IPI-BFA-BRRI International Workshop on
Balanced fertilization for increasing and sustaining crop productivity

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Putting potassium in the picture: achieving improved nitrogen use efficiency

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Calculating global cereal NUE

Crop [1]	Crop production[2]	N [1] concentration in grain	Total N removal in grain
	Million mt	g/kg	Million mt
Maize	695	12.6	8.8
Rice paddy	634	12.3	7.8
Wheat	606	21.3	12.9
Barely	139	20.2	2.8
Sorghum	56	19.2	1.1
Millets	32	20.1	0.6
Oats	23	19.3	0.4
Rye	13	22.1	0.3
Total	*220*		*34.7*

Global N consumption in 2006/07 = 98 million mt, of which cereals was 56.3%[3]

Cereals' N from soil and deposition = 16.6 million mt[1].

Calc: (34.7-16.6)/98*0.56=33%

How much is there?

- A 1% increase in NUE worth USD 234 million! [1]

- Excess of N in the Mississippi River is worth USD 750 million per year[1].

(1) Raun and Johnson, Agron. J. 91(3), 1999
(2) FAOSTAT, 3/2008
(3) IFA, 2008

Calculating GHG production costs of N, P and K

• Agriculture accounts for 15% of human's activities GHG emissions (and deforestation to another 11%)

• Nitrous oxide from fertilized soils (with Nitrogen) accounts for 2,128 million mt CO_2-eq (~30% of total ag GHG)

• Production of fertilizers accounts for ~400 million mt CO2-eq

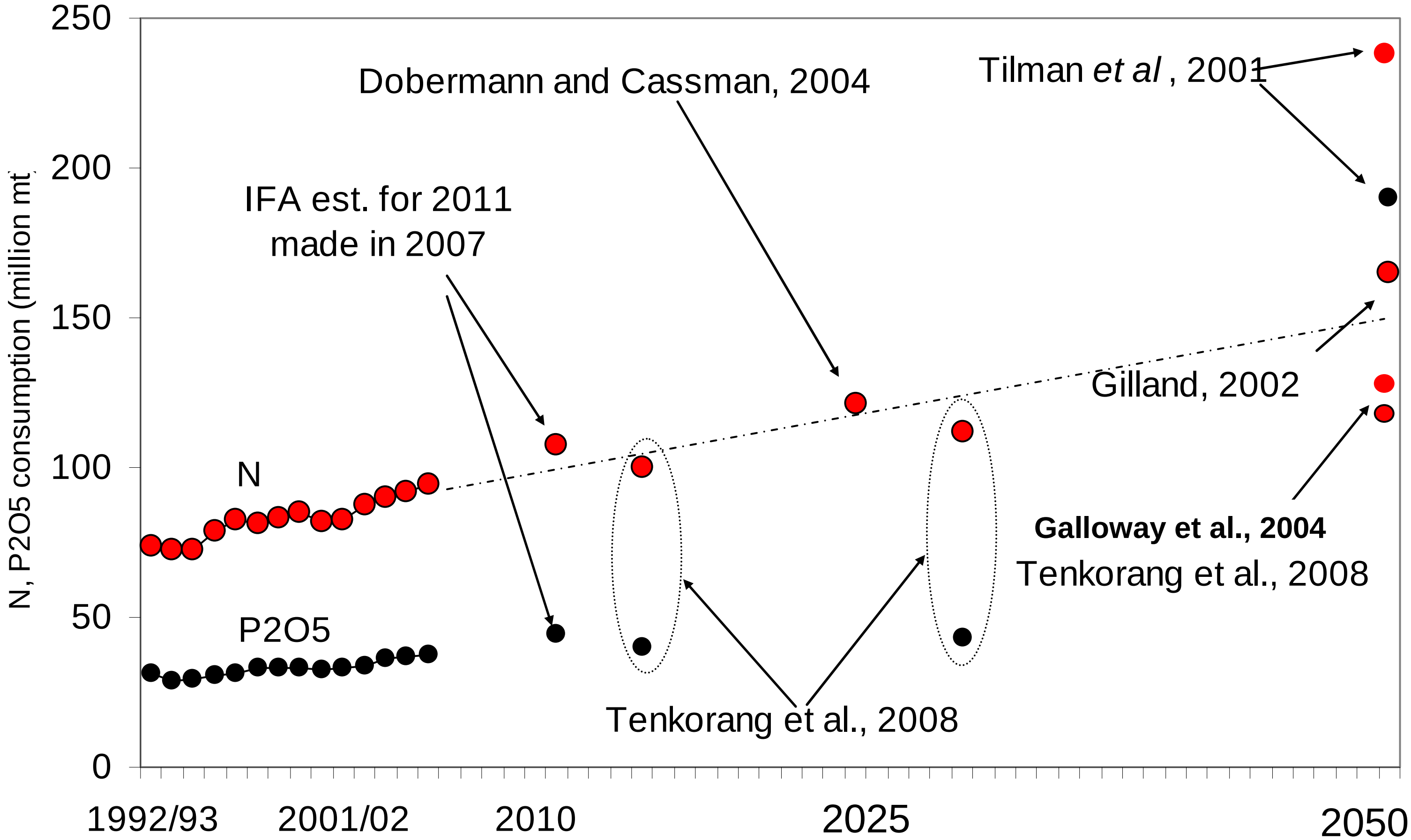
Source: World Bank, 2007

Nutrient	Quantity used 2006/07 [1]	GHG production cost[2]	Total GHG cost
	million mt)	*kg CO_2-eq per 1 kg nutrient*	*million mt CO_2-eq*
N	**97.9**	**3.14**	**308**
P	**38.9**	**0.7**	**27**
K	**27.1**	**0.75**	**20**

(1) IFA, 2008.
(2) Kongshaug, 1998.

Potash mining in the UK

N & P projections by various sources



Improved N use efficiency will bring

- Higher profits to the farmer
- Better environmental stewardship (this has a cost too)
- Will prepare us for the much higher use of N. Better start now.

IPI-ISSAS experiment in Changsha, 2008.

How can NUE improve?

- Rotations
- Hybrid / cultivars
- Conservation tillage
- N source
- Precision ag
- Foliar and fertigation application
- Extension (tool and essence)
- Removal of constrains:
  - Irrigation
  - Balanced fertilization

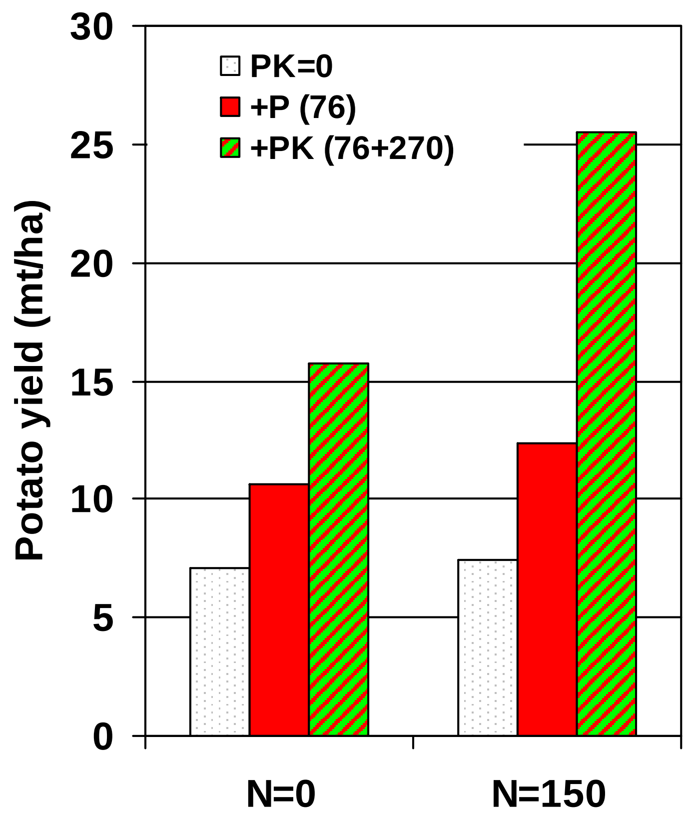
- Balanced fertilization with Potassium
  - Potassium is removed by harvest in large quantities and thus requires large replenishing doses
  - The rewards for balanced K nutrition are substantial

Outputs and inputs	N	P	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

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

"It does no good to worry about nitrogen use efficiency and managing your nitrogen properly if your soil test potassium or phosphorus is low"

(Greg Schwab, University of Kentucky soil fertility)



Adapted from Milford and Johnston, 2007; IFS proc. 615.

Some typical responses: the higher soil K, the better is the response to applied N

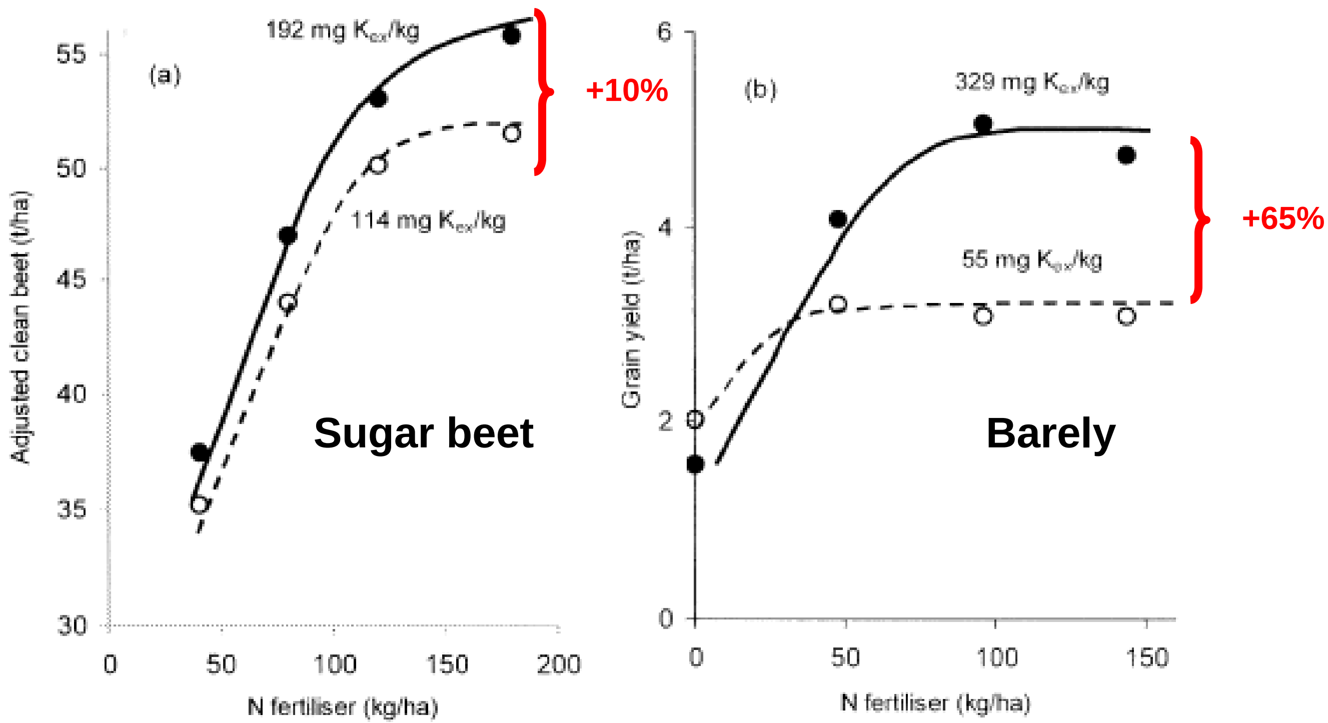
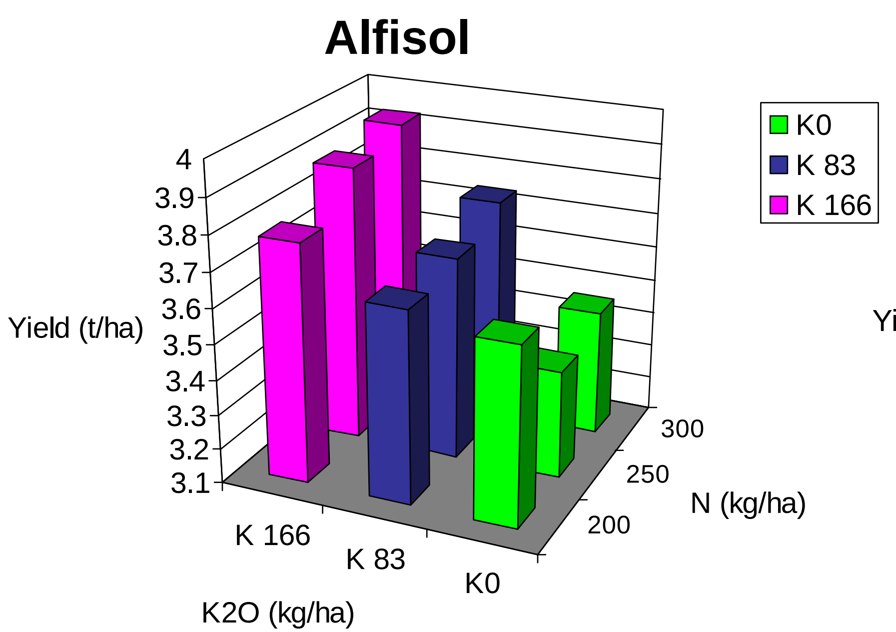
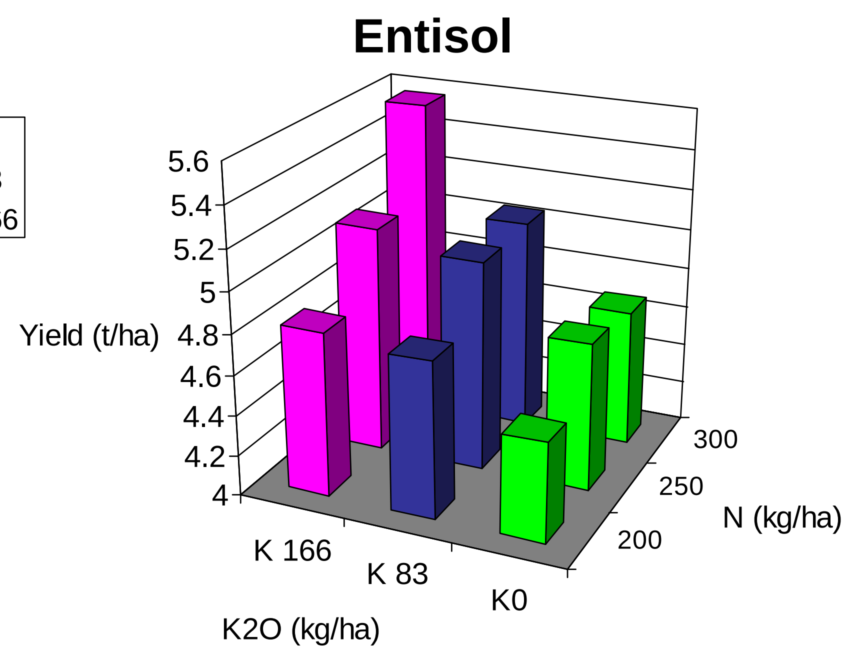


Figure 1. *Interactions between exchangeable soil K (Kex) and N fertiliser on the yield of (a) sugar beet at Saxmundham and (b) spring barley on Hoosfield, Rothamsted.*

Milford and Johnston, 2007; IFS proc. 615.

Residual effect of applying different levels of nitrogen and potassium to rice on the following crop of wheat in alfisol and entisol in Jiangsu Province, China

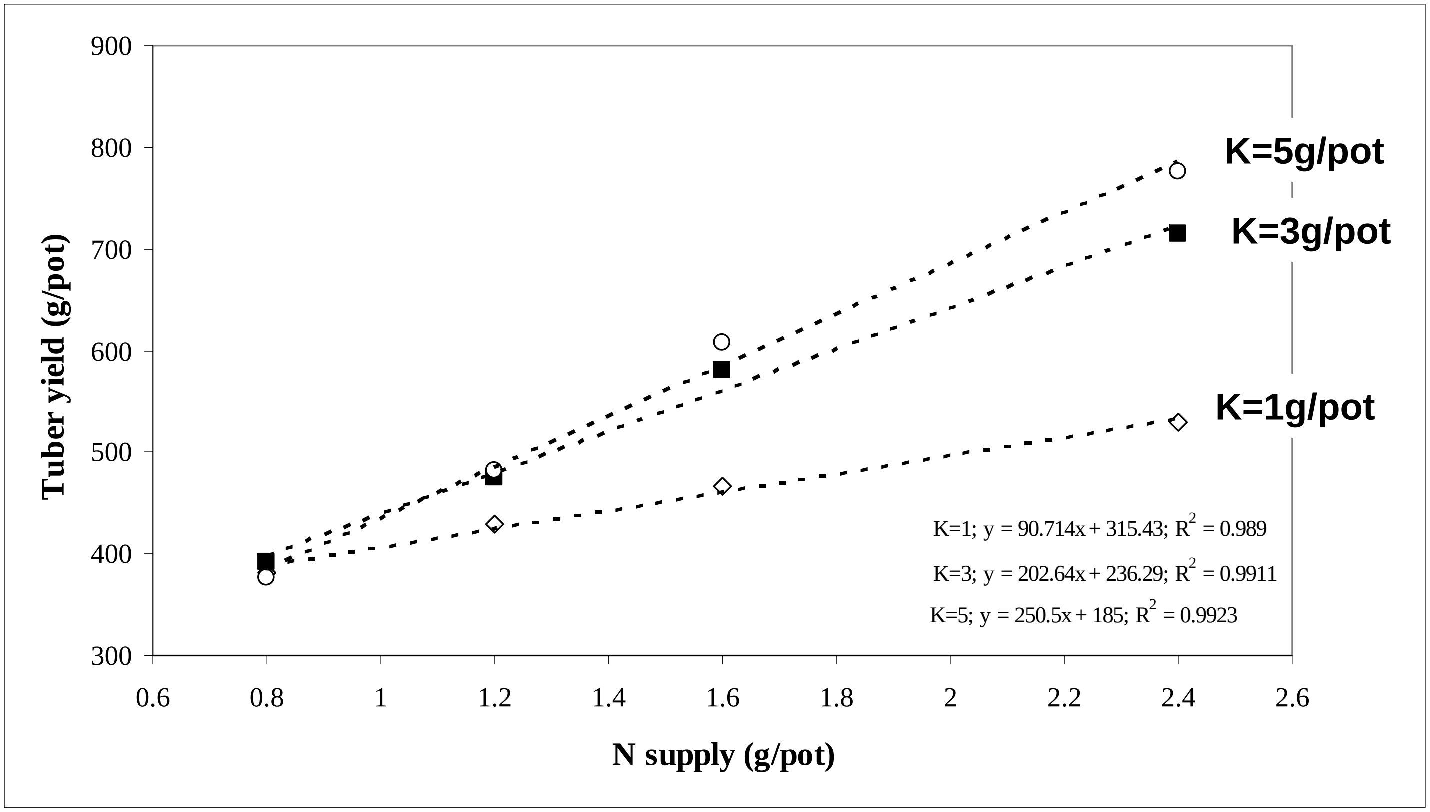




Adapted from Bijay-Singh, Yadvinder-Singh, Patricia Imas and Xie Jian-chang
Advances in Agronomy, Volume 81, 2004.

Tuber yield response to N applied under three levels of K

Higher agronomic efficiency of N with K



Adapted from Gerend´as *et al*., 2007.

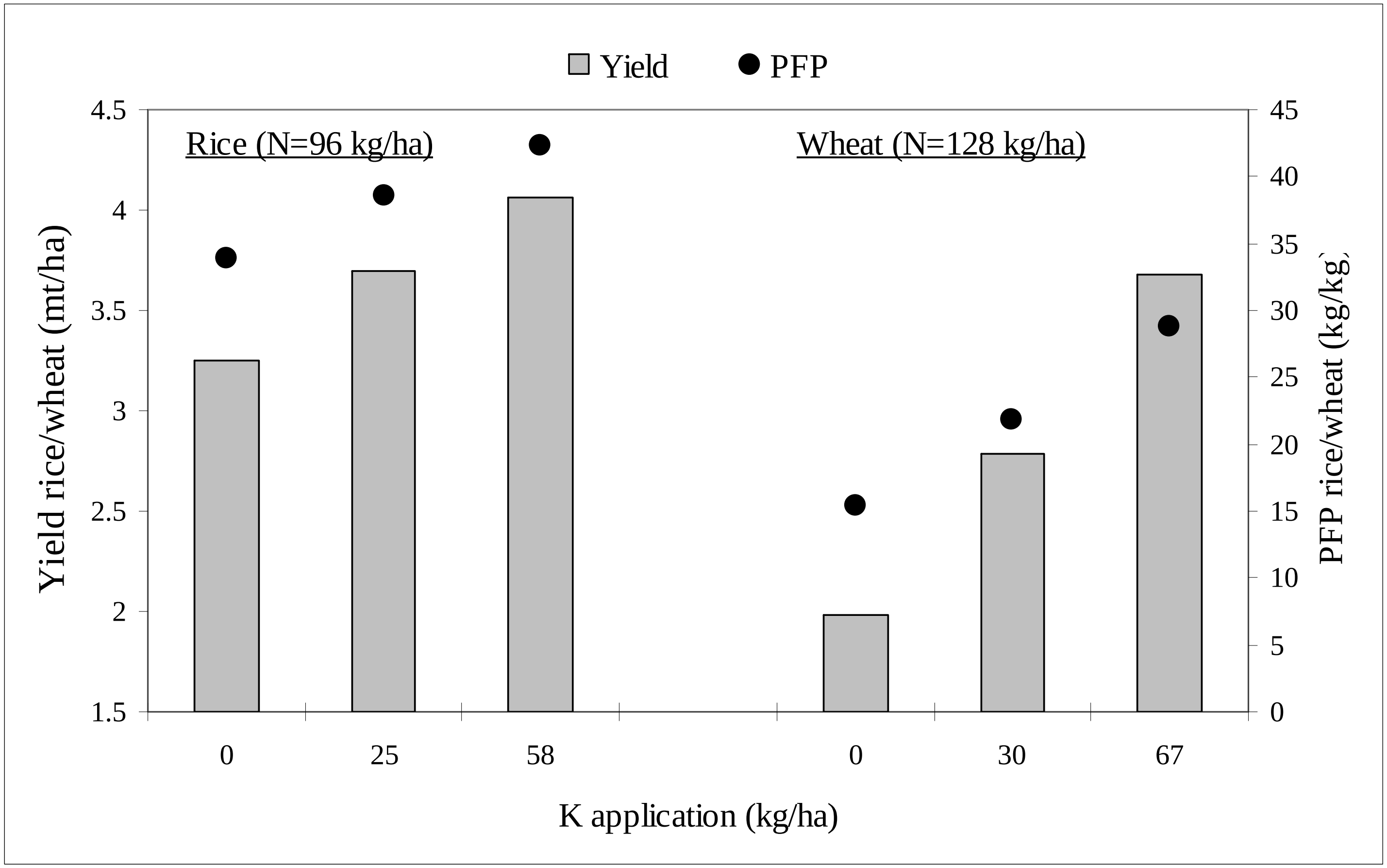
Balanced fertilization improves NUE

Site	AE_N			PFP_N		
	FP	SSNM	Increase	FP	SSNM	Increase
	kg grain / kg N		*%*	*kg grain / kg N*		*%*
1	9.27	18.3	97	36.7	51.2	40
2	8.31	16.4	97	31.9	45.4	42
3	9.69	13.3	37	49.2	50.0	2
4	13.0	16.4	26	42.3	43.6	3
5	8.32	17.1	106	29.0	40.0	38
6	7.56	17.9	137	23.1	35.7	55
All(1)	8.79	16.1	83	34.7	44.2	27

Effect of site-specific nutrient management (SSNM) on Agronomic Efficiency of N (AEN) and Partial Factor Productivity for N (PFPN) in irrigated, transplanted rice fields at six sites in Punjab, India, during 2003 and 2004

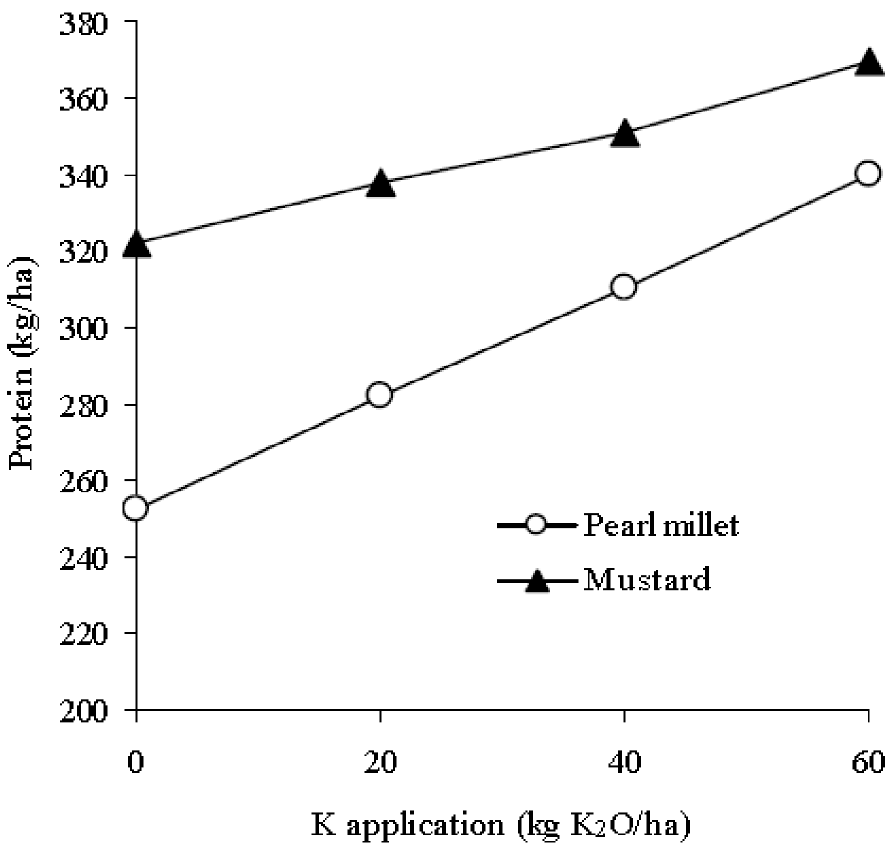
(Adapted from Khurana *et al*., 2007)

Rice and wheat yields and PFP with increasing levels of potassium, at 96 and 128 kg N/ha in rice and wheat, respectively



IPI-BRRI experiment in Bangladesh, based on Islam et al., 2007

Protein concentration and yield of pearl millet and mustard.



Treatments		Protein content	
Pearl millet	Mustard	Pearl millet	Mustard
………..kg/ha……..…		……….%.……...	
$N_{120}P_{60}K_0$		9.89	18.96
$N_{120}P_{60}K_{20}$	$N_{80}P_{30}K_0$	10.51	19.33
$N_{120}P_{60}K_{40}$	+25 kg $ZnSO_4$	10.95	19.66
$N_{120}P_{60}K_{60}$		11.61	20.11
CD (05)		0.81	1.00

Studies on potash responses to field crops in light textured soils of Southern Haryana, India.
By S.S. Yadav, Sultan Singh, Abha Tikoo and J.S. Yadava, Chaudhary Charan Singh Haryana Agricultural University, Regional Research Station, Bawal (Rewari) 123 501, Haryana (India). E-ifc 13, September 2007

Typical yield increases and increased NUE achieved at IPI on-farm experiments in various crops in Asia and Europe.

Crop	Country	Analyzed parameter	N rates[1]	K rates	Yield increase[2]	Increase in NUE[3]
			………..…….kg/ha…		………………	……%......
Maize	India	grain	125	30-90	200-1,300	18 (6-29)
	China[4]	grain	150-300	75-180	200-1,800	18 (5-29)
	Ukraine	grain	30	30	720	15.5
Rice	Bangladesh	grain	100	33-66	690-900	26.3 (23-30)
Rape seed	China[5]	seeds	180	112.5-187.5	142-704	44 (35-53)
Sugar cane	India[6]	cane	240-340	85-200	2,200[7]	70
Sunflower	Hungary[8]	seeds	80	100-200	200-1,100	(10-30)
	India	seeds	60	30-90	400	18
Wheat	China[9]	grain	180-300	75-150	200-1,370	19 (2-26)
Winter rye	Belarus[10]	grain	90	60-120	230-610	(10-23)

(1) N rates in these experiments were kept constant
(2) Yield increase in response to potassium fertilization
(3) Average and range in brackets
(4) Average of 5 locations in Shandong and Hebei provinces
(5) Average of 2 locations in Hubei province
(6) Fertigation (drip) experiment
(7) Increase in yield was achieved also due to inclusion the potassium through the fertigation system
(8) Average of 3 years
(9) Average of 3 locations in Shandong and Hebei provinces
(10) Conducted on 4 different K level soils (104-299 mg/kg available K)
(*Note:* All experiments were conducted by IPI coordinators during the past 7 years).

Published also at IFA, Fertilizers & agriculture 9/2007 issue; http://www.fertilizer.org/ifa/publicat/f&a/2007_09pt.asp).

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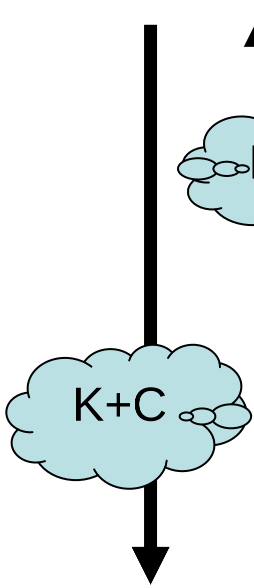
What is behind these responses?

High K and N-K partnerships

Circulation of K between shoot and root in relation to nitrate and malate transport.

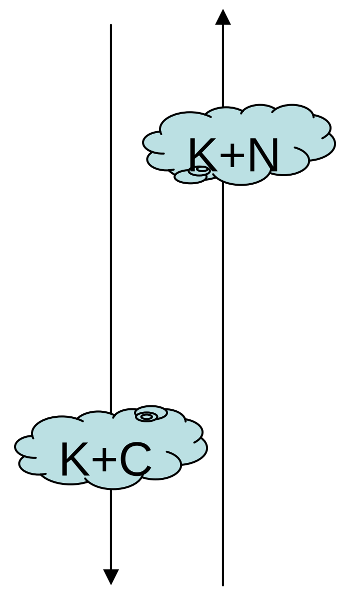
<u>High K supply</u>
Good yield and quality;
Rapid N metabolism



Quick N transfer
Causes efficient N uptake;
better root growth

+K **-K**

<u>Low K supply</u>
Poor yield and quality;
C accumulation

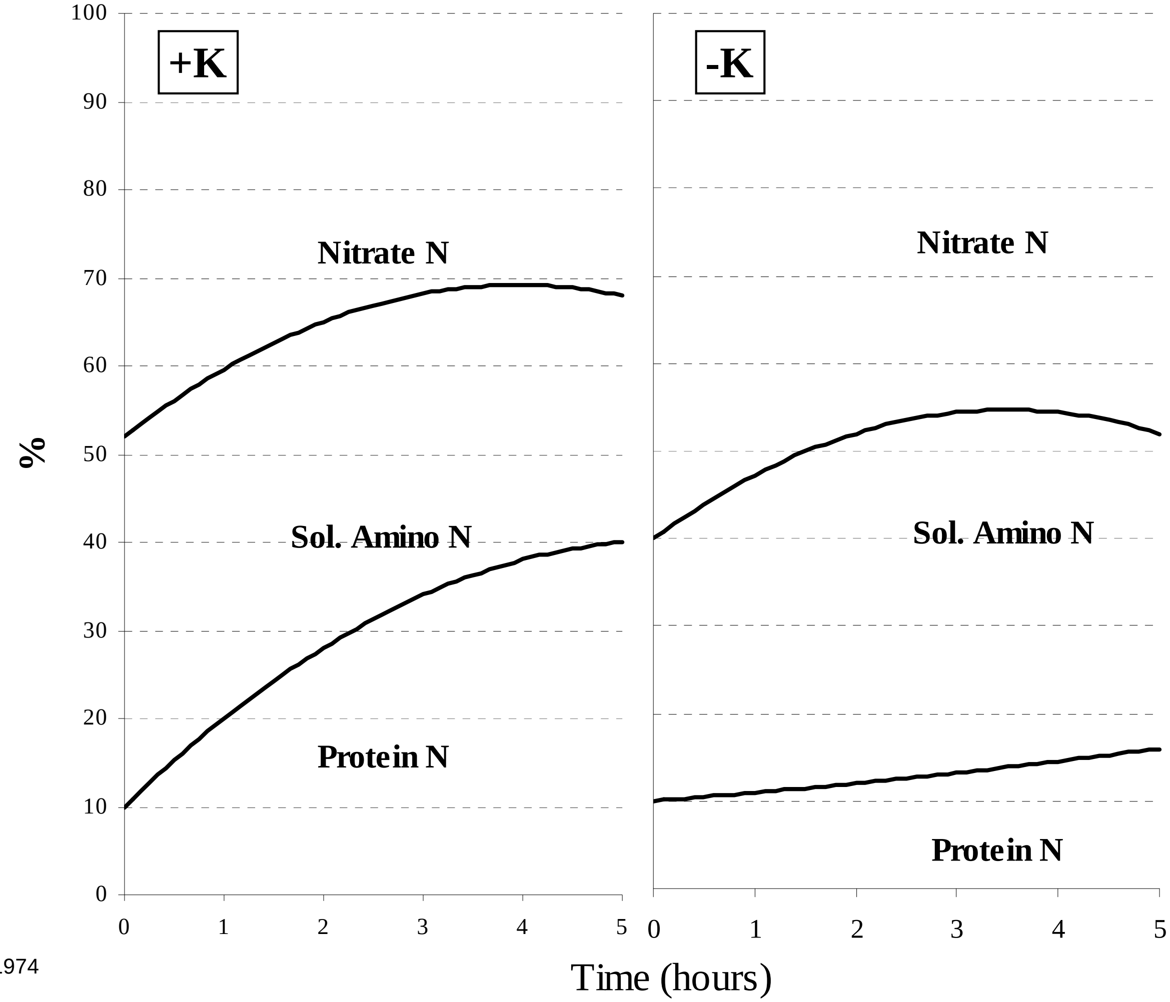


N accumulation,
restricted N uptake

After Marschner et al., 1996 the model of Ben Zioni *et al*., 1971.

NK interaction?

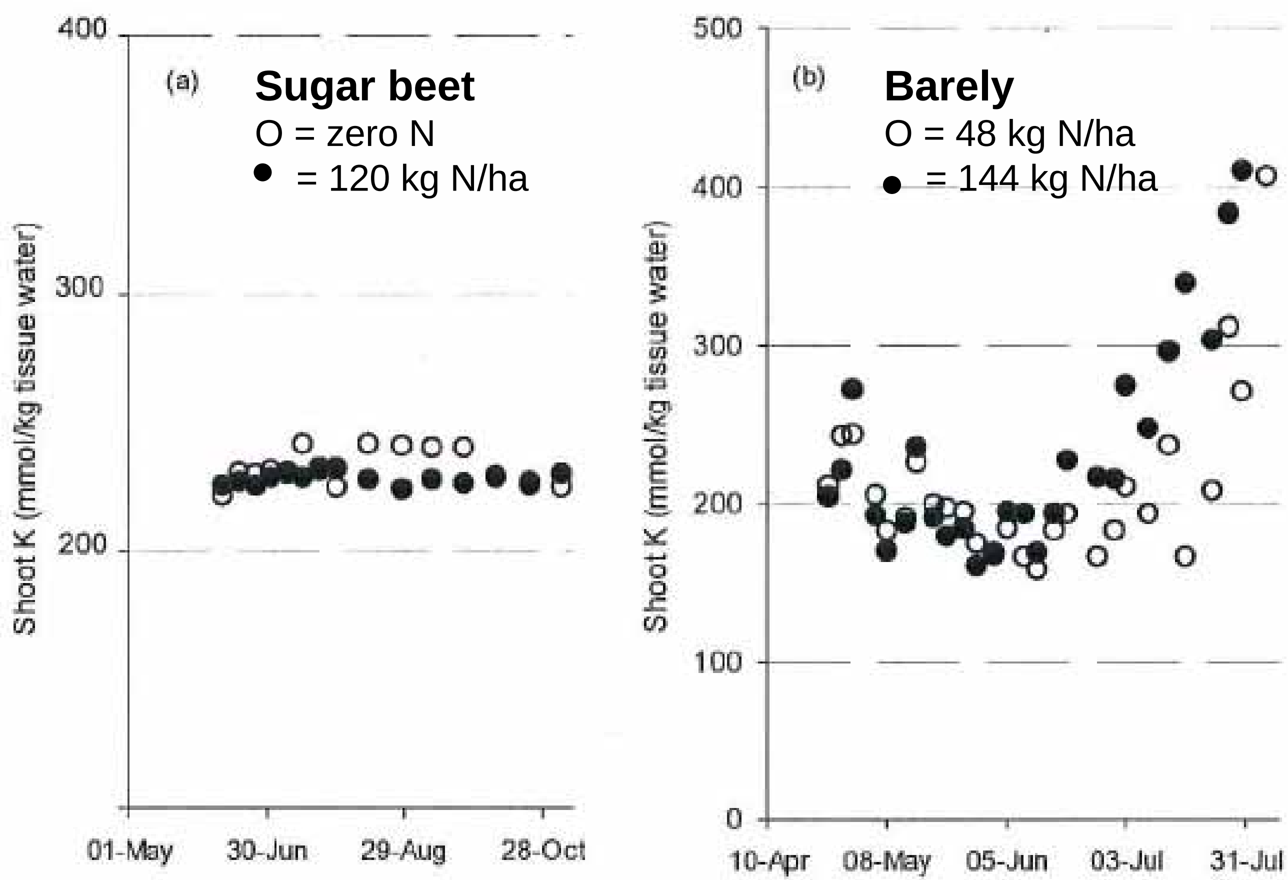
Higher N assimilation and lower free nitrate in the tissue



after Koch and Mengel, 1974

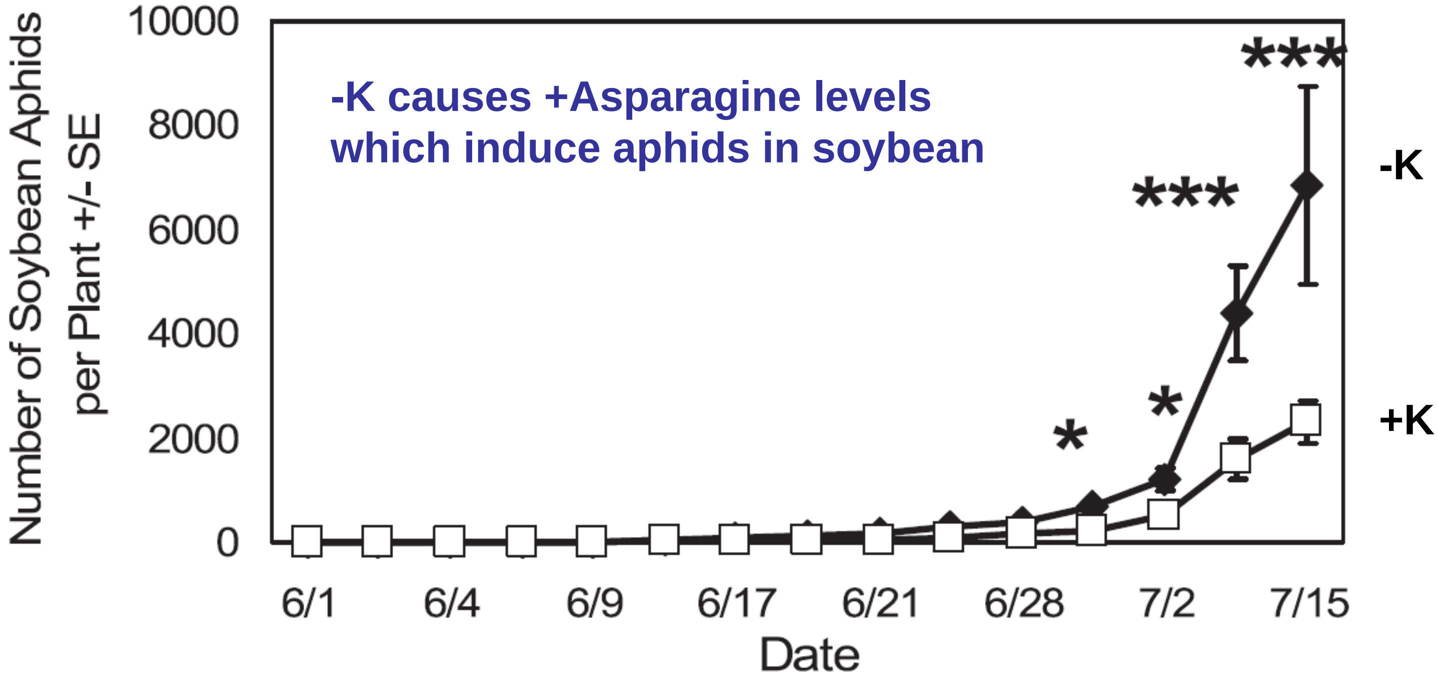
NK interaction?
Seasonal changes in the conc. of K in shoot tissue water

K conc. remains constant or changes with growth patter to maintain required osmoticum



Milford and Johnston, 2007

NK interaction? Soil Potassium Deficiency Affects Soybean Phloem Nitrogen and Soybean Aphid Populations

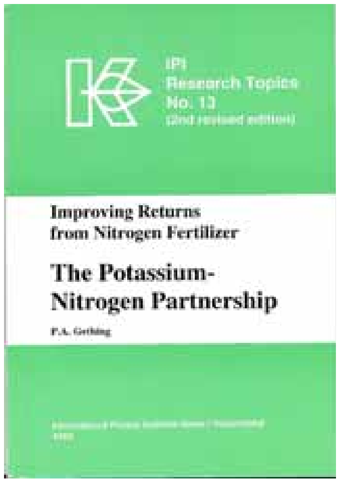


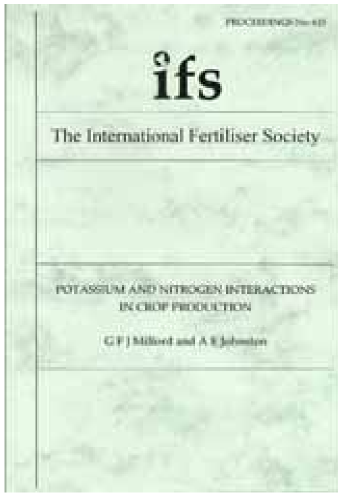
Walter and Difonzo, 2007

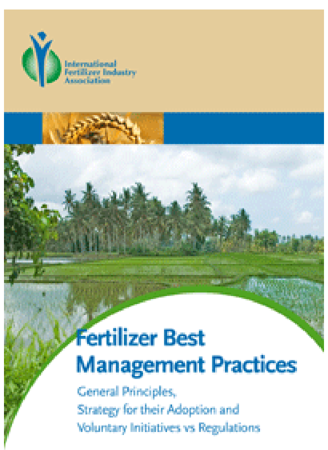
Conclusions

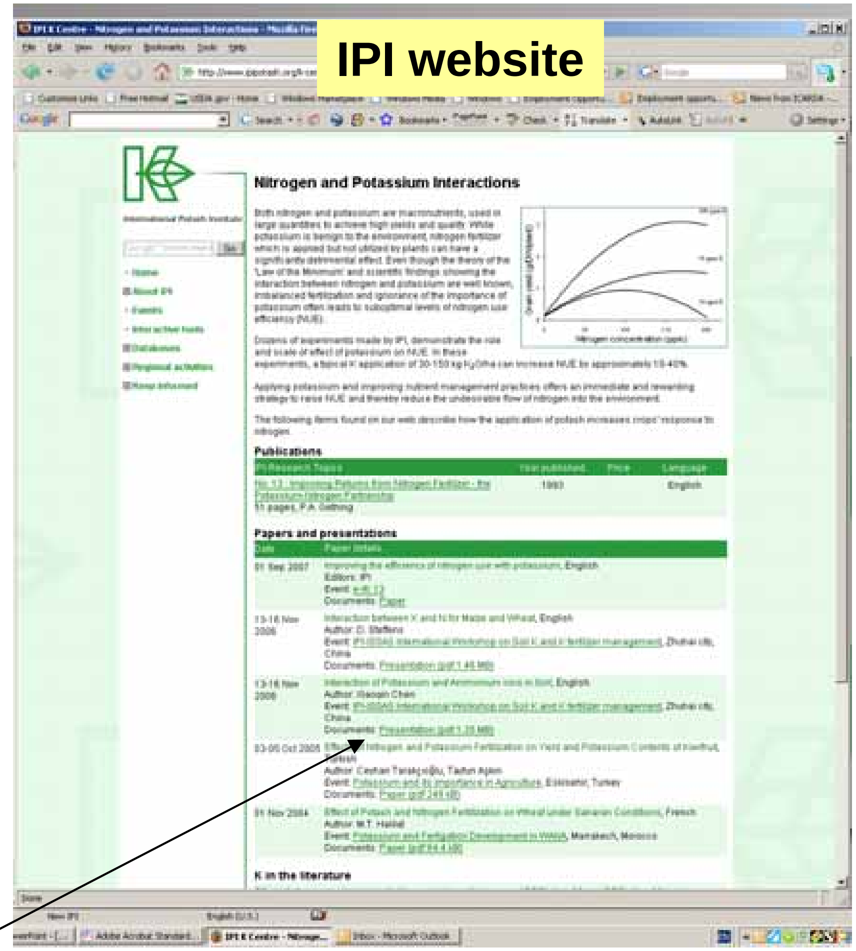
- There is an urgent need to put NUE high on the agenda, for both efficiency and environmental reasons
- Balanced fertilization is an immediate, cheap tool to achieve a higher NUE
- A gain of 20% in NUE can be easily achieved via balanced fertilization with potassium
- The relation between N and K involve in protein formation, growth, influence on amino acids composition – all which affect yield and quality
- NUE is, and will be more and more on our agenda. With current commodity and input prices, let's deal with it NOW.

Literature on NK interaction and NUE









K in the literature section

Acknowledgments / Our team

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Dr. Alexey Naumov is Professor at the Faculty of Geography at the Lomonosov Moscow State University, and is IPI coordinator for Latin America.

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Thank you for your attention

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