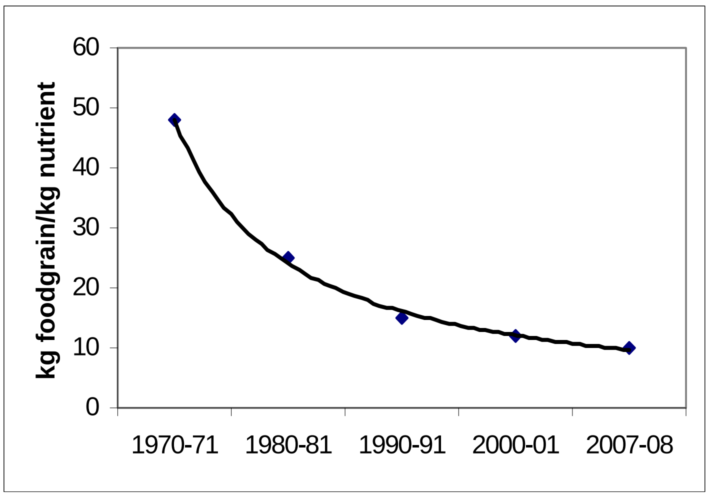
Implications of Soil Fertility to Meet Future Demand: The Indian Scenario

A. Subba Rao
Director
Indian Institute of Soil Science
Bhopal

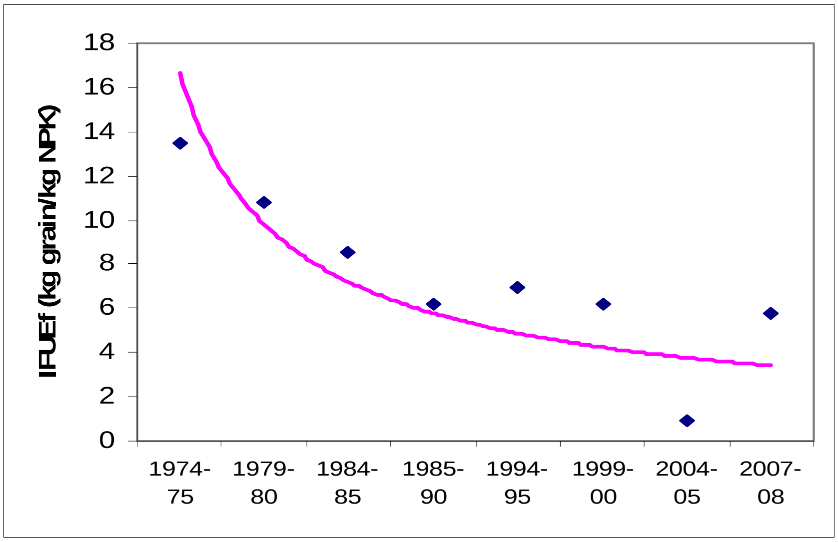
This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

Partial Factor Productivity of Fertilizer NPK (PFPf)



This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

Incremental Fertilizer Use Efficiency



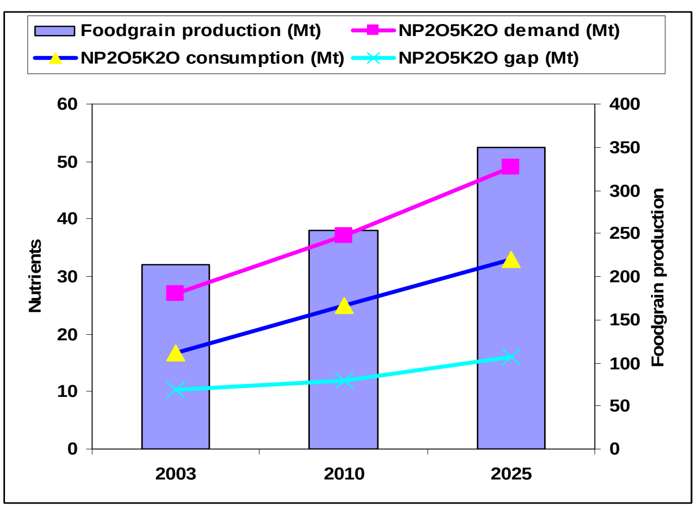
Major Issues of Soil Fertility and Fertilizer Use

This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

Major Issues

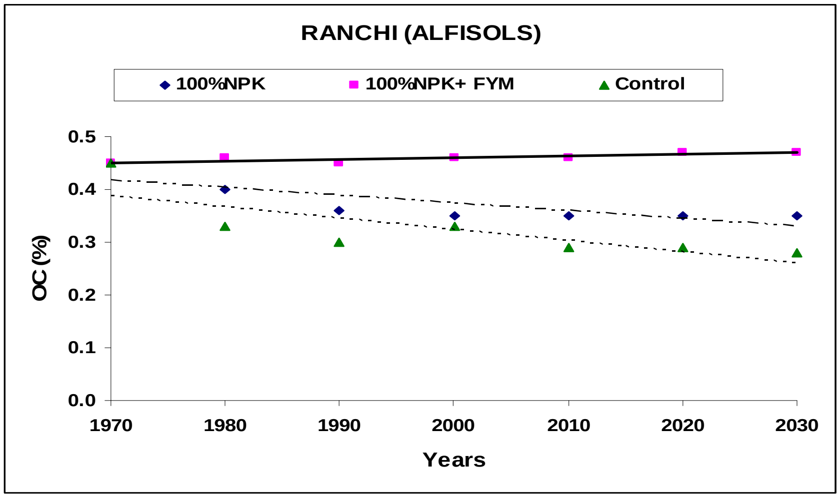
- **Wide nutrient gap between nutrient demand and supply**
- **High nutrient turn over in soil-plant system coupled with low and imbalanced fertilizer use**
- **Emerging deficiencies of secondary and micronutrients**
- **Poor nutrient use efficiency**
- **Decline in organic matter status**
- **Insufficient input of organic sources because of other competitive uses**
- **Fertilizer subsidy**

Food Grain Production Vs Nutrient Supply-Demand-Gap



This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

Declining soil organic matter status

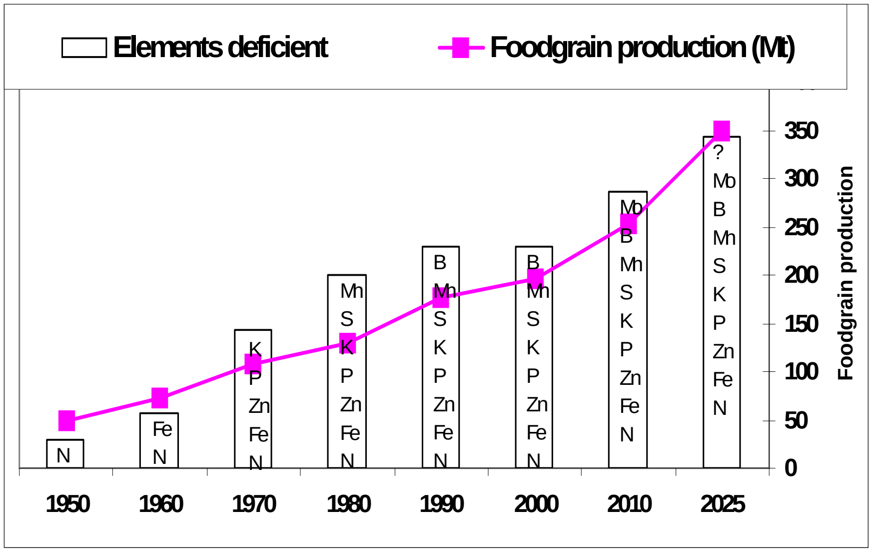


Imbalanced Fertilizer Nutrient Use

Year	N:P:K
1990-91	6:2.4:1
2000-01	7:2.7:1
2006-07	5.3:2.2:1

This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

Emerging Nutrient Deficiencies



Critical limits and extent of deficiency in Indian soils

Nutrient	Critical limits (ppm)	Extent of deficiency (% samples)
S	10	41
Zn	0.6	49
Fe	4.5	12
Cu	0.2	3
Mn	2.5	4.4
B	0.5	32

Fig. 1 Extent of zinc deficient soils in different agro-ecological zones of India

This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

Emerging Soil Fertility Management Strategies for Meeting Future Demands

Nutrient Management Options Available

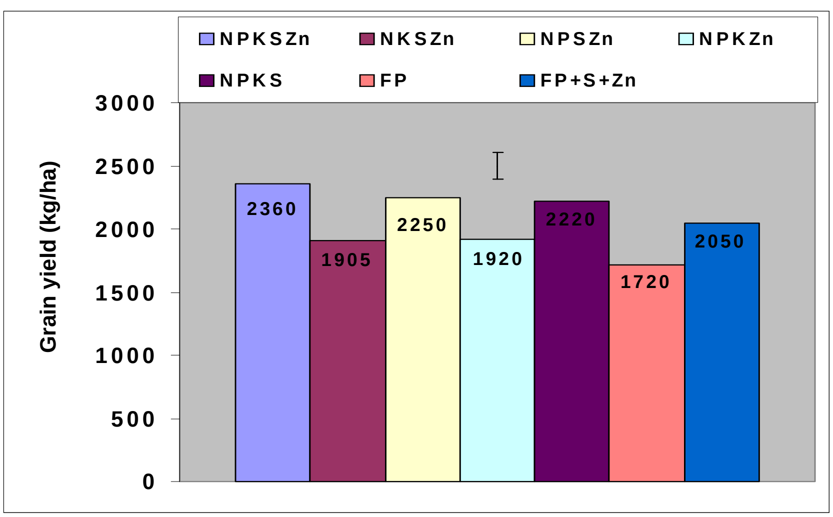
- **Selection of Suitable Crops/Cropping Systems**
- **Improved Nutrient Management Practices**
- **Balanced Fertilization through Inorganic Fertilizers**
- **Integrated use of Fertilizers and Organic Manures**
- **Soil Test Based Fertilizer Recommendations**
- **Conservation Agriculture Practices**

This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

Balanced Fertilization of Crops

Crop	Control Yield (kg/ha)	N Applied (kg/ha)	AE_N (kg grain/kg N)		Increase in AE_N (%)
			N Alone	+PK	
Rice (wet season)	2,740	40	13.5	27.0	100
Rice (Summer)	3,030	40	10.5	81.0	671
Wheat	1,450	40	10.8	20.0	85
Pearl millet	1,050	40	4.7	15.0	219
Maize	1,670	40	19.5	39.0	100
Sorghum	1,270	40	5.3	12.0	126
Sugarcane	47,200	150	78.7	227.7	189

Balanced Fertilization in Soybean



This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

Exact Assessment of Requirement of Nutrients – STCR Approach

Crops	Treatment	Nutrient dose (kg/ha)			Yield (kg/ha)
		N	P_2O_5	K_2O	
Wheat	STCR target 5 t/ha	126	41	49	4887
	State Recommendation (SR)	120	40	60	4567
	Farmers' Practice (FP)	80	0	57	3662
Pearl-millet	STCR target 5 t/ha	100	43.5	42	2540
	SR	80	40	40	2020
	FP	46	0	23	1360
Mustard	STCR target 2.55 t/ha	97	35	75.5	2281
	SR	100	40	40	1890
	FP	60	0	57	1312

Nutrient Potentials of Organics and their Availability

Manure	Total quantity available (mt)	Total nutrients (000t/yr)			
		N	P_2O_5	K_2O	Total
Cattle dung manure	279	2813	2000	2069	6882
Crop residue	273	1283	1966	3904	7153
Rural compost	285	1431	861	1423	3715
City refuse	14	98	64	112	294
Sewage sludge	0.5	5	3	3	11
Press mud	3	33	79	56	168

This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

Availability of organic resources during 2000-2025

Resource	2000	2010	2025
Resources (theoretical potantial)[1]			
Human excreta (dry) (million t)	16.5	18.5	21.5
Livestock dung (sun dry) (million t)	375	396	426
Crop residues (million t)	300	343	496
Nutrients (theoretical potential)[1]			
Human excreta (million t $N+P_2O_5+K_2O$)	2.00	2.24	2.60
Livestock dung (million t $N+P_2O_5+K_2O$)	6.64	7.00	7.54
Crop residues (million t $N+P_2O_5+K_2O$)	6.21	7.10	20.27
Nutrients (considered tappable)[2]			
Human excreta (million t $N+P_2O_5+K_2O$)	1.60	1.80	2.10
Livestock dung (million t $N+P_2O_5+K_2O$)	2.00	2.10	2.26
Crop residues (million t $N+P_2O_5+K_2O$)	2.05	2.34	3.39
Total	5.05	6.24	7.75

All data pertaining to nutrients in dung and in residues are counted twice to the extent these are fed to the animals.

Tapable = 30% of dung, 80% of excreta, 33% of crop residues.

Efficient Use of Applied Nutrient in Biological Systems

This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

Nitrogen Management Strategies

Selection of Suitable Cropping Systems

Growing of leguminous fodder and Feeds, inclusion of legumes, oil seeds, pulses in inter crops, crop rotations and cover crops

- **Different crops tap different soil layers for meeting their nutrient and water requirements depending upon their root and shoot system**
- **Help in meeting part of heavy N needs of modern intensive cropping systems such as rice-rice, rice-wheat, maize-wheat etc.**
- **Help in sustaining soil organic C status in the long run.**
- **Some legumes have the ability to solubilize concluded P and highly insoluble Ca bound P by their root exudates.**

This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

Real Time N Management

Year (No. of sites)	Method of N application	Agronomic efficiency (kg grain kg^{-1} N)	Recovery efficiency (%)
2000-02(27)	RN	15.8	33.3
	LCC (-B)	22.1	46.6
	LCC (+B)	22.0	46.7
	LSD (0.05)	3.5	4.5

Rn = Recommended fertilizer management; LCC = Leaf color chart;

-B = No basal N applied at transplanting; =B = 20 kg N ha^{-1} applied as basal

Source: Yadvinder Sigh et al., 2007

Phosphorus Management Strategies

This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

Trend of Soil Fertility Status

- First soil fertility map of Ramamurthy and Bajaj (1969) showed 4% soils were high in available P.
- In 2002, around 20% of soils are high in available P status.
- Need to utilize residual P or accumulated P.

(i) Soil test maintenance P requirement.

(ii)Residual P management strategy.

Residual P Management of Black Soils under Soybean-Wheat System

- Fertilizer-P applied to soybean showed residual effects in two succeeding crops while the P applied to wheat had a significant residual effect on only one succeeding crop.
- The P applied to soybean was more efficiently utilized than that applied to wheat in the system.
- On P deficient black soils, application of 39 kg P/ha to either soybean or wheat and no P to the following crop in the soybean-wheat rotation produced similar yield as 26 kg P/ha each to soybean and wheat. This strategy had saved 13 kg P/ha/year.

This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

Soil Test P Maintenance

P supply strategy (PSS)*	Soil test maintenance P requirement (STMPR) of soybean-wheat rotation (kg ha^{-1} yr^{-1})	Yield levels of rotational crops at STMPR (Mg ha^{-1})		Total annual P removal at STMPR (kg ha^{-1} yr^{-1})
		Soybean	Wheat	
PSS-I	36.1 (22.2 + 13.9)@	1.91	4.10	25.2
PSS-II	26.3 (16.2 + 10.1)	1.86	4.06	23.4
PSS-III	24.1 (14.8 + 9.3)	1.90	4.01	23.7

* PSS-I, PSS-II and PSS-III imply P supply through inorganic (fertilizer), organic (FYM) and integrated (fertilizer+FYM) sources, respectively to soybean. P supply to wheat was solely through fertilizer under all strategies.

@ Figures in parentheses indicate the P rates for component crops of annual soybean-wheat rotation obtained by splitting STMPR in the same ratio of 1.6:1 as was used in the treatments for soybean and wheat.

Strategies for enhancing P use efficiency in crops in acid soils.

Cropping System	Agro-climatic zone	Strategy
Maize-wheat	Western Himalayan region (pH <6.0)	Apply 60 kg P_20_5/ha as a mixture of SSP and rock phosphate in a ratio of 1:2 to maize. However, apply SSP to following wheat for higher FUE.
Rice-rice	Eastern Himalayan region (pH<5.1)	Apply 30 kg P_2O_5/ha to summer as well as monsoon rice in the form of rock phosphate or a mixture of SSP and RP in 1:1 ratio.
Rice-rice	Brahmaputra Valley	Apply MRP at 40 kg P_2O_5/ha at 20 day before rice transplanting
Rice-rice	Lower Gangetic Plain region	Use SSP and rock phosphate in 1:2 ratio as basal dressing for higher P use efficiency.
Rice-rice	Central Plateau & Hills region	Recommended P dose is 60 kg P_2O_5/ha as rock phosphate.
Pulses	Southern plateau & Hills region	Rhizobium inoculated seed should be treated with 1.5 kg of finely powdered lime (300 mesh). Liming rate should be determined by soil test method and the rate should be such that it can only upset the Al toxicity and does not impair the K and Ca balance.
Rice-rice	East Coast Plains & Hills region West Coast Plains & Hills region	Apply 60 kg P_2O_5/ha as rock phosphate 3 weeks before transplanting.

Source: Subba Rao et al. (2004)

Potassium Management Strategies

Productivity (kg ha^{-1}) under balanced and imbalanced use of nutrient at Bangalore

Centre/ Cropping System	Control	N	NP	NPK	NPK+ FYM	NPK+ Lime
Bangalore (Alfisols)						
Finger millet (2005)	426	392	432	4009	4416	3688
Average (17 years)	591	761	978	4313	4855	4127
Maize (2004-05)	118	75	175	2020	2453	2242
Average (17 years)	280	396	635	2113	2530	2292

This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

1. Recycling of Crop Residues

- About 336 million tonnes of crop residues are produced per year which can supply about 5.1 million tonnes of K.
- Several strategies have been developed for efficient recycling of mechanical borne wheat and rice residues.

Effect of Wheat Residue Management Options and N Sources on Soybean seed Yield (kg/ha)

N sources	Wheat residue management options for soybean		
	Burning	Soil incorporation	Surface retention
Control	402	440	459
Fertilizer-N	525	608	600
FYM	611	696	690
PM	588	656	678
GLM	505	567	579
l.s.d.(P=0.05)	ROM-23.3	N source-27.5	RMOxN source-NS
Source: Reddy (2007)			

This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

2.Value Added Compost with Mica Waste

- **India has the world's largest deposits of mica.**
- **Mica contains about 8-10% K_2O.**
- **75% of muscovite mica in electrical industry generated as the waste.**
- **Nishant and Biswas (2007) developed enriched compost using rice straw, dung, rock phosphate and waste mica.**
- **Biotite mica is rarely used for any commercial purpose but very large reserves are available.**

3. Mobilization of K from indigenous minerals

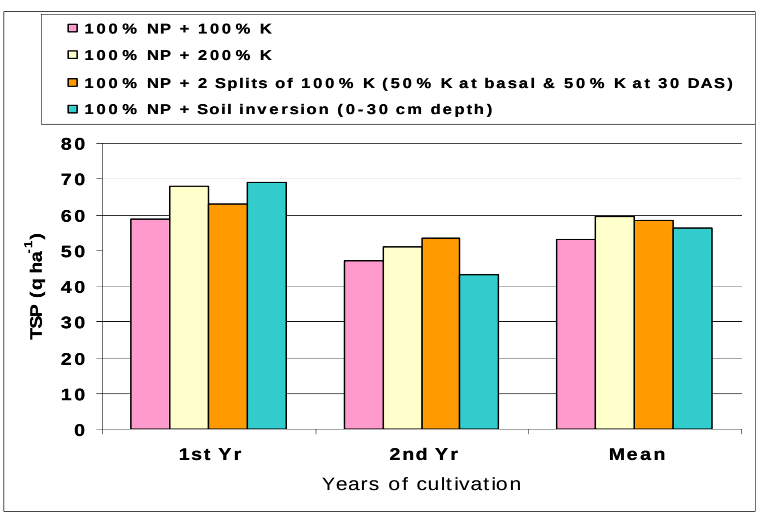
- **About 938 million tonnes of glauconite sandstones in Satna district of M.P. and adjoining U.P.**
- **It contains about 5.4% K_2O.**
- **Techniques such as composting, partial acidulation should be developed for solubilizing K from glauconite.**

This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

4. Situations Which Need Split Application of K

- **Rice grown in light textured soils and acid soils in high rainfall areas in order to reduce leaching losses;**
- **Low tillering and late maturing varieties, where the natural supply of K from soil plus irrigation wiii decreases in the later stages of crop growth**
- **In highly reduced soils where conditions may hinder K uptake; and**
- **During the monsoon season, several studies conducted in Tamil Nadu, Uttar Pradesh, West Bengal and Tripura states have indicated the beneficial effect of application of K in 2-3 splits in rice.**

Effect of K Management on Finger millet - Cowpea System



This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

5. Higher Doses of K to Heavy Feeders

- **Potato, Tapioca**
- **Plantation crops like Tea, Rubber, Coconut**
- **Leafy vegetables such as Cauliflower, Cabbage**
- **Forage crops like Alfalfa**
- **Leaf quality - Tobacco**

Sulphur Management Strategies

This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

S Management Strategies

- Fertilizers S application should be based on available sulphur status of soils.
- Sulphur application may preferably made prior to sowing or bud initiation are flowering under moist conditions.
- Efficient utilization of residual S (accumulated S).

Fertilizer S Recommendations Based on Available S Status of Soils

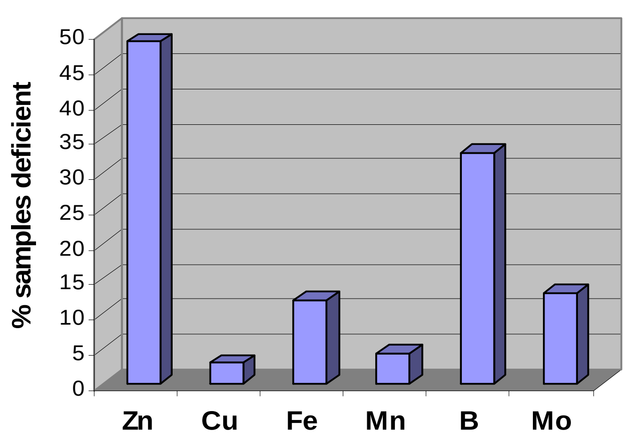
Available S (mg/kg) in soil	S fertility class	Amount of S to be applied (kg/ha)
<5	Very low	60
6-10	Low	45
11-15	Medium	30
16-20	High	15
>20	Very High	0
Source: (Singh 1999)		

This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

Micronutrient Management Strategies

This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

Extent of Micronutrient Deficiency in India



This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

Strategies

- Application of 5 kg Zn/ha is sufficient on alluvial, red and laterite soils.
- 10 kg Zn/ha is optimum on Vertisols.
- 5-10 kg Zn/ha had significant residual effect for 3-6 crops without reduction in yield.
- 1-1.5 kg B/ha to alternate crops for oilseed based cropping systems.
- Regular application of FYM 8-10 t/ha can control micronutrient deficiencies.
- When 4-5 t/ha FYM is applied, Zn rate can be reduced by 50%.

Strategies

- Basal application of micronutrients is found more efficient than top dressing.
- Liquid fertilizers can be used for fertigation in drip irrigation.
- 2-4 sprays of 0.5% micronutrient solutions (Zn, Fe, Mn) can effectively control deficiencies on standing crops.

Components of Balanced Fertilization Under Different Situations

Situation	Component of balanced fertilization (Nutrients whose application needed)
Red and lateritic soils	N, P, K with lime
Newly reclaimed alkali soils	N & Zn
Many areas in alluvial soils, wheat belt	N, P, K, Zn & S / N, P, Zn & S / N, P & Zn / N, P, K, & Zn
Many areas under oil seeds	N, P, K, & S / N, P, & S / N, P, Zn & S / N, P, S & B
Legumes in oilseeds	N, P, K, Ca & Mo
Malnad area of Karnataka	N, P, K, Mg, S and Zn
High yielding tea plantation	N, P, K, Mg, S and Zn
Source: Tandon and Narayan (1990)	

Future Research

This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.

Future Research

- **Precision agriculture is likely to play a greater role in which site-specific nutrient management has to be coupled with temporal specific nutrient needs of crop. Very little work has been done on this aspect.**
- **Nutrient management strategies need to be developed for mobilizing nutrients from indigenous and cheaper minerals and industrial by-products so that pressure on costly imported fertilizers can be reduced.**
- **Plant analysis, usually used for horticultural and vegetable crops, must be made more popular.**

- **Many small and marginal farmers in developing countries felt that the application of fertilizers is risky as they are not sure to harvest good crop due to other associated problems such as pests, weeds, waterlogging etc involved in the crop production. Therefore, improved nutrient management technologies should be recommended and popularized among the farmers along with other pest, weed and water management options as a package of practices.**
- **The K balance of Punjab, Haryana and other Northern Indian states appears to be worst in the country as the K consumption is very meager. It remains to be seen that how long soil K reserves could sustain present level of crop productivity. Keeping in view the continuous depletion of K reserves by intensive cropping, a close watch is needed to monitor K deficiency assuming significance in crop production.**

This presentation was made at the IPI-OUAT-IPNI International Symposium, 5-7 November 2009, OUAT, Bhubaneswar, Orissa, India. The Role and Benefits of Potassium in Improving Nutrient Management for Food Production, Quality and Reduced Environmental Damage.


Thank You