POTASSIUM MANAGEMENT IN VEGETABLES, SPICES AND FRUIT CROPS

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Introduction

India is the second largest producer of vegetables and fruits but largest producer of spices in the world, next to China. Inspite of this, the dietary recommendation of vegetables is not available to all. Amongst various reasons for poor yield and production of vegetables in the state, the poor nutrient management is important. Fertilizer application to many of the fruit crops is arbitary and often erratic. In view of the growing importance of fruit crops both for home consumption and export, the question of adequate fertilizer management is of special significance. Fruit crops in general remove much higher quantities of potassium and usually carry high amount of K in the marketable parts. A rational fertilizer management in spices also ensures the quantity and the quality. Potassium is the third major essential plant nutrient along with N and P. It is essential for the growth and development of all plants and animals.It is absorbed by the plant roots as cation (K^+) .Most crops absorb as much or more K than they absorb N from the soil. Higher production of food, fibre and other crops also results in higher removal of potassium from soil. Nutrient removal continues to exceed nutrient addition. Many Indian soils are deficient in K and the area is increasing. The application of potassium is not only responsible for higher production and superior quality produce but also safeguards best monetary returns from all possible ways. It activates more than 60 enzymes which are directly or indirectly involve in plant growth processes. Much of the absorbed potassium remains in the plants as a free cation (K^+) in highly mobile form.

The Potassium being one of the important primary nutrients in soil, is responsible for quality products of fruits and vegetables through an increase in sugar contents of crops, plays an important role in photosynthesis and increases water use efficiency.

Orissa has a tremendous potential for cultivation of varieties of vegetable crops almost round the year, taking the advantages of the agro-ecological flexibility that the state experiences. However the state maintains a very low profile in respect of productivity of the vegetable crops (11.5 t/ha) and one of the main reasons that could be attributed to this, is the low fertilizer use, more particularly the use of potassium. Although the potassium content of the soils of orissa is medium, many vegetable crops have been found to give good response to application of potassium. The vegetable crops such as potato, sweet potato, radish, brinjal, tomato, turnip, carrot, onion and chilli are the principal vegetable crops cultivated in orissa which need care with regard to potassic fertilizer for getting higher yields of good quality.

Systematic outlay of steps involved in executing nutrient management program

<table>
<tr><td>MARKET
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Soil analysis
Irrigation &drainage
Water analysis</td><td>MARKET
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<tr><td>FERTILIZER
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<tr><td>INTERACTIONS
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Fertigation
Foliar</td></tr>
<tr><td colspan="4">EVALUATION
Fruit yield and quality(fresh vs. processed)
Tree size, foliage cover, canopy density, growth habit
Leaf tissue and soil analysis(visual & laboratory)
Economics</td></tr>
</table>

Functions and role of potassium:

i. Promotes photosynthesis, thus leading to formation of carbohydrates, oils, fats and proteins (photosynthates).
ii. Promotes the transportation of photosynthates to storage organs of plants(seeds, roots, fruits, tubers).
iii. Formation and translocation of sugars in plants(sugarcane, sugar beet, sweetpotato and other tuber crops)
iv.Enhances the production of protein thus improves the efficiency of fertilizer nitrogen.
v. Increases the ability of plants to withstand stress conditions such as pest, disease attack, drought and frost.
vi. Making the plants more resistant to lodging.
vi. Enhances the absorption of water by the root stand leads to water economy of plants in general.
vii.Development of healthy root system, resistant of plants to poor aeration and drainage condition
viii. Improves quality of crops (tobacco, fruit and fibre crops)
ix. Improves size and co lour of fruits
x. Favors the production of oil in plants (oil palm, rape seed, groundnut, soybean)
xi. Efficient biological N fixation.

Deficiency symptoms:

i. Reduction in growth rate and vigor

ii. Darkening of leaves

iii. Appearance of white, yellow, orange chlorotic spots or strips on older leaves, usually starting from the leaf tips and margins.

Iv. The chlorotic areas become necrotic, the tissue dies and leaves dry up.

v. The symptoms spread to younger leaves and finally the plants die.

vi. Hidden hunger of plants

vii. Decrease resistance

viii. Roots poorly developed and affected by rot

ix. Increase in disease and pest incidence

x. Reduction in quality of produce

Table 1.Fertilizer schedule for some important vegetable crops suitable for Orissa

Sl.No.	Crop	FYM(cartload/ha)	N(kg/ha)	P_2O_5(kg/ha)	K_2O(kg/ha)
1	Brinjal	25	125	75	125
2	Tomato	25	125	70	75
3	Chilli	25	110	70	75
4	Okra	25	110	60	75
5	Cabbage	25	120	40	60
6	Cauliflower	25	125	40	60
7	Knolkhol	10	75	50	50
8	Beans	20	25	50	25
9	Country bean	25	25	50	50
10	Parwal	25	25	40	112
11	Radish	25	50	50	100
12	Onion	25	62	50	90
13	Sweetpotato	15	120	60	75
14	Colocasia	20	50	50	80
15	Yam	15	80	60	80
16	Pumpkin	25	50	60	75
17	Snake gourd	25	50	30	75
18	Ridge gourd	20	50	30	75
19	Cucumber	20	50	30	75
20	Bitter gourd	25	50	30	50
21	Watermelon	25	55	55	55

In most of the crops potassium removal is much larger than nitrogen.

Potassium is often described as the quality element for crop production. Its beneficial effect on crop quality shows in many ways, such as fruit weight, total soluble solids, total sugar and ascorbic acid content etc.

Table 2.Potash removal relative to N and P for different crops

Sl.No.	Crop	Produce	Removal Kg/ton of produce N P_2O_5 K_2O			Ratio of K_2O andP_2O_5 removal relative to N		
						N	P_2O_5	K_2O
1	Potato	Tuber	3.9	1.4	4.9	100	35.9	125.6
2	Cassava	Tuber	7.8	1.2	5.1	100	15.4	65.4
3	Cowpea	Fodder	13.8	6.6	17.6	100	47.8	127.5
4	Tomato	Fruit	4.1	1.5	5.9	100	36.6	393.9
5	Coconut	1000nuts	7.1	3.5	10.7	100	49.3	150.7
6	Cardamom	Pods	122.0	14.0	200.0	100	11.5	163.9
7	Cashew nut	Nuts	88.0	25.0	42.0	100	28.4	47.7
8	Mango	Fruit	6.7	1.7	7.4	100	25.0	110.0
9	Banana	Fruit	5.6	1.3	20.5	100	22.7	366.5
10	Citrus	Fruit	1.1	0.6	2.9	100	54.6	259.1
11	Pineapple	Fruit	1.8	0.5	6.3	100	30.0	353.3
12	Papaya	Fruit	2.8	0.8	2.3	100	26.7	80.0
13	Grape	Fruit	8.0	2.0	9.0	100	25.0	112.5
14	Lichi	Fruit	22.0	3.5	29.0	100	15.9	131.0

Table 3.Removal of Potassium from the soil by some vegetable crops

Sl. No.	Crop	Yield(t/ha)	Removal of K_2O(kg/ha)
1	Potato	40	310
2	Tomato	50	190
3	Brinjal	50	300
4	Cabbage	70	480
5	Cauliflower	50	350
6	Knolkhol	20	170
7	Carrot	30	200
8	Radish	20	120
9	Beet	25	112
10	Onion	35	160
11	Leek	30	240
12	Cucumber	40	120
13	Pumpkin	50	160
14	Muskmelon	15	97
15	Pea	9	88
16	Beans	15	160
17	Okra	20	90
18	Celery	30	300
19	Lettuce	30	160
20	Spinach	25	200
21	Asparagus	5	150
22	Cassava	40	350
23	Sweet potato	40	340
24	Elephant-foot yam	50	245
25	Yam	14	86

Table 4.Effect of K with N application on yield of tomato(t/ha)

Rate of K_2O(kg/ha)	Rate of	N	(kg/ha)
	132	198	264
0	15.6(41)	16.5(56)	20.5(55)
330	38.7(80)	45.8(85)	58.7(85)

Figures in parenthesis indicate % marketable

Table 5.Fertigation scheduling and uptake of potassium

Crop	Total K(kg/ha)	Crop development stage	Crop development week	K application Rate(kg/ha/day)
Cucumber	112	1	1	0.9
		2	2	1.5
		3	6	1.9
		4	1	1.5
Tomato	149	1	2	0.9
		2	3	1.5
		3	7	1.9
		4	1	1.5
		5	1	0.9
Pepper	112	1	2	0.9
		2	3	1.5

Table 6 .Effect of different levels of K on yield of Cabbage

Treatments(kg/ha)	Yield(q/ha)
K-0	66.95
K-75	67.80
K-150	83.10
C.D.(0.05)	2.87

Table 7 Effect of K application on Chilli(cv.pant)

Doses of K_2O(kg/ha)	Yield of green chilli(q/ha)
K-0	17.51
K-40	18.28
K-80	19.70
C.D.(0.05)	9.25

Table 8.Effect of different doses of Potassium on bulb yield of Onion(cv.Nasik red)

TreatmentsK_2O(kg/ha)	Bulb Yield(q/ha)
K-0	50.00
K-50	72.83
K-100	72.67
C,D.(0.05)	6.82

Table 9 Accumulation of potassium at different stages of potato growth in the plains
Days after planting

Plant part	30	40	50	60	70	80
			K_2O(Kg/ha)			
Leaves	29	49	35	37	29	28
Stems	13	9	6	8	8	6
Tubers	1	25	62	82	98	121
Roots	6	4	2	2	2	2
Total(K_2O)	49	87	105	129	137	157

Table10. Accumulation of potassium(K_2O kg/ha) at different stages of potato growth in the hills

Plant part	Days after planting		
	65	85	105
Tops	108	89	64
Tubers	29	121	160
Roots	15	9	-
Total K_2O	152	219	224

Table 11.Response rates of potato to K application in different soils

Rate(kg/ha)	Response, kg tuber /kg Nutrient applied			
	Alluvial	Hill	Black	Red
29	76	72	21	48
59	64	59	15	42
88	55	49	13	38
118	44	31	8	31
146	34	27	6	25

Table 12. Doses of K for top dressing potato on the basis of tissue testing

Potato cultivar	Petiole K%	Kg K_2O /ha to be top dressed	Response to top Dressing ,t/ha
Kufri jyoti	10.0	105	4.2
	10-11	80	3.2
	11-12	43	2.3
	12.0	43	1.8

Table 13. Removal of potassium by some of the fruit crops

Crop	Yield(t/ha)	Uptake of K(kg/ha)
Mango	15	100
Banana	58	1180
Guava	20	150
Pineapple	85	530
Papaya	80	175

Table 14. Uptake of Potassium from some important fruit crops

Sl.No.	Crop	Yield(t/ha)	Total K uptake(Kg/ha)
1	Banana	38	1053
2	Pineapple	84	440
3	Papaya	150	415

Table .15. Effect of K application on yield attributing characters and yield of banana

K_2O applied(g/plant)	Yield	components		
	Kg/ bunch	Hands/ bunch	Fruit/ bunch	Fruit length (cm.)
0	4.4	7.5	114	18.3
150	6.6	8.1	130	19.0
450	7.2	8.9	140	19.5
600	7.9	9.2	164	20.0

Table 16. Effect of potash on banana yield and quality

Quality parameters

K_2O applied (g/plant)	Total yield(t/ha)	Fruit weight(g)	Total soluble solids(Brix)	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	20.1	16.7	9.86
CD(5%)	0.87	4.45	0.18	0.15	0.50

Table 17. Vegetative growth, yield and fruit quality of micro propagated 'Robusta' banana at different K doses

K dose(g/plant)	Plant ht. at Shooting(cm.)	Pseudostem Circum ference at shooting(cm.)	Leaf length (cm.)	Leaf Width (cm.)	Canopy spread at Shooting (cm.)	Days to shooting
0	143.72	50.28	126.39	111.39	26.31	277.00
100	144.86	54.17	127.50	119.72	28.14	292.00
200	144.97	55.42	132.64	124.86	30.14	275.00
300	145.81	58.06	135.143	128.19	31.33	282.00
CD at5%	4.59	3.82	3.64	6.52	1.00	NS

Table18. Vegetative growth, yield and fruit quality of micro propagated 'Robusta' Banana at different K doses

K dose(g/plant)	Days to maturity	Days from Shooting to maturity	Bunch wt. (kg)	Finger wt. (g)	TSS (%)	Pulp/Peel ratio
0	373.0	96.0	8.2	135.3	22.9	3.53
100	377.0	98.0	11.1	170.6	23.1	3.61
200	374.0	99.0	12.2	181.5	23.3	3.65
300	383.0	101.0	13.5	186.0	23.4	3.67
CD(0.05)	11.6	6.8	2.3	21.1	0.07	-

Table19. Critical concentration of K(%) in the dry matter of leaf parts of banana

Lamina-3	Mid-rib-3	Petiole-7
3.0	3.0	2.1

Table 20. Effects of N and K levels on bunch weight (kg) of banana(cv.Champa)

Levels	K_2O-150	K_2O-300	K_2O-450	K_2O-600	Mean
N-75	6.5	6.8	6.9	7.2	6.85
N-150	6.7	6.9	7.2	7.3	7.03
N-225	6.8	7.0	7.5	7.8	7.28
Mean	6.67	6.9	7.2	7.43	
Treatment			C.D.(0.05)		
N			0.316		
K			0.274		
NxK			0.547		

Table 21. Effect of levels of K on growth, yield and quality of ratoon banana

K_2Olevel (g/plant)	Full bunch wt.(kg)	No. of Hands/bunch	No. of fingers/bunch	Wt. of Finger (g)	Fruit Yield (t/ha)	Total soluble Solids(%)	Pulp :Peel ratio
50	5.1	6	56	90.5	15.6	20.4	2.1
100	6.3	6	61	104.3	19.5	21.5	2.4
200	10.7	7	86	123.7	33.0	22.3	2.7
300	12.0	8	94	128.8	37.1	22.7	2.9
400	19.6	10	137	143.3	60.3	24.3	3.4
500	9.6	7	80	119.5	29.5	23.2	2.3
CD(0.05)	0.41	0.68	5.11	7.08	1.22	0.60	0.25

Table 22. Effect of NPK application on yield and quality of banana

Treatments Doses (g/plant/yr)			Quality Parameters					
N	P_2O_5	K_2O	TSS (%)	Reducing Sugar (%)	Acidity (%)	Starch (%)	Yield (kg/plant)	No. of Fingers /bunch
0	0	0	15.90	6.36	0.176	3.23	19.66	191.6
75	90	300	17.03	7.63	0.166	2.10	33.93	240.6
150	90	400	17.33	7.80	0.183	1.96	40.43	246.1
CD(0.05)		0.50	0.76	NS	0.310	1.90	2.30	

Table23. Yield attributes of coleus as influenced by potash

	K levels(kg/ha)				
	25	50	75	100	SE/CD(0.05)
No. of tubers/plant	11.42	14.35	12.81	11.33	1.185/NS
Mean tuber Wt.(g)	9.78	10.00	12.57	9.72	0.664/1.917
Tuber yield (t/ha)	8.15	9.11	8.88	8.58	0.486/NS

Table 24. Potassium budgeting in 'Nagpur' mandarin orchards
(A case study of K mining in central India)

Requirement (kg/ha) -83
Added by growers (kg/ha)-27
Added through annual leaf fall (kg/ha)-20
Deficit(kg/ha)-36
One orchard cycle-25years

Table 25. Effect of K on flowering, yield and quality of Mango(cv.Amrapalli)

Treatments	Male flower/plant	Hermophrodite/ plant	Sex ratio	No. of Fruits/ plant	Yield/ Plant (kg)	Fruit wt.(g)	Pulp Wt.(g)
K-0	181	68	1:2.63	79	13.26	169.00	103.25
K-100	190	72	1:3.03	84	15.18	181.50	103.75
K-150	220	94	1:1.92	86	16.24	183.75	109.00

Table 26. Effect of K on quality of Guava

K levels(g/plant)	Fruit weight(g)	TSS	Total sugar(%)	Reducing sugar(%)	Acidity(%)	Vit.C(mg/100g.)
K-0	136.7	8.8	8.01	4.89	0.27	190.4
K-130	141.5	8.8	8.22	5.11	0.29	193.2
K-260	146.4	8.9	8.38	6.04	0.30	196.0

Table 27. Effect of potassium on growth and yield of Papaya(cv.Pusa magesty)

K_2O(g/plant)	Plant ht.(cm.)	Stem girth (cm)	Days to 1st fruiting	No. of fruits /plant	Fruit wt. (gm.)
0	119	22.6	278	2	472
90	128	24.9	268	3	697
180	133	26.3	256	5	767
360	150	28.9	252	7	925
540	158	30.3	249	8	969
720	146	27.5	260	5	719
900	141	26.5	264	5	688
CD(0.05)	11.6	1.2	8.8	1.3	68.4

Table 28. Effect of nutrients on tuber yield of arrowroot

Treatments K2O/N(kg/ha)	Tuber yield(t/ha) 0	25	50	75	Mean
0	5.34	12.30	9.17	10.50	9.33
25	7.71	10.67	8.96	7.30	8.66
50	12.54	8.84	11.00	9.96	10.59
75	8.55	10.96	13.37	12.30	11.29
Mean	8.54	10.69	10.62	10.02	

CD N-1.468, K-1.468, NxK-2.93

Table 29 Fertilizer(K) application in Acid lime crop

The plants need 2-3 fertilizer applications each year.

(i) Pre rainy season

(ii) Middle of the rainy seasons

(iii) Rainy season is about to end .

The fertilizer is applied in the following manner

Age of the plant	K_2O(g/plant)
1st year	200
2nd year	400
3rd year	600
4th year	800
5th year and above	800

Table 30. Food sources of K

Vegetables	Portion	K content(mg)
Asparagus	½ cup	279
Avocado	½ medium	530
Broccoli, cooked	1 cup	456
Cucumber, sliced	½ cup	80
Green beans, cooked	1 cup	373
Mushrooms	1 cup	550
Tomato	1 each	273
Tomato juice	1 cup	537
Fruits		
Banana	1 medium	451
Orange	1 medium	273
Grape fruit, white	½ grape fruit	175
Orange juice	1 cup	474
Watermelon slice	1 cup	186

The international trade in spices has grown by leaps and bounds and Indian spices holds the same spell. An estimated 500,000 tones of spices and herbs valued at 1500 million US dollars are now imported globally every year. An impressive 46% of this supply comes from India.

From the hilly areas to the coastal zones the climate and soils are conducive to cultivation of a number of spices namely Ginger, Turmeric, Chilli, Coriander, Cumin, Fenugreek etc. Black pepper, Cardamom, ginger, garlic and turmeric are extensively cultivated in the hilly regions , while seed spices like Coriander, Cumin, Ajwan seeds (Bishop's weed) and Fenugreek have good potential in the dry red and laterite region. Chilli is a major crop in the saline soils of the coastal region of the state and the alluvial zone grows Ginger, Turmeric and other seed spices.

Table 31. Potassium requirement of spices

Crop	K_2O(kg/ha)
Ginger	45
Turmeric	60
Chilli	30
Onion	113
Garlic	53
Coriander	19
Fenugreek	19
Black cumin	15
Ajwanseed(Bishop weed)	53

Small addition of potassium hydride in spices dramatically lowers the temperature for hydrogen absorption.

Application of potassium phosphate (0.3%) In Pepper :
Resulted in highest values of
Sprouting-90.33%
Plant height-19 cm.
Number of leaves/plant -20.67
Oleoresin-8.8-11.95%
Peperine-3.6-4.5%
Disease incidence-17.67%
Fungi population-15x102 cfu/g of soil
Tricoderma population- 5.33x102 cfu/g of soil
Bacterial population-153x104 cfu/g of soil
Contain highest amount of minimum disease incidence

Table 32. Potassium requirement of Cardamom

Age of plant	Kg/ha –Rain fed areas
2nd year planting	70 (2 applications)
3rd year planting	70 (3 applications)

Role of potassium on growth and yield of turmeric:

Turmeric (*Curcuma longa*) is a rhizomatous spice crop cultivated in India since ancient times. The growth, yield, chlorophyll content of leaves, foliar nutrient composition and highest yield of cur cumin content were observed with a combination of mulching+application of 120 kg/ha N and 160 kg/ha K2O.

Table 33.Effect of K on growth and yield of turmeric

K(kg/ha)	Plant ht.(cm.)	Tiller/ Clump	Rhizome Yield(t/ha)	Additional Cost due to K_2O(Rs)	Cost of additional produce due toK_2O(Rs)	Additional benefit Over control(Rs)
0	2.7	57.5	8.14	437	6320	5883
45	3.1	64.3	9.72	873	8360	7487
90	3.1	64.9	10.23	1310	7520	6210
135	3.1	63.8	10.02	-	-	-

N.B: Cost of MOP-Rs.580.00/q

Cost of turmeric rhizome-Rs.4000.00/t

Pooled analysis for growth and rhizome yield (Table 33) indicated increased number of tillers and height of plants and significantly increased rhizome yield over control due to application of potassic fertilizer @ 45 and 90 kg K_2O/ha.Highest additional income due to application of potassic fertilizer was calculated to be Rs.7487.00 under application of 90 kg K_2O/ha.

A potassium dose of 90 kg/ha K_2O was found to be most suitable for the turmeric in dry land situation of Phulbani. Half of K_2O is to be applied at the time of planting and rest half at the time of second top dressing(90 days after planting).In acid soils the application of lime and FYM further increased the yield.

Role of potassium on growth and yield of Ginger:

For ginger the recommended dose of K_2O is 100 kg/ha, which is to be applied at the time of planting and at the time of second top dressing(90 days after planting).

Table 33.Effect of graded doses of K on the yield of ginger

K_2O (kg/ha)	Rhizome yield(q/ha)
K-0	81.7
K-50	86.8
K-100	91.7
K-150	91.7

Table 34.Recommended doses of K for Chilli, Garlic and Coriander

Crop	K(kg/ha)
Chilli	75
Garlic	50
Coriander	20

Efficient use of Fertilizer potassium:

Soil: There is a clear relationship between potassium status of soil and fertilizer K application. The exchangeable and water soluble K are the forms which are considered to be readily available to plants. They are in equilibrium with non- exchangeable and mineral K. The yield of vegetables, fruits and spices is dependent on mineralogical composition of the soil, the amount of each constituent, moisture supply, the nature and intensity of plant cover. There is difference in magnitude of crop response to fertilizer K between various soil groups. Within a soil group, the upland soils owing to more leaching and lighter texture, contain less K than the low land clayey soils having restricted drainage.

Crop: Crops differ in their responsiveness to applied potassium . Coconut, tea, coffee, rubber, other plantation crops and potato are among the K loving crops. Banana and papaya respond well to potassium. Legumes appear to need more potassium than non-legumes. The crops in which the biomass, grain yield and grain K content is high are most responsive to potassium .The short duration and externally nutrient dependent crops are more responsive to potassium than long duration crops.

Stress Situations: Under dry conditions less amount of K movement to the roots. Helps in closing stomata, maintaining leaf area under conditions of moisture stress, enlarges leaf area, increases starch content in tubers, drought tolerance, adequate K uptake under low temperature and reduce frost damage. K/Na ratio as asuitable selection criterion for salt tolerance.

Disease incidence: It helps in the control of diseases by enabling the plant to develop leaves with strong epidermal walls and thick cuticle, preventing the entry of germinating spores from the leaf surface. It reduces moisture on leaf surface which is necessary for spore germination, by checking transpiration and restricting the presence of soluble nutritional substances such as free amino acids and reducing sugars in the tissues.

Time of application: Split dressing of potassium is expected to increase its efficiency in situations where leaching losses are considerable, either because of long duration of the crop or light texture of the soil.

Intensity of farming: Potassium had a positive response to crops like potato, coconut, tapioca etc.

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