Potassium Management for Crops in Soils of Orissa

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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.

- The state of Orissa is located in Coromondal coast of India experienced tropical monsoon climate.
- Annual rainfall is 1497mm.
- It is the 10th largest and 11th populous state in India accounts for 5% geographical area and 4% population of the country
- Agriculture contributes 28% to Net State Domestic Production.
- It employs 64% of the work forces.

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Net Cropped area of the state is 6.2 million ha

Rice occupies 50% of cultivated area

Pulse occupies 22% of cultivated area

Oilseed occupies 9% of cultivated area

Vegetable occupies 7% of cultivated area

Spices, Jute, Sugarcane and other occupies 12% of cultivated area

Productivity of different crops in Orissa as compared to all India (2004-05)

Crops	Productivity (qha^{-1})	
	Orissa	All India
Rice	14.55	19.84
Wheat	13.32	26.02
Maize	13.22	19.07
Arhar	6.83	6.67
Groundnut	15.15	10.20
Sugarcane	686.00	647.52
Potato	94.95	179.23

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Fertilizer consumption rate and ratio of N and K in Orissa

Year	$N+P_2O_5+K_2O$ Kg ha^{-1}	N: K_2O ratio
1980	7.6	5.9
1990	21.0	5.1
2000	31.0	6.7
2005-06	46.0	5.76
2006-07	52.0	4.87
2007-08	57.0	4.43
2008-09	62.0	4.33

Soil Taxonomic Orders

Soil Order	TGA (million ha)	% of TGA
Inceptisols	7.49	48
Alfisols	5.62	36
Entisols	1.53	10
Vertisols	0.93	6

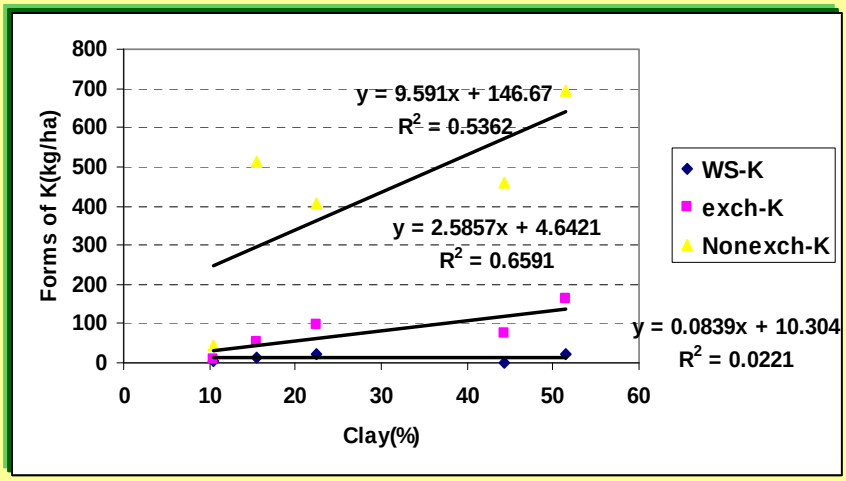
Mineral Composition of Different Soil Orders

Soil Order	Orthoclase (%)	Muscovite Mica (%)	Abundance Class Mineralogy
Inceptisols	9.8 - 41.1	0 - 6.1	Kaolinite > Illite
Alfisols	7.0 - 42.5	1.0 - 4.8	Kaolinite > Illite > Montmorillonite
Entisols	22.5 - 38.6	1.1-14.8	Illite > Montmorillonite > Kaolinite
Vertisols	12.4 - 26.9	2.7-11.0	Illite = Montmorillonite

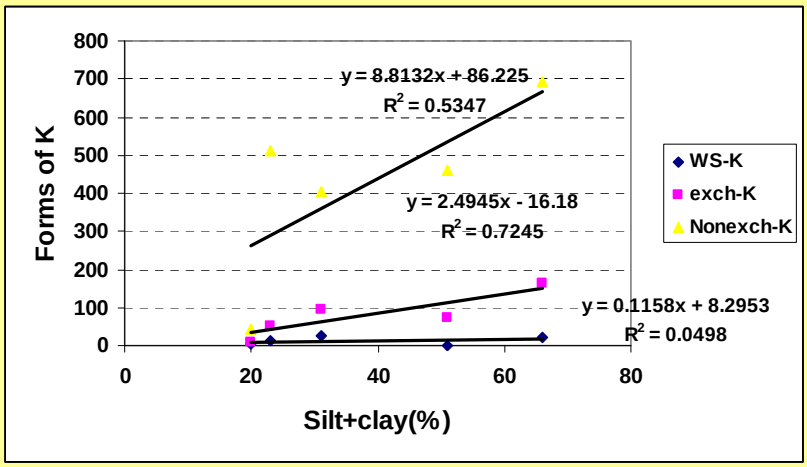
Distribution of Potassium in different soils

Soil type	WS-K	Exch.-K	Non-Exch.-K	Lattice-K	Total-K
	(kg ha^{-1})				
Inceptisol (Central farm)	4.45 (0.86)*	7.45 (1.43)	44.5 (8.56)	463.60 (89.15)	520.0
Alfisol (OUAT Orchard)	1.15 (0.03)	74.3 (1.77)	461.75 (10.99)	3662.8 (87.21)	4200.0
Vertisol (Balugaon)	21.7 (0.70)	164.0 (5.29)	692.3 (22.33)	2222.0 (71.68)	3100.0
Entisol (Pipili)	12.0 (1.0)	53.45 (4.45)	510.55 (42.55)	624.0 (52.0)	1200.0
Saline Soil (Chilka)	24.3 (1.52)	96.35 (6.02)	405.35 (25.33)	1074.0 (67.13)	1600.0

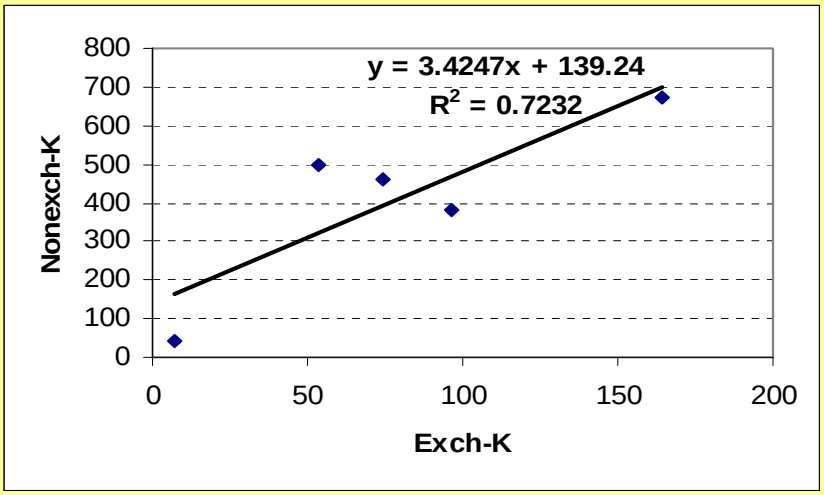
Correlation between different forms of K with clay (%)



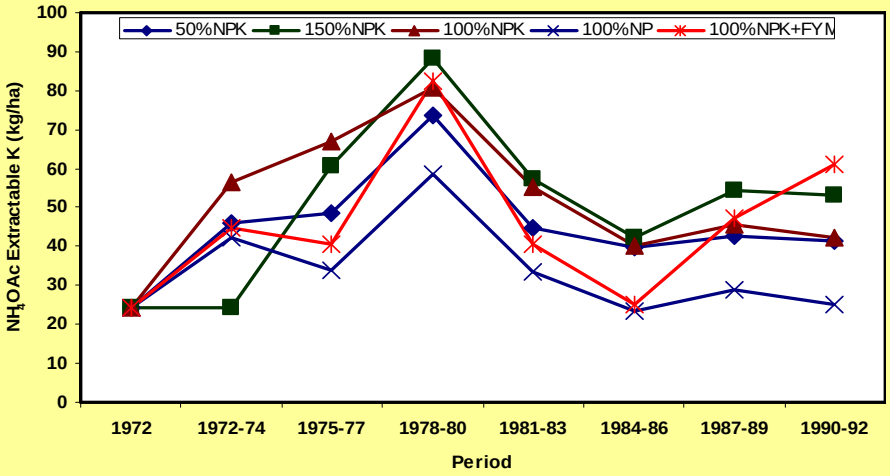
Correlation between different forms of K with Silt + Clay (%)



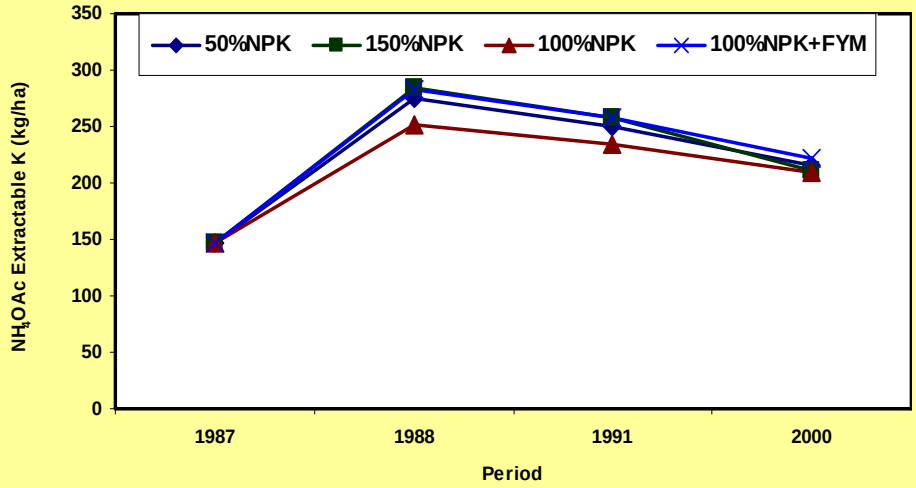
Correlation between Non-exchangeable and Exchangeable K



Variation in NH_4OAC Extractable (available) K status of soil (3 years average) under long term manuring at Bhubaneswar centre



Variation in NH_4OAC Extractable (available) K status of soil under long term manuring at Keonjhar centre



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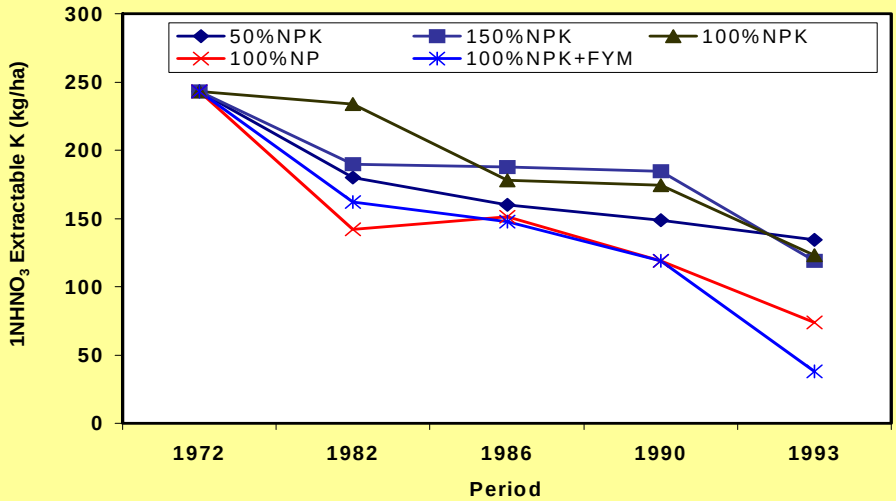
Variation in 1N HNO_3 Extractable K over the years at Bhubaneswar



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Effect of treatments on K status of laterite soils of Bhubaneswar from 1972 to 1988(after 32 crops of rice)

Treatments	1N NH_4OAC –K (kg ha^{-1})			1N HNO_3 –K (kg ha^{-1})		
	0-0.15 m	0.15-0.30 m	0.30-0.45 m	0-0.15 m	0.15-0.30 m	0.30-0.4 m
100% NP	35	26	33	150	154	113
100% NPK	45	35	56	230	195	200
100% NPK + FYM	43	25	38	167	102	147
150% NPK	55	35	60	243	201	227
50% NPK	48	35	55	200	158	183
Initial	25	44	71	240	233	313

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Effect of treatments on K status of Mixed red and black soils of Keonjhar from 1990 - 2000 in rice-oilseed/pulse sequence

Treatments	1N NH_4OAC –K (kgha^{-1})			1N HNO_3 –K (kgha^{-1})		
	0-0.15 m	0.15-0.30 m	0.30-0.45 m	0-0.15 m	0.15-0.30 m	0.30-0.45 m
100% NP	227	205	220	533	660	573
100% NPK	208	224	221	640	667	673
100% NPK + FYM	219	299	255	813	960	817
50% NPK	212	250	253	593	633	706
Initial	144	325	298	706	950	1098

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Cumulative effect of treatments on Step –K and CR-K after 22 years of rice-rice cropping at Bhubaneswar

Treatments	Step-K (mg kg^{-1})			CR-K (mg kg^{-1})		
	0-0.15 m	0.15-0.30 m	0.30-0.45 m	0-0.15 m	0.15-0.30 m	0.30-0.45 m
100% NP	43	51	74	15	16	22
100% NPK	84	54	108	16	18	24
NPK (150%)	98	88	105	17	18	25
100% NPK + FYM	72	54	97	16	17	24
Initial	96	97	111	17	20	26

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Crop Response to *Applied Potassium*

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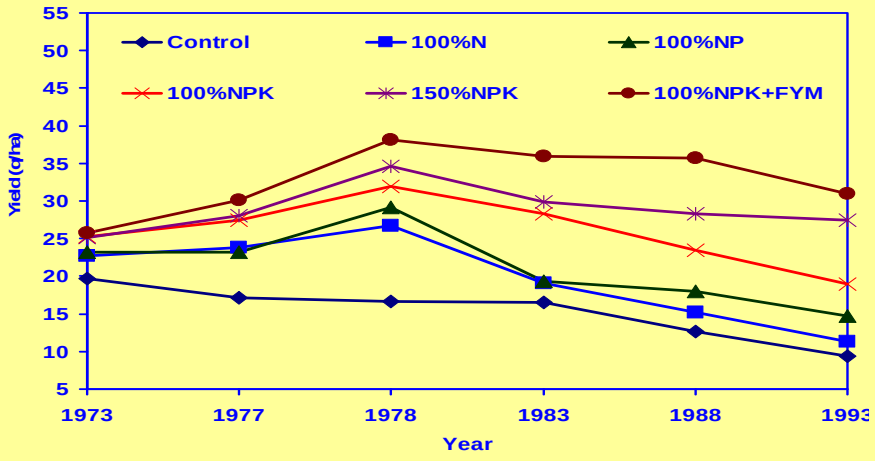
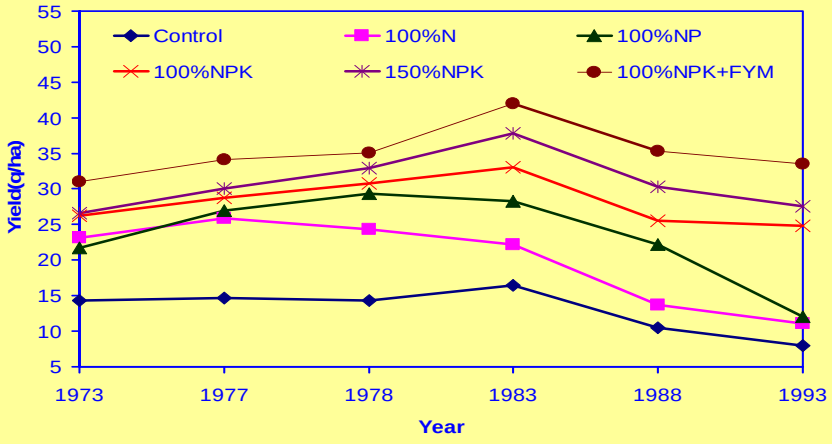
Long term effect of nutrients on Rice yield (*Kharif*)



Long-term effect of nutrients on Rice yield (Rabi)



Crop response to K application (over NP) at Bhubaneswar in LTFE trial during 22 years of cropping

Year	Yield Response(qha^{-1})	
	Kharif Rice	Rabi Rice
1978	5.14	1.65
1983	2.90	1.50
1988	8.95	4.80
1993	5.36	3.30

Effect of K rate on hybrid rice yield (two consecutive season) at Bhubaneswar

Treatments	Grain Yield (tha^{-1})	Chaff (tha^{-1})	Grain:Straw ratio	Harvest Index
T1- K Control	8.0	1.00	1: 1.44	0.39
T2 – 25% K	9.3	0.90	1:1.29	0.42
T3- 50% K	10.7	0.80	1:1.15	0.45
T4 – 75% K	11.2	0.70	1: 1.15	0.45
T5 – 100% K	13.9	0.48	1: 1.01	0.49
C.D.(0.05)	0.5	0.08		

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Area and productivity of some important Vegetables grown in Orissa during 2003-04

Vegetables	Recommended K (kg ha^{-1})	Productivity (t ha^{1})		K Removal (kg ha^{-1})
		Orissa	India	
Potato	90	12.85	17.6	310.0
Sweet Potato	75	8.37	-	340.0
Cauliflower	60	14.17	18.4	350.0
Cabbage	60	27.61	23.4	480.0
Brinjal	125	14.50	15.9	300.0
Tomato	75	13.28	17.7	190.0
Okra	75	8.68	10.4	90.0
Pea	25	8.72	9.6	88.0
Others	-	9.81	13.2	-

Effect of levels of K on yield and quality of banana in alluvial soil

K (g/plant)	Yield (t/ha)	Fruit weight (g)	Total soluble Solid (%)	Total Sugar (%)	Ascorbic acid (mg/100 g pulp)
200	37.0	115.2	18.4	12.6	5.69
400	50.7	132.7	19.3	14.2	7.45
600	55.9	138.8	20.0	16.7	9.86
C.D. (0.05)	0.87	4.45	0.18	0.15	0.50

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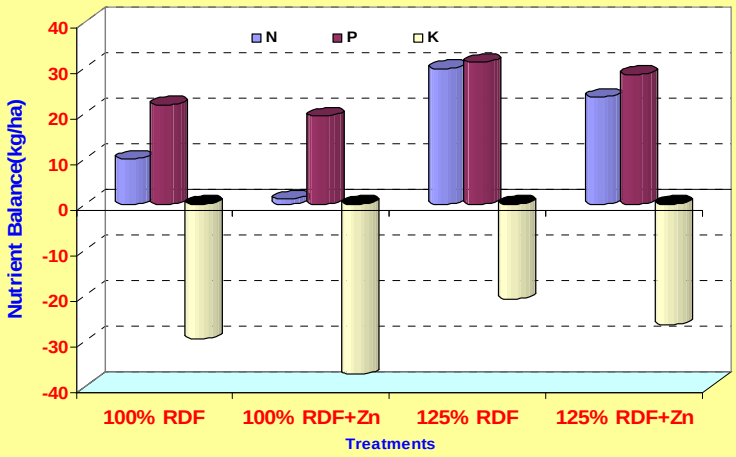
Response of paddy to Potassium under dry land (Rainfed) condition in different broad soil groups of Orissa

Soil Group	District	Upland Rice		
		No. of Trial	Yield (qha^{-1})	
			N_{90} P_{60}	Yield Response (kg grain/ kg K_2O
Mixed Red & yellow	Bolangir	17	26.15	4.4
	Sundergarh	10	23.18	4.8
Red & Laterite	Bolangir	16	28.80	6.4
	Sundergarh	6	32.84	-
	Ganjam	10	23.30	4.8
Mixed Red & Black	Ganjam	8	36.68	7.8
Coastal saline	Ganjam	3	42.01	-

Mean annual K uptake and balance in some selected treatments under rice – rice cropping system (41 cropping cycles)

Treatments	Yield (qha^{-1})		Mean Annual K Uptake (kg ha^{-1})	Mean Annual K Balance (kg ha^{-1})
	Kharif	Rabi		
Control ($N_0P_0K_0$)	15.6	13.1	56.0	-56.0
100% N	20.9	20.5	84.0	-84.0
100% NP	22.5	27.98	90.0	-90.0
100% NPK	29.8	32.1	137.0	-37.0
100% NPK + FYM	34.8	37.59	167.0	-47.0
150% NPK	30.3	34.0	187.0	-7.0

Nutrient balance of rice-groundnut cropping system in alluvial soils of Nimapara



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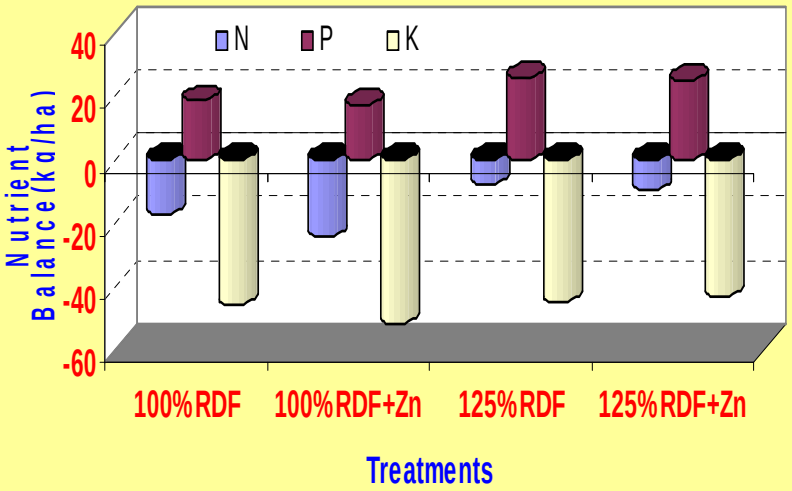
Nutrient balance of rice-green gram cropping system in laterite soils of Nayagarh



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Effect of levels of K on Root growth in Inceptisol (Central Farm)

	T_5	T_4	T_3	T_2	T_1
Rot length (cm)	22.0	20.	17.0	24.5	22
Root Mass(g)	17.56	10.7	12.68	12.88	14.45
Root Volume (cm^3)	38.0	30.0	24.0	20.0	26.0
Root Density (g/cc)	0.46	0.36	0.53	0.64	0.55

Effect of levels of K on Root growth in *Alfisol* (Bhubaneswar)

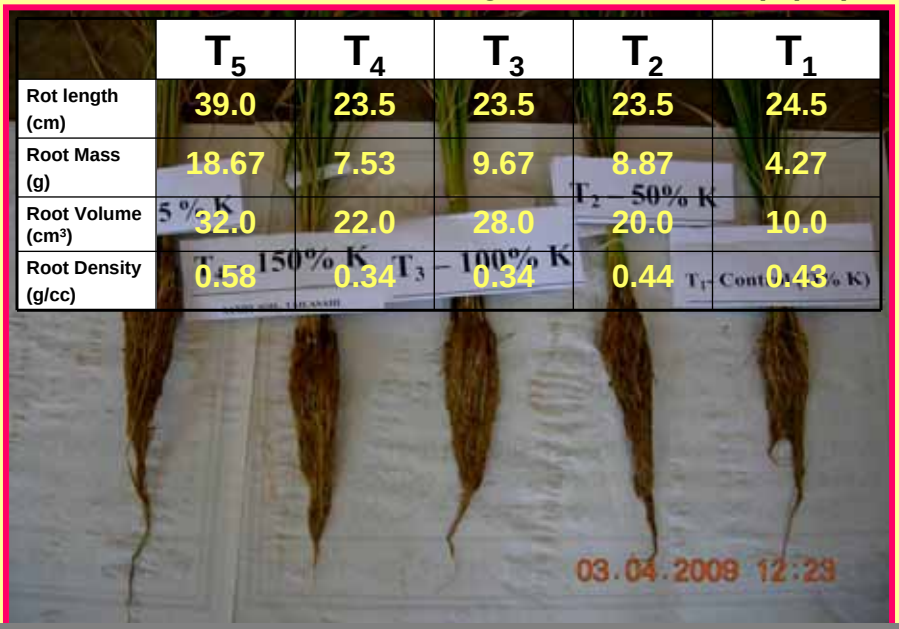
	T_5	T_4	T_3	T_2	T_1
Rot length (cm)	30.0	30.0	32.0	30.0	22.0
Root Mass (g)	20.02	14.60	17.01	9.49	3.95
Root Volume (cm^3)	54.0	44.0	42.0	28.0	10.0
Root Density (g/cc)	0.36	0.30	0.40	0.34	0.39

Effect of levels of K on Root growth in *Vertisol* (Balugaon)

	T_5	T_4	T_3	T_2	T_1
Rot length (cm)	30.0	24.5	23.2	23.5	17.0
Root Mass (g)	10.55	12.15	14.75	8.52	6.48
Root Volume (cm^3)	16.0	20.0	22.0	14.0	12.0
Root Density (g/cc)	0.66	0.60	0.67	0.60	0.54

Effect of levels of K on Root growth in Entisol (*Pipili*)

	T_5	T_4	T_3	T_2	T_1
Rot length (cm)	39.0	23.5	23.5	23.5	24.5
Root Mass (g)	18.67	7.53	9.67	8.87	4.27
Root Volume (cm^3)	32.0	22.0	28.0	20.0	10.0
Root Density (g/cc)	0.58	0.34	0.34	0.44	0.43



Effect of levels of K on Root growth in Saline soil of Chilka

	T_5	T_4	T_3	T_2	T_1
Rot length (cm)	25.0	16.8	17.0	29.5	18.0
Root Mass (g)	8.72	6.47	10.54	10.74	9.12
Root Volume (cm^3)	12.0	6.0	14.0	11.0	14.0
Root Density (g/cc)	0.72	1.08	0.75	0.98	0.65

Effect of Soil type on root growth of rice

Conclusion

- **Important K bearing minerals are muscovite, biotite and feldspar. The soils are medium to high in available K.**
- **The ratio of N: K2O fertilizer in Orissa is very wide (5.7 during 2005 – 06). Low application of K to crops leads to depletion of K by 242.87 thousand tones per year.**
- **There was no response to K application during first 10 years of cropping, but gradually the magnitude of response increased since available K become limiting and induce yield depression (LTFE).**

- **K estimation by Ammonium acetate method does not correlate with yield. 1N HNO_3 estimation of K is recommended.**
- **The dose of K for different crops in Orissa needs revision**
- **A sustainable fertilizer management strategy must ensure the farm productivity, optimum economic return without deteriorating agricultural environment. This could be achieved by adopting an holistic input – output mechanism.**

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THANK YOU

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