society of Plant Nutrition and Fertilizer Sciences and Shaanxi Society of Soil Science, held in Yangling of Shaanxi province. Dr. Li gave a presentation on 4R nutrient stewardship, briefly introduced our IPNI and detail introduced the concepts of 4Rs as well as Nutrient Expert by using some case studies in China.Nearly 160 leaders and technicians from county and city level Agricultural Extension & Service Center, Soil and Fertilizer Station, Agricultural Protection Center and faculty/students from Northwest A&M University participated in this training activities.

Demonstration of Rapeseed Balanced Fertilization

On March 27 of 2014, invited by Huazhong Agricultural University and local Agricultural Bureau, Dr.Fang Chen attend the field demonstration activity of rapeseed balanced fertilization in Wuxue county of Hubei province. Total 56 participants from the Soil and Fertilizer Working Station of Hubei Agricultural Department, Plant Protection & Soil and Fertilizer

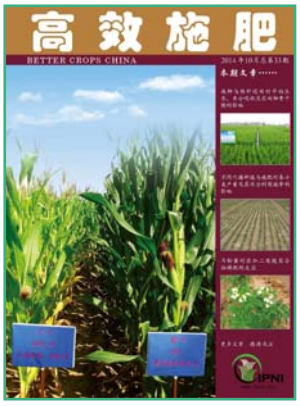
Institute of Hubei Academy of Agricultural Science, Huazhong Agricultural University and other provincial Academies of Agricultural Science from Chongqing and the provinces of Hunan, Jiangsu, Anhui and Henan. The participants visited 13 rapeseed field experiments and some demonstration plots which conducted for study the effect and application technology of potassium fertilizer for local farmers.

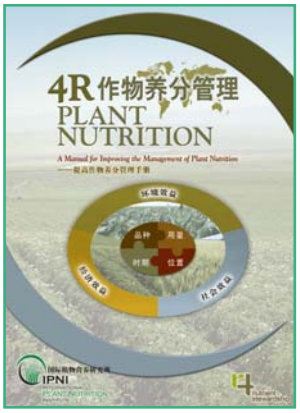
Publications

There are two issues of *Better Crops China* published in 2014. The first issue was special issue for potassium nutrition and fertilization, summarizing yield response of main crops to potassium application and economic benefit by potash use. The second issue was about research progress on nutrient management and some translated articles.

4R Plant Nutrition was translated into Chinese by IPNI China Program and put in the website *(http://www.ipni.net/4R; http://china.ipni.net/article/CNP-3103)*

A new book titled "Research on Nutrient Management and Its Environmental Effects in Agro-ecosystems in the Southeast China" was published by IPNI Wuhan Office in December of 2014. There were 18 authors including chief editors Kaiyuan Wan, Fang Chen and Guoshi Zhang provided their contribution for the book. The book have total 270 pages and 402,000 words and collected 27 summary reports or research papers from our cooperative research projects in recent years, and the themes mainly include "Spatial characteristics of soil fertility and 4R nutrient stewardship", "Fertilization and environment", "Evaluation of farmland non-point pollution and restoration".





2014 IPNI Scholar Award

The International Plant Nutrition Scholar Awards are open to applicants who are graduate students attending a degree granting institution located in any country with an IPNI program. Priority is given to the relevance of the proposed research in support of IPNI's mission. Students in the disciplines of soil and plant sciences including agronomy, horticulture, ecology, soil fertility, soil chemistry, crop physiology, and other areas related to plant nutrition are encouraged to apply. Awards of US $2,000 each will be awarded to winners. Review of applications will be conducted on a regional basis, including the following: North America, Latin America, Eastern Europe & Central Asia, China, South Asia, Southeast Asia, Australia/New Zealand, and Africa.

The IPNI Scholar Award Program has once again expended its reach by awarding scholarships to 30 graduate students from the world in 2014, among which 5 graduate students from China received the Award. They are Chao Ai, from Institute of Agricultural Resource and Regional Planning, Chinese Academy of Agricultural Sciences; Yanshu Hao, from College of Resources and Environment, Huazhong Agricultural University;Yanling Chen, from College of Resources and Environment, China Agricultural University; Junfeng Pan, from College of Resources and Environment, Anhui Agricultural University; Xiao Wang, Wuhan Botanical Garden, Chinese Academy of Sciences. April 30th will be the deadline for the application of 2015 IPNI Scholar Award. Anyone who has interests, please check the IPNI website: *www.ipni.net* for application process.

The International Plant Nutrition Institute (IPNI) is a not-for-profit, science-based organization dedicated to the responsible management of plant nutrition for the benefit of the human family. IPNI began operating in January of 2007 and now has active programs in Africa, Australia/New Zealand, Brazil, China, Eastern Europe/Central Asia and Middle East, Latin America-Southern Cone, Mexico and Central America, Northern Latin America, North America (Canada and U.S.A.), South Asia, and Southeast Asia.

As a global organization, IPNI has initiatives addressing the world's growing need for food, fuel, fiber, and feed. There is widespread concern for issues such as food security and the relationship of crop production to the environment and ecosystems. IPNI programs are achieving positive results in many areas. The program coordinators and IPNI regional directors are Ph.D. scientists. Through cooperation and partnering with respected institutions around the world, IPNI adds its strengths to agronomic research, education, demonstrations, training, and other endeavors. Best management practices for nutrient stewardship encourage the concept of applying the right product (source), at the right rate, at the right time, and in the right place.

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