IFA Agriculture Conference

Optimizing Resource Use Efficiency for Sustainable Intensification of Agriculture

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Balanced crop nutrition: Fertilizing for crop and food quality

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Topics

- **How common is "Unbalanced fertilization"?**
- **Outcome of unbalanced crop nutrition**
  - India
  - China
  - Egypt
  - Bulgaria
- **Balanced and timely nutrient application**
  - Long term observations
  - Organic agriculture?
  - Effect on yields, quality and plant health
  - Economics & extension
- **Conclusions**

IPI experiment in Haryana, India (PI, 2004)

How common is Unbalanced Fertilization?

IPI experiment in Chhattisgarh, India (VN, 2004)

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Why K is always complaining?

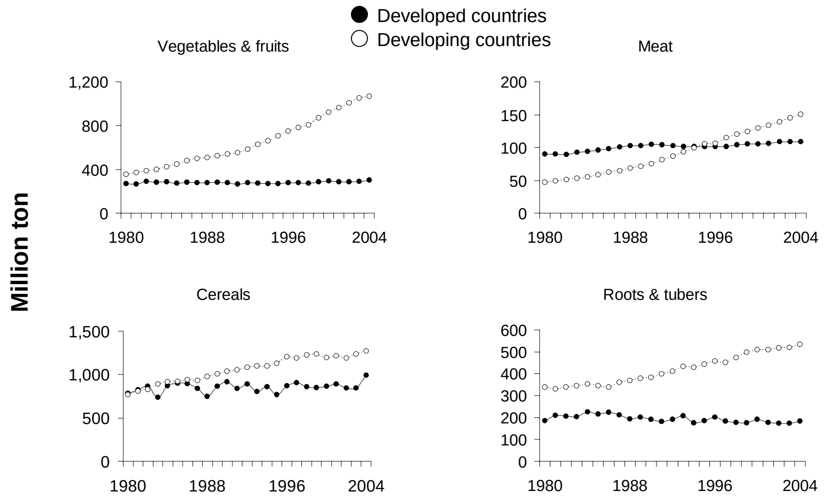
Global balance: Annual macronutrient content of crops, crop residues, and input of mineral fertilizers

Global outputs and inputs	Nitrogen (N)	Phosphorus (P)	Potassium (K)
	10^6 tonne		
Harvested crops	50	10	20
Crop residues	25	4	40
Total crop phytomass	75	14	60
Fertilizers (inorganic)	80	14	19
Ratio Fertilizer / total crop phytomass	***80/75=~1***	***14/14=~1***	***19/60=~0.3***

K is partially replaced

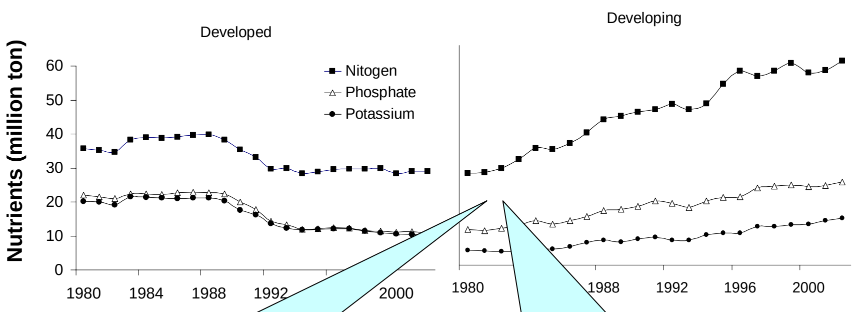
Adapted from V. Smil, 1999: *Crop residues: Agriculture's largest harvest*. Bioscience, Vol. 49 No. 4, pp299-308

Production of major crop groups in developed and developing countries, 1980-2004



Source: FAO, 2005

Nutrient consumption in developed and developing countries, 1980-2004



Q: Do these fresh supplies of nutrients suffice their removal in harvested and crop residues?

A: Growth rates are similar, yet the weigh is unbalanced

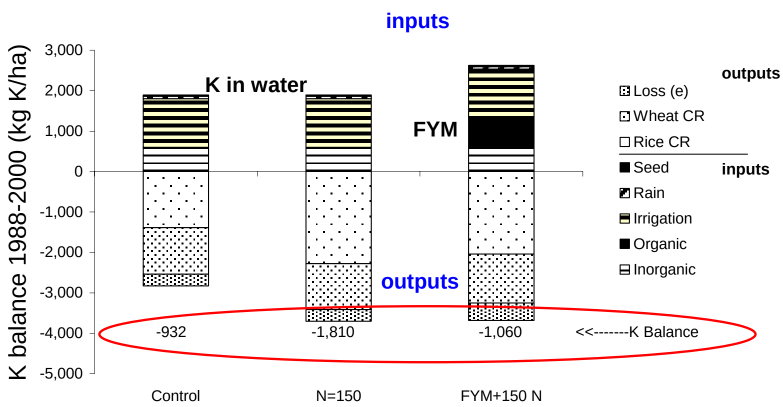
Source: FAO, 2005

Production and growth rates of major crop groups and averaged nutrient consumption in developed and developing countries (1980-2004)

Crop / factor	Developed countries			Developing countries		
	1980	2004	average growth rate (%)	1980	2004	average growth rate (%)
	Million ton			*Million ton*		
Cereals	783.7	990.7	*1.4*	766.2	1,273.3	*2.2*
Fruit & Vegetables	271.8	301.2	*0.5*	355.6	1,067.9	*4.7*
Roots and tubers	184.4	182.7	*0.2*	337.8	532.7	*1.9*
Soybean	51.1	91.6	*3.4*	29.9	112.7	*6.0*
Meat	89.7	81.6	*0.8*	47.0	150.6	*5.0*
Nutrient consumption (growth rate, %)			***N= (0.8) P_2O_5 = (3.0) K_2O = (2.8)***			***N= 3.8 P_2O_5 = 4.1 K_2O = 5.8***

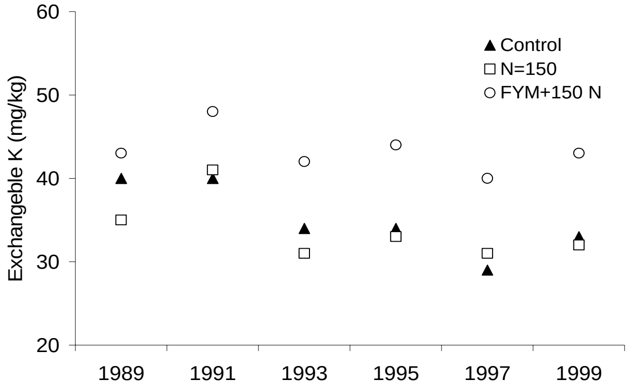
Source: FAO, 2005

Apparent K balance during 1988-2000 in a long-term rice-wheat experiment, Punjab, PAU



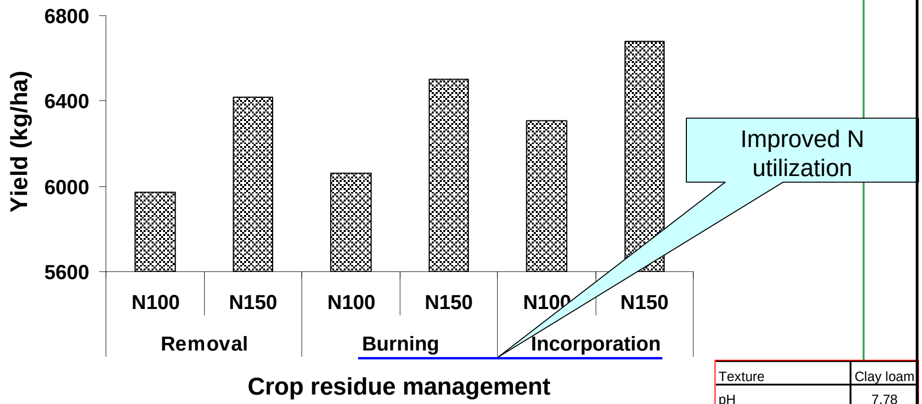
Source: Yadvinder,Singh, Bijay,Singh, Ladha, J. K., Khind, C. S., Gupta, R. K., Meelu, O. P., and E. Pasuquin. (2004). Long-Term Effects of Organic Inputs on Yield and Soil Fertility in the Rice-Wheat Rotation. Soil Sci. Soc. Am. J. 68:845-853.

Long-term effects of inorganic and organic inputs on available K content in soil



Source: Yadvinder,Singh, Bijay,Singh, Ladha, J. K., Khind, C. S., Gupta, R. K., Meelu, O. P., and E. Pasuquin. (2004). Long-Term Effects of Organic Inputs on Yield and Soil Fertility in the Rice-Wheat Rotation. Soil Sci. Soc. Am. J. 68:845-853.

The importance of crop residues:
Rice yields with different residue management at two N levels



K=60 kg K2O/ha

Texture	Clay loam
pH	7.78
O.C. (%)	1.18
Available N (kg/ha)	225
Available P (kg/ha)	41.8
Available K (kg/ha)	239

Source: IPI India, GBPUAT Pantnagar project, 2005

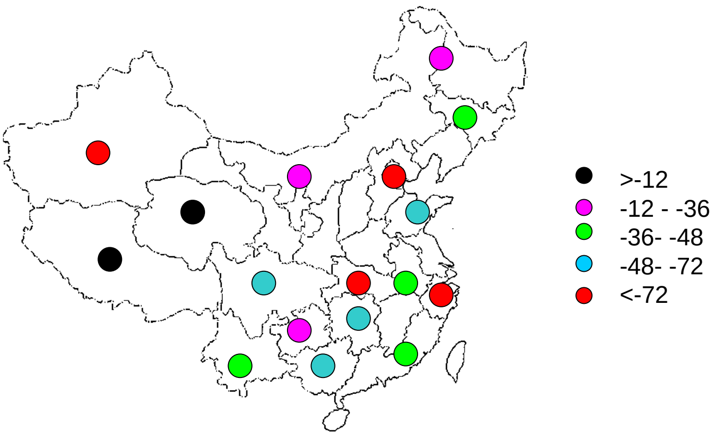
Interim conclusions - India

- ***"Current K fertilizer recommendations for P and K are inadequate in the long run"***
- ***The decline in SOM is not the reason of negative yield trends***
- ***Adverse changes in climatic parameters….. and decreased soil supply of available K are associated with declining yields***
- ***CR management are critical for K balance and nutrient use efficiency.***

IPI experiment in PAU, India (PI, 2004)

Source: Yadvinder,Singh, Bijay,Singh, Ladha, J. K., Khind, C. S., Gupta, R. K., Meelu, O. P., and E. Pasuquin. (2004). Long-Term Effects of Organic Inputs on Yield and Soil Fertility in the Rice-Wheat Rotation. Soil Sci. Soc. Am. J. 68:845-853.

Change of K balance in the agroecosystems in China from 1997 to 2001



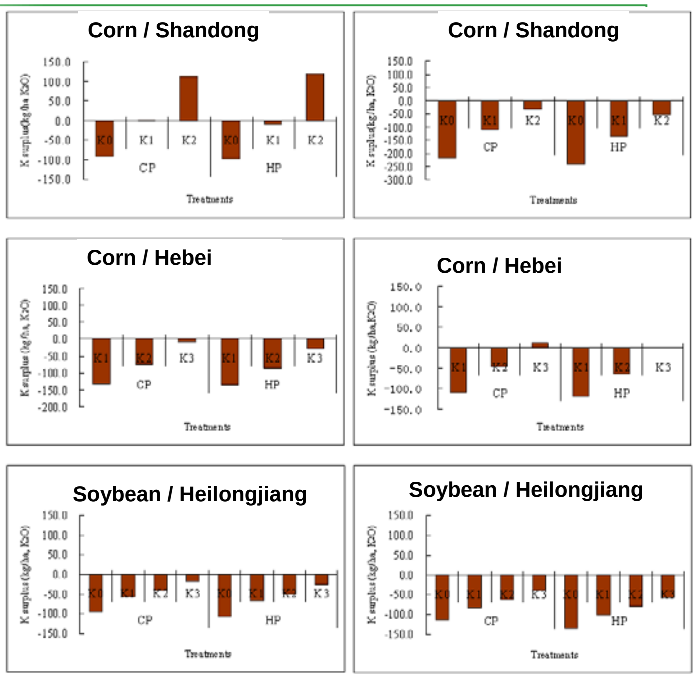
Adapted from Shen et al., 2005. Spatial and temporal variability of N, P and K and K balance for Agroecosystems in China. Pedosphere 15(3): 347-355.

Large N & P surpluses are accompanied with K deficit

Province	N balance	P_2O_5 balance	K_2O balance	Comments
	Kg/ha/year			
Beijing	90-150	26-45	>(72)	Low K input
Shanghai	>200	>45	>(72)	High K; high removal; leaching
Jiangsu	>200	>45	>(72)	High K; high removal; leaching
Zhejiang	>200	26-45	>(72)	High K; high removal; leaching
Hubei	151-199	>45	>(72)	High K; high removal; leaching
Xinjiang	<37	<9.9	>(72)	Low K input

Adapted from Shen et al., 2005. Spatial and temporal variability of N, P and K balance for Agroecosystems in China. Pedosphere 15(3): 347-355.

K balance of corn and soybean in various locations in China



Source: Bai, Chen, Zhang, Cheng, Jiang, Liu, Xiao and Wu. Annual report to IPI, January 2006.

Interim conclusions - China

- ***Low K inputs (e.g. Xinjiang and Beijing)***
- ***High yet not sufficient K inputs, along with N & P surpluses***
- ***High correlation between K negative balance and:***
  - ***GOVA - per capita Gross Output Value of Agriculture (r=0.470**)***
  - ***NIRH - per capita net income of rural households (r=0.511**) (1)***

  (** significant at $P < 0.01$)

Nutrient removal!!!
(China, 2003)

(1)Source: Shen et al., 2005. Spatial and temporal variability of N, P and K and K balance for Agroecosystems in China. Pedosphere 15(3): 347-355.

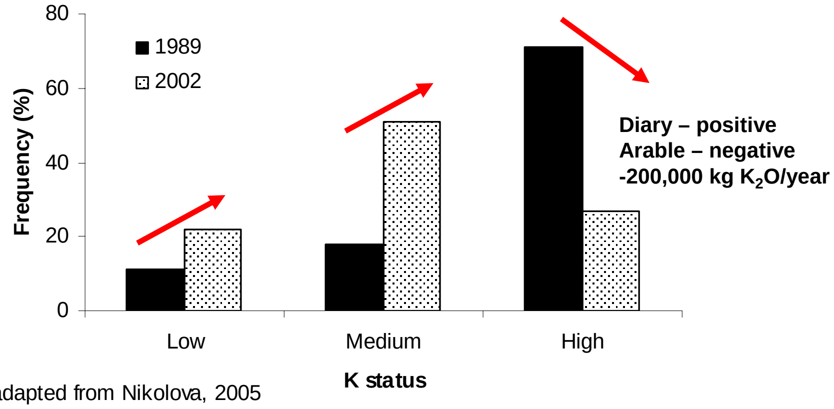
Mean (2002-2004) area, production, yield and calculated removal rates of potassium in various crops in Egypt

Crop	Area ('000 ha)	Production ('000 mt)	Yield (t/ha)	K_2O Removal (mt) (1)	
				Straw removed	Straw left in field
Rice	626	6,143	9.8	168,000	25,000
Wheat	1,045	6,882	6.6	140,000	41,800
Fruit	443	7,447	16.8	66,450	66,450
Vegetables & melons	576	14,854	25.8	115,200	115,200
Total				489,650	248,450

Application = ~50,000 tonnes K_2O/year

Source: FAO
(1) Source: K+S / Nutrient removal; accessed December 2005 http://www.kali-gmbh.com/duengemittel_en/TechService/NutrientsRemoval/graincrops.cfm

Different K status in soils of Bulgaria 1989 to 2002



adapted from Nikolova, 2005

Source: Nikolova, M. T. (2005). Potassium balance on field, farm and country level in Bulgaria. *In*: N. Fotyma (eds) "Fertilizers and Fertilization", Polish Fertilizer Society – CIEC, Pulawy, Poland. V3: (24). pp89-104.

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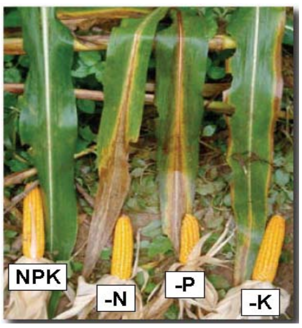
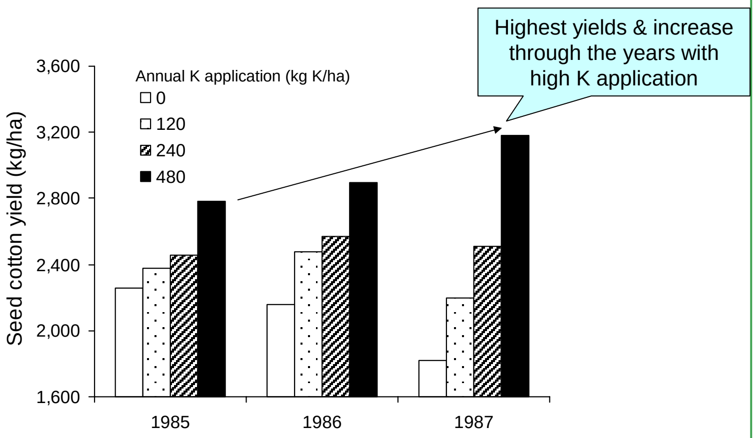
Balanced and timely nutrient application

SSP application (China, 2002)



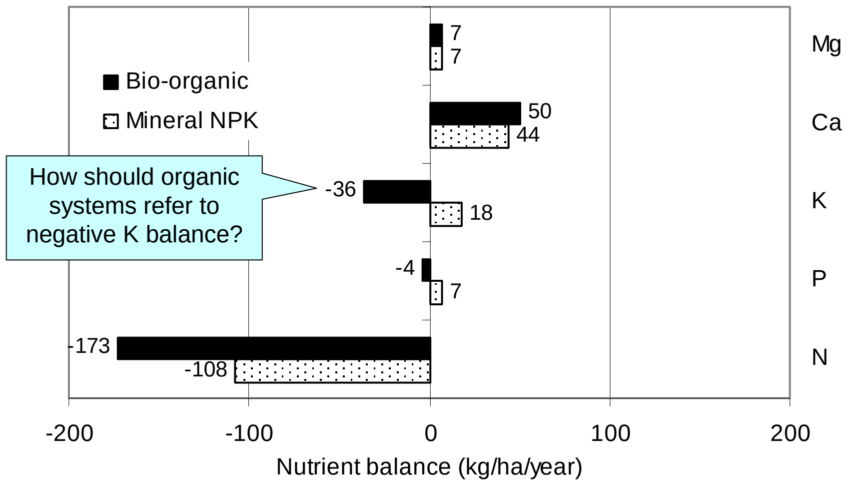
SEAP experiment in Indonesia (2005)

Response of annual seed cotton yield to annual K applications on a vertisol



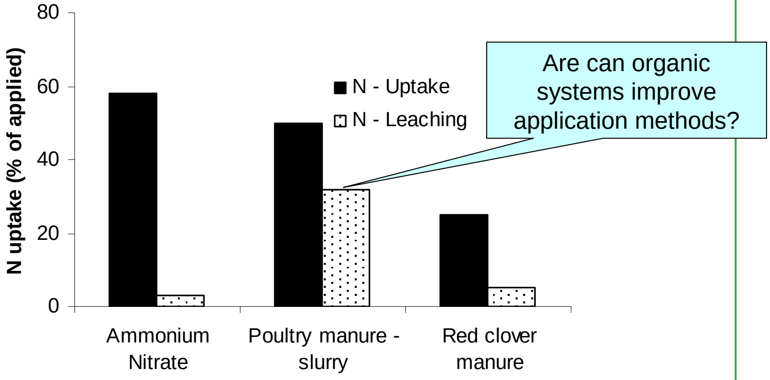
Adapted from Dobermann et al., 2005. Balancing short – and long-term goals in nutrient management. *In*: Plant nutrition for food security, human health and environmental protection. 15th Int. Plant Nut. Coll. (IPNC). Beijing, China. pp 60-61.

Nutrient balance after 21years comparing organic and mineral fertilization treatments



Adapted from Mäder P, Fließbach A, Dubois D, Gunst L, Fried P, Niggli U. (2002) Soil fertility and biodiversity in organic farming. Science, V. 296, pp 1694-1697.

Nitrogen in harvested crops and leaching: A challenge for organic agriculture



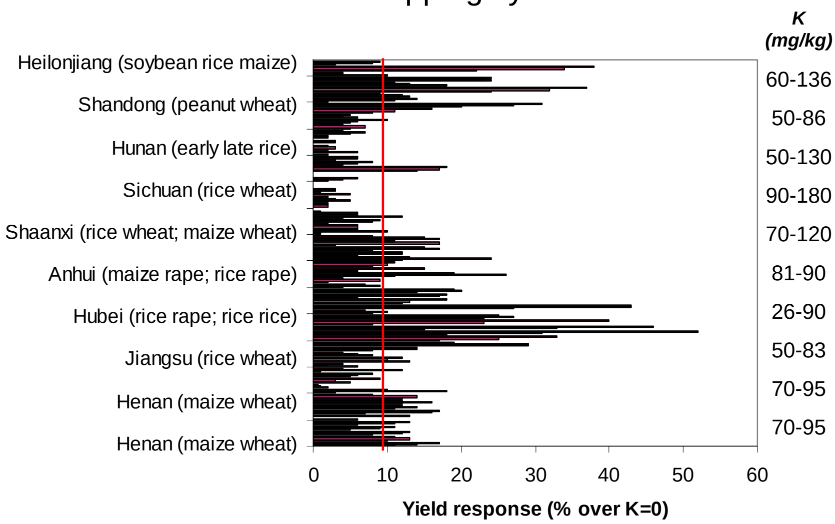
Source: Dahlin, S., Kirchmann, H., Kätterer, T., Gunnarsson, S. and L. Bergström. (2005) Possibilities for Improving Nitrogen Use From Organic Materials in Agricultural Cropping Systems. AMBIO; Vol. 34, No. 4, pp. 288–295.

Effect on yields, quality and plant health

- Effect of balanced fertilization at field level: Simple and not even innovative
- Obtained with, and demonstrated to large groups of farmers
- Adopting various technologies
- From different locations where we (IPI) are operating

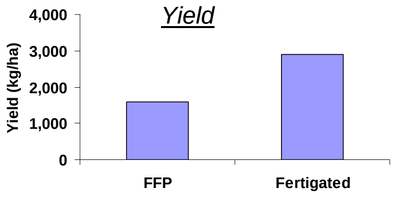
China

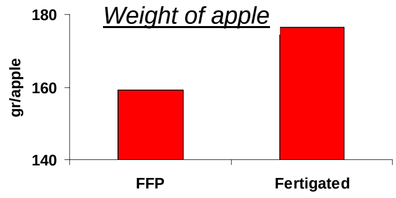
Simple fertilization practices: Yield response to K application in various provinces with different cropping systems

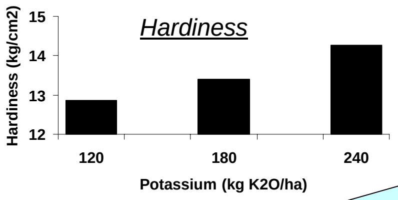


Source: IPI-ISSAS 2003-2005 report

China New technology: IPI fertigation project in apple (Yantai, Shandong, 2005)





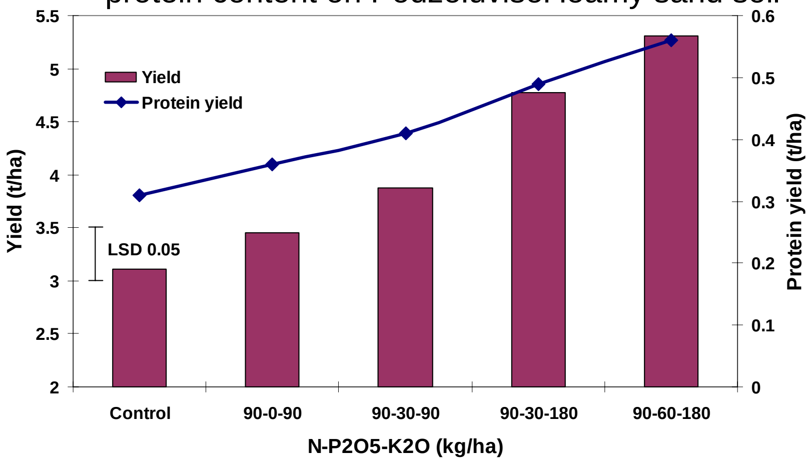


>WUE & NUE

Source: IPI China 2006: IPI-NATESC project, annual report 2005.

Belarus

Effect of fertilizer treatments on wheat grain yield and protein content on Podzoluvisol loamy sand soil



K is used also to reduce radionuclides (e.g. ^{137}Cs & ^{90}Sr) in agri products

Source: IPI East Europe / Belarus, 2004

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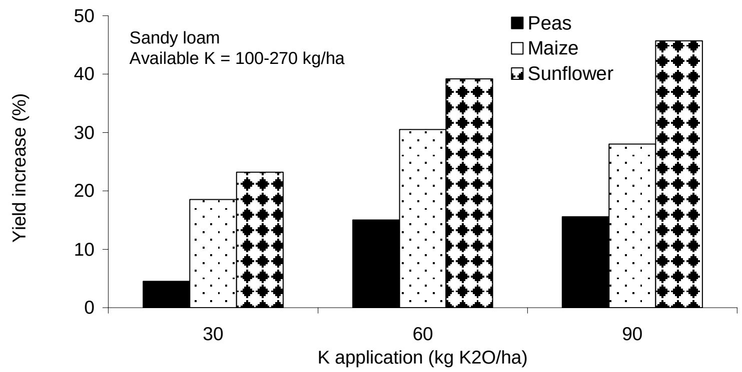
Potassium effect on yield increase in Peas, Maize and Sunflower



Source: IPI India PAU project, 2004

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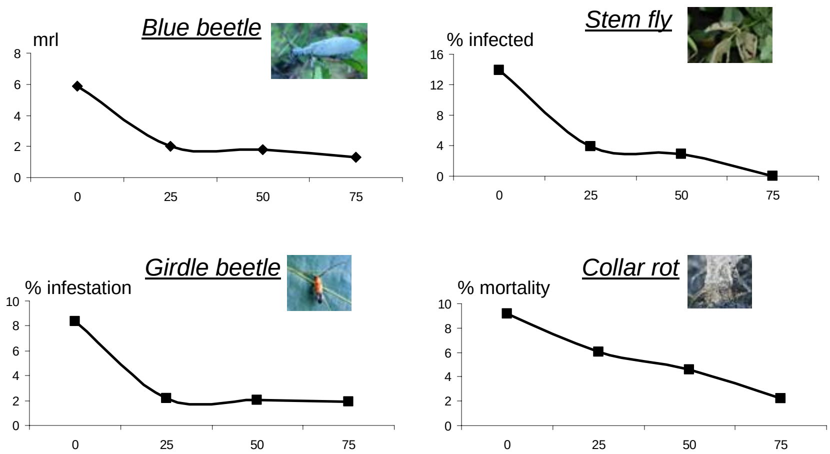
India

Effect of K on infection of soybean from various insects and disease



K application (kg K_2O/ha, as MOP)

N=20 kg N/ha
P=60 kg P_2O_5/ha

Source: IPI India 2005: IPI-ICAR project, annual report 2004.

Effect of real-time N management on sheath blight intensity and rice yield in the 2001 wet season at IRRI in the Philippines.

N management	Disease intensity (%)	Grain yield (t/ha)
Fixed time and rate	33 (6)	4.0 (0.8
SSNM, real time	21 (11)	4.5 (0.2)


A standard leaf color chart (LCC)

Source: Buresh, R.J., C. Witt, Alam, M.M., Ramanathan, S., Chandrasekaran, B., Laureles, E.V. and M.I. Samson. (2005). Site-specific nutrient management for rice: principles and implementation. *In*: Plant nutrition for food security, human health and environmental protection. 15th Int. Plant Nut. Coll. (IPNC). Beijing, China. pp 1062-1063.

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Benefits from balanced fertilization practices

Site	Crop	Benefits		
		Best treatment	FFP	Difference
Southern India[1]	Rice, SSNM ($)	520	352	168 (+47%)
Central Luzon, Philippines[1]	Rice, SSNM ($)	1,218	1,078	140 (+13%)
Indore, India[2]	Soybean, split K ($)	641	470	171 (+36%)
Pune, India[3]	Sugarcane, drip + K (WUE)	1.5	0.6	X2 WUE

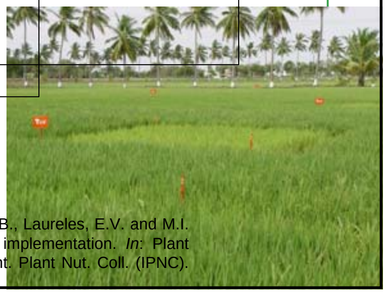
Sources:
(1) IRRI 2005
(2) IPI India NRCS project
(3) IPI India VSI project

Balanced fertilization - Whom to address? Lessons from SSNM in India

Parameter	Fertilizer K (kg/ha)	
	Old Delta	New Delta
Current recommendation	42	42
Use by surveyed farmers	21	37
SSNM recommendation	42	65

Need to convince:

1. ***Local extension / university***
2. ***Farmers***



Source: Buresh, R.J., C. Witt, Alam, M.M., Ramanathan, S., Chandrasekaran, B., Laureles, E.V. and M.I. Samson. (2005). Site-specific nutrient management for rice: principles and implementation. *In:* Plant nutrition for food security, human health and environmental protection. 15th Int. Plant Nut. Coll. (IPNC). Beijing, China. pp 1062-1063.

Conclusions

1. **Negative K balances are mainly caused by high CR removal and insufficient K fertilization**
2. **Common reasons for inadequate K use are scientific convincement and its penetration through to farmers**
3. **Long term inadequate K supply leads K depletion and thus to stagnation and reduction of yields: The rebound is not always immediate**
4. **Significant increased returns in terms of yields and quality may be achieved by**
   - **Adoption of simple, clear fertilizer recommendations**
   - **And in employing advanced tech (fertigation)**
5. **The effect of K on disease intensity is of high importance and need to be understood better**
6. **Balanced fertilization generates higher profits for the farmers, not necessarily through reduced inputs**
7. **The role of education and extension in delivering the up-to-date knowledge on nutrient management is crucial, challenging and continuous.**

Pune, India

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Acknowledgments / Our team

Hillel Magen, Director of the International Potash Institute (IPI).

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Dr. Christian Witt is Director of the Joint Mission of IPI and PPI-PPIC's South East Asia Program (SEAP).

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India, 22-25 November, 2006

- ***Organizers:***
  - **IPI**
  - **Punjab Agric. Univ. (PAU)**

- ***Co-sponsored by:***
  - **Fertilizer Assoc. of India (FAI)**
  - **Indian Council Agric. Res. (ICAR)**
  - **Bangladesh Fertilizer Assoc. (BFA)**
  - **National Fertilizer Secretariat Sri Lanka.**