Balanced Fertilization

For sustainable yield and quality in tropical fruit

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Status Of Fruit Crops In India

- Area - 3.8 million ha (m.ha)
- Production - about 45.5 million tones
- 10% of world fruit production
- Meets only 46% of the need of the country
- Demand by 2025 AD - 120 mt.
- The production expected 88 mt.
- Wide gap between demand and supply
- Warrants increase in production and productivity

Mineral nutrients

- Major contributor to enhancing crop production
- Enhanced use of fertilizers- adverse effects on the environment
- Nutrient use efficiency
  - Improved soil management - to increase the productivity of any crop
  - Balanced fertilization

Nutrient requirements of fruit crops

- **Fruit crops yield high & mine heavily the nutrients from the soils**
- **Estimate of the nutrient requirement：**
  - **Nutrient reserves in the trees**
  - **Soil nutrient status**
  - **Fertilizer recommendation requires leaf analysis**
  - **Crop residues**

Mango

- Needs regular fertilization for maintaining proper growth and heavy yield of crop every year.
- Not at all manured or even if it is manured, it is unbalanced.
- 82 to 88.5% of the active roots - 300 cm
- Highest activity of roots at 120 cm from the trunk,
- Nutritional requirements depends- the type and nutrient status of the soil , age of the tree etc.

TNAU Recommendation

Stage	FYM (Kg/ tree)	N	$P_2 O_5$	K_2O
		Kg /tree		
Pre bearing	10	0.2	0.2	0.3
Annual Increase	10	0.2	0.2	0.3
Bearing	50	1.0	1.0	1.5

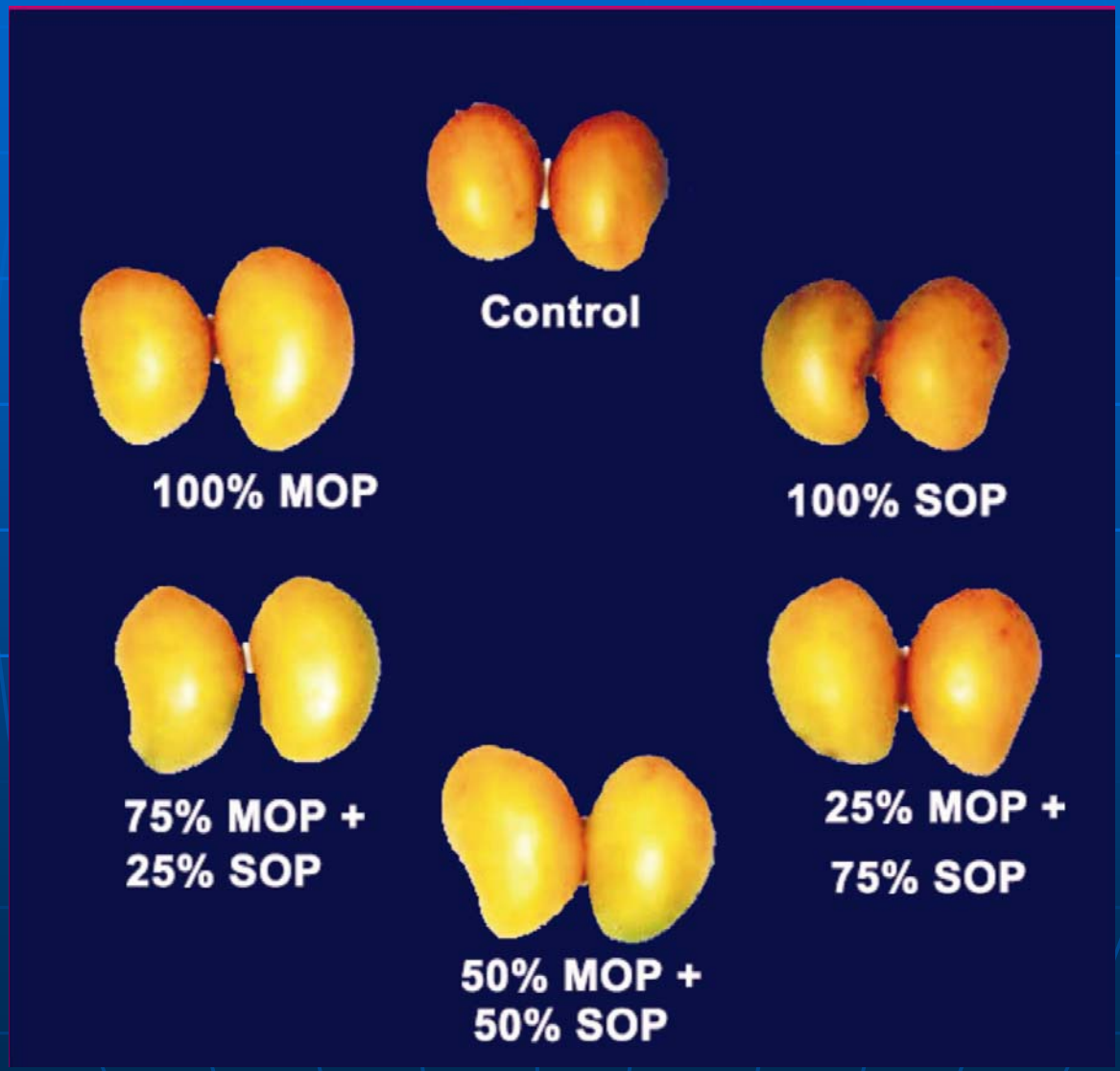
Studies on the efficacy of Sulphate of Potash (SOP) on yield and quality of mango under tropical belt of India.

- To assess the effect of Sulphate of Potash (SOP) on yield and quality of mango.
- To integrate SOP as a source of potassium nutrition for mango.

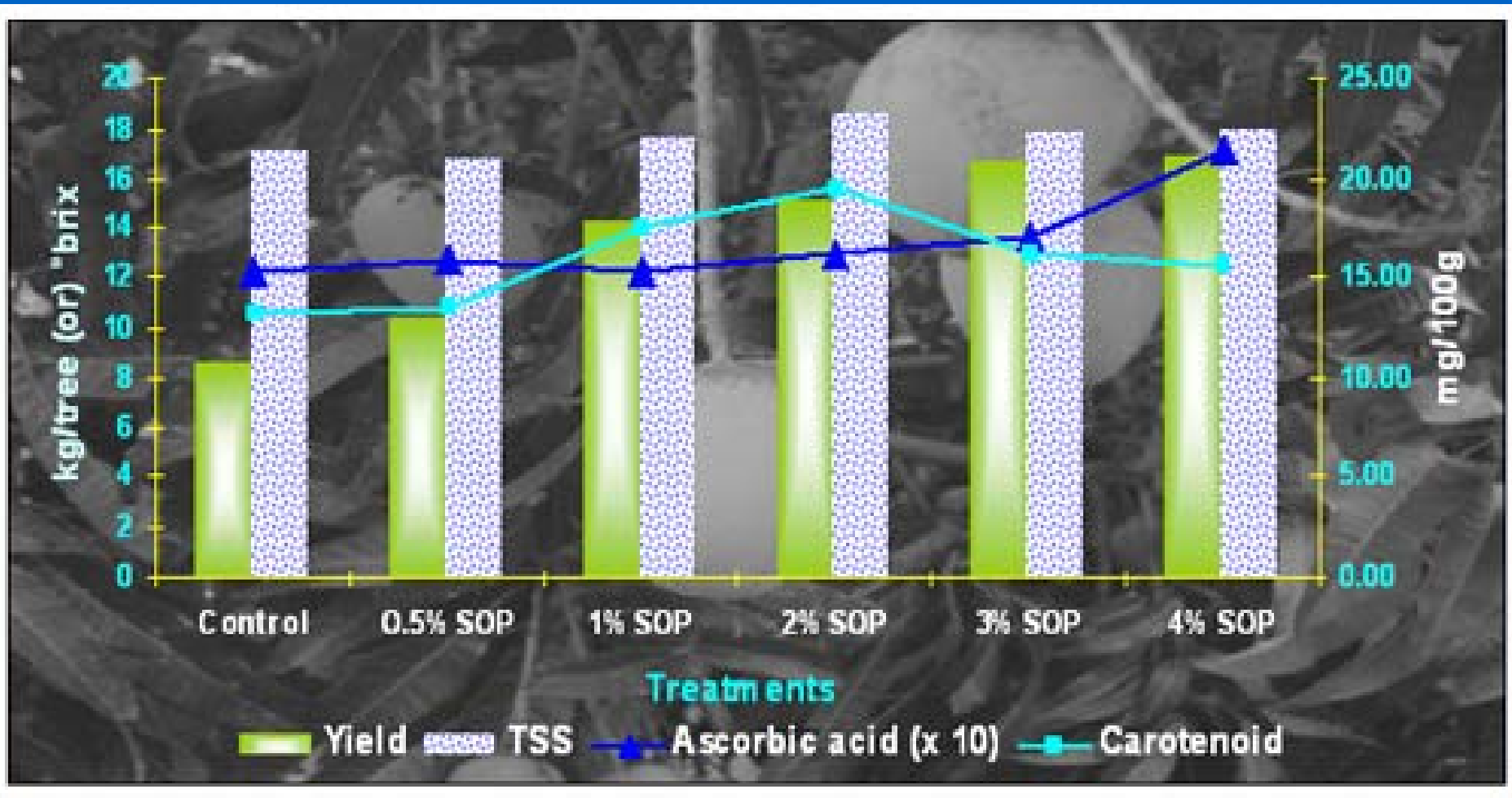
Effect of SOP soil application on Mango

K dose	Fruit No/ plant	Yield / plant	T.S.S	Carotenoid (mg/100g)
0 % K	33.9	8.2	17.2	5.87
100 % as MOP	40.8	13.2	17.8	6.39
50 % as MOP: SOP	58.9	14.0	16.6	13.05

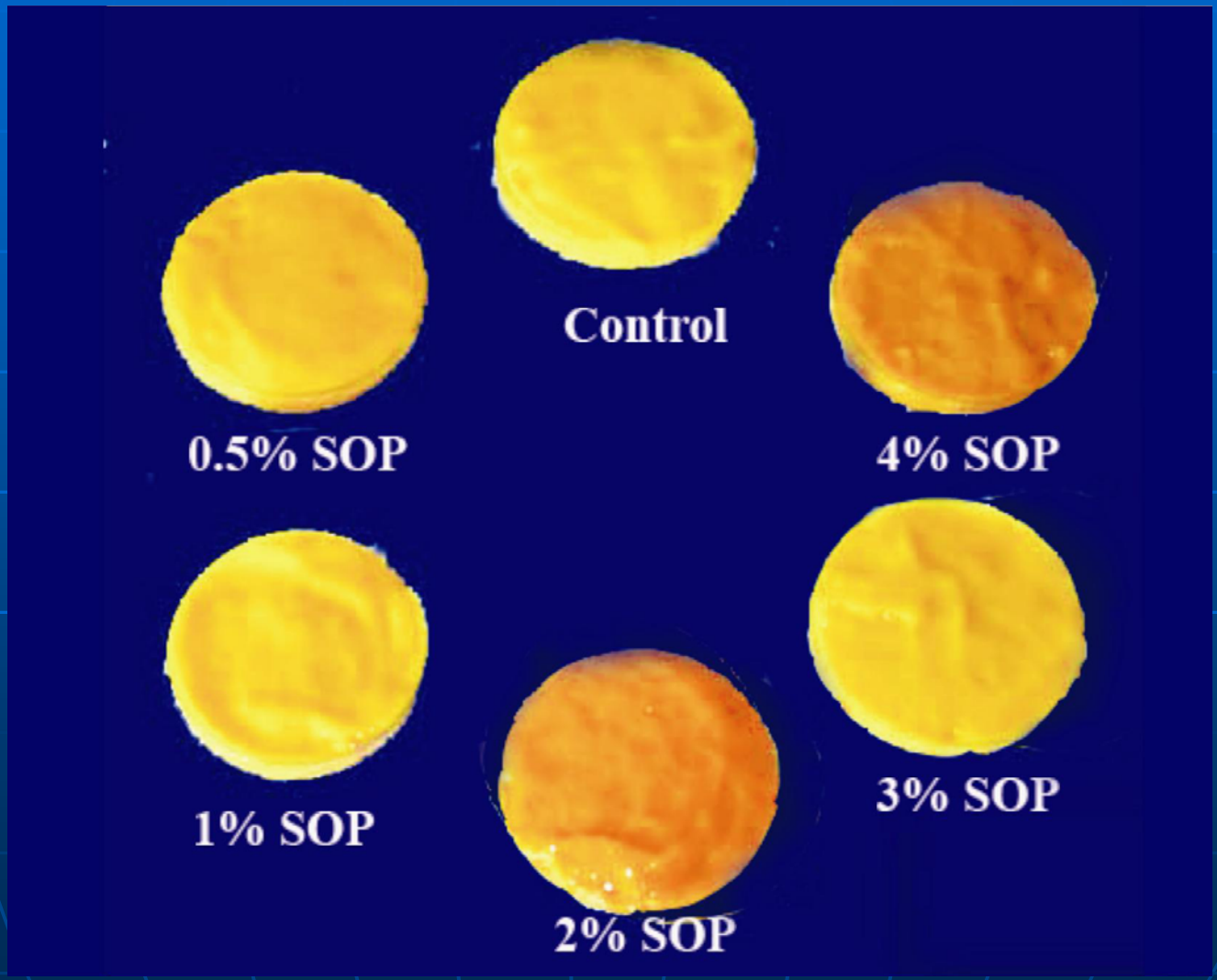
Effect of soil application of SOP on fruit size in mango cv. Alphonso



Effect of spraying of SOP on yield and quality traits of mango cv. Alphonso



Effect of foliar spray of SOP on pulp colour in mango cv. Alphonso



Effect of fertigation on yield characters in mango cv.Ratna

Treatments	Number of fruits tree^{-1}	Mean fruit weight (g)	Fruit yield (kg tree^{-1})
100% of RDF as soil application	116.5	364.6	40.8
100% N + 100 % P + 50 % K of RDF through fertigation	126.7	340.8	40.2
100% N + 100 % P + 75 % K of RDF through fertigation	142.7	436.3	54.0
100% N + 100 % P + 100 % K of RDF through fertigation	160.0	465.3	59.8
CD(0.05)	6.14	12.50	1.43

RDF: (800:400:800 g NPK plant $^{-1}$ year^{-1})

Effect of fertigation on mango flowering

T_1 - 100% RDF as soil application

T_2 - 100% RDF through fertigation

Effect of fertigation on fruit size in mango

100% RDF (Soil application)

100% RDF (Fertigation)

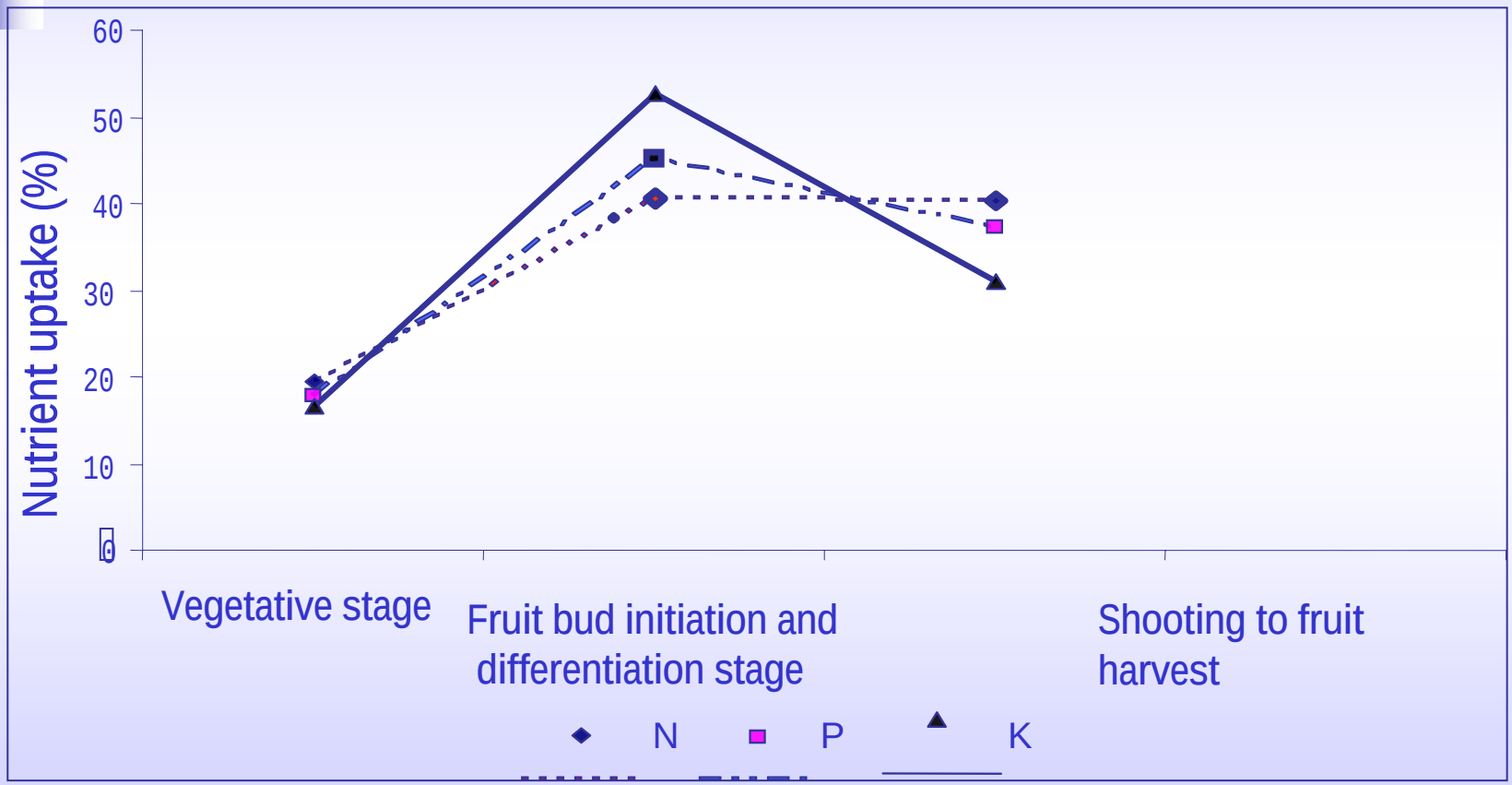
50% RDF (Fertigation)

BANANA

Average amount of nutrient removed (kg/ha) in banana and plantains (yield : 50 t/ha)

Nutrient	Nutrient removed (kg/ha) by the entire plant	Proportion of fruits (%)	Nutrient available from crop residues (Kg/ ha)
N	388	49	198
P	52	56	23
K	1438	54	661
Ca	227	45	125
Mg	125	39	76
S	73	32	50
Mn	12.5	4	12
Fe	5.9	15	5
Zn	4.7	12	4
B	1.27	55	0.6
Cu	0.37	54	0.2

Nutrient uptake in banana at different growth stages

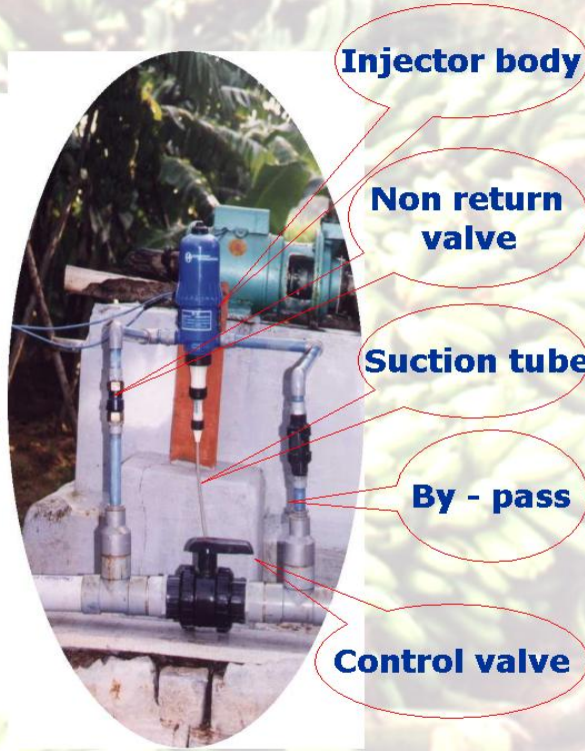


Fertilizer recommendations for banana (g plant-$^{-1}$) in various states

States	N	P	K
West Bengal	240	45	240
Kerala	225	225	225
Tamil Nadu	110	35	330
Goa	75	75	240
Assam	110	35	330
Bihar	125	80	225
Orissa	80	32	90
Uttar Pradesh	200	100	250

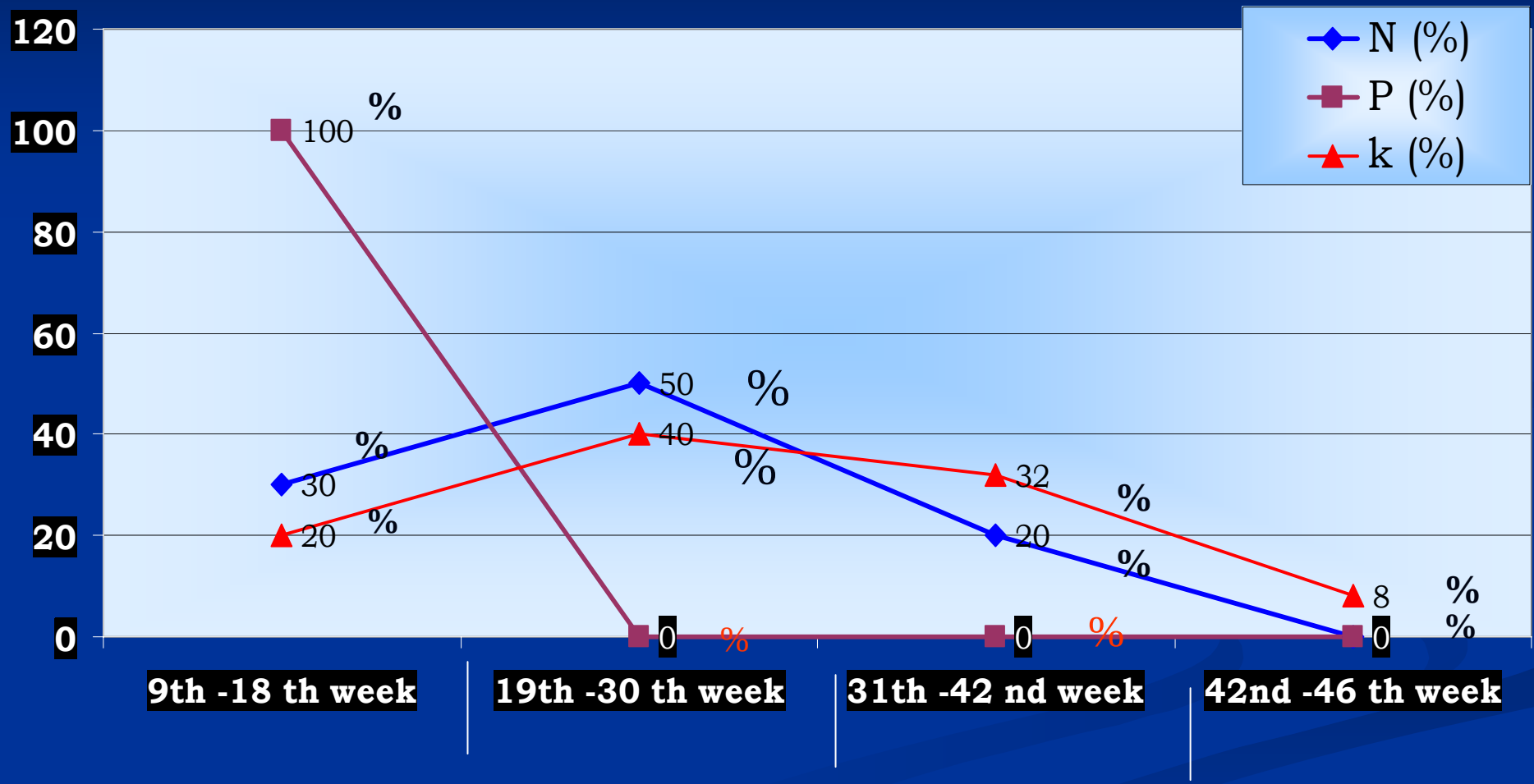
FERTIGATION IN BANANA

- Need based scheduling
- 50% saving in fertilizers
- Efficient nutrient uptake
- 30 - 60% increased yield
- Reduced labour input



Fertigation system -Dosatron

Scheduling of NPK at various stages of banana



Fertigation studies in banana under normal and high density planting system

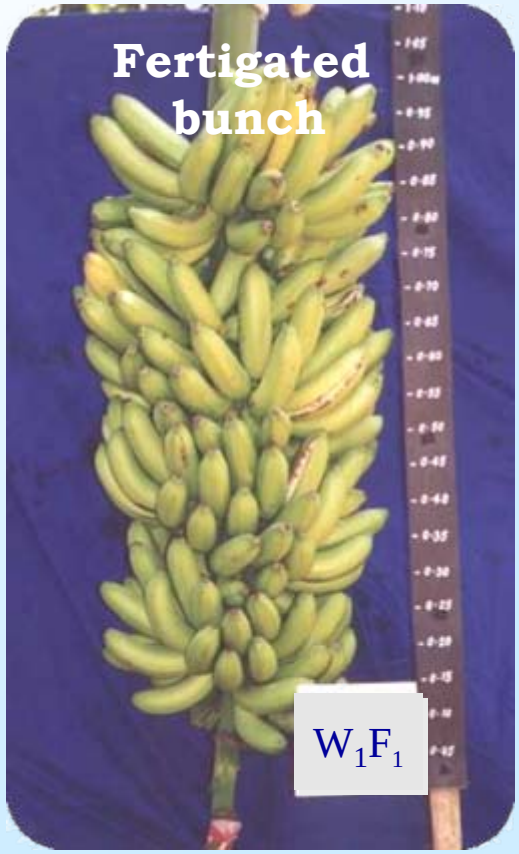
Treatments	Bunch weight (Kg)	
	HDP	NP
T1 – 100% of RDF through fertigation	34.14	38.52
T2 –75% of RDF through fertigation	31.63	34.93
T3 – 50% of RDF through fertigation	26.85	32.40
T4 – Conventional	20.48	23.59
CD (0.05)	0.67	1.69

RDF - (110:330 g N and K g/plant)

Mahalakshmi *et al*., 2001

High density planting- 3 suckers/pit

Bunch characters under NP system through fertigation



Bunch characters under HDP system through fertigation

Control bunch

Control hand

Fertigated bunch

Fertigated hand

Effect of sources of fertilizers for fertigation in banana cv. Robusta

Treatments		Bunch Wt.(kg)	Yield (MT/ha)	Leaf Nutrient status (%)			B/C ratio
				N	P	K	
Water soluble fertilizers	100% of RDF	25.51	127.5	3.03	0.36	2.32	1.21
	75 % RDF	19.33	96.7	2.92	0.34	2.22	0.98
Conventional fertilizers	100% of RDF	22.87	114.2	2.81	0.32	2.11	3.32
	75 % RDF	17.84	89.20	2.74	0.31	1.99	2.65
CD		0.17	-	0.024	NS	NS	-

RDF - (110:330 g N and K g/plant)

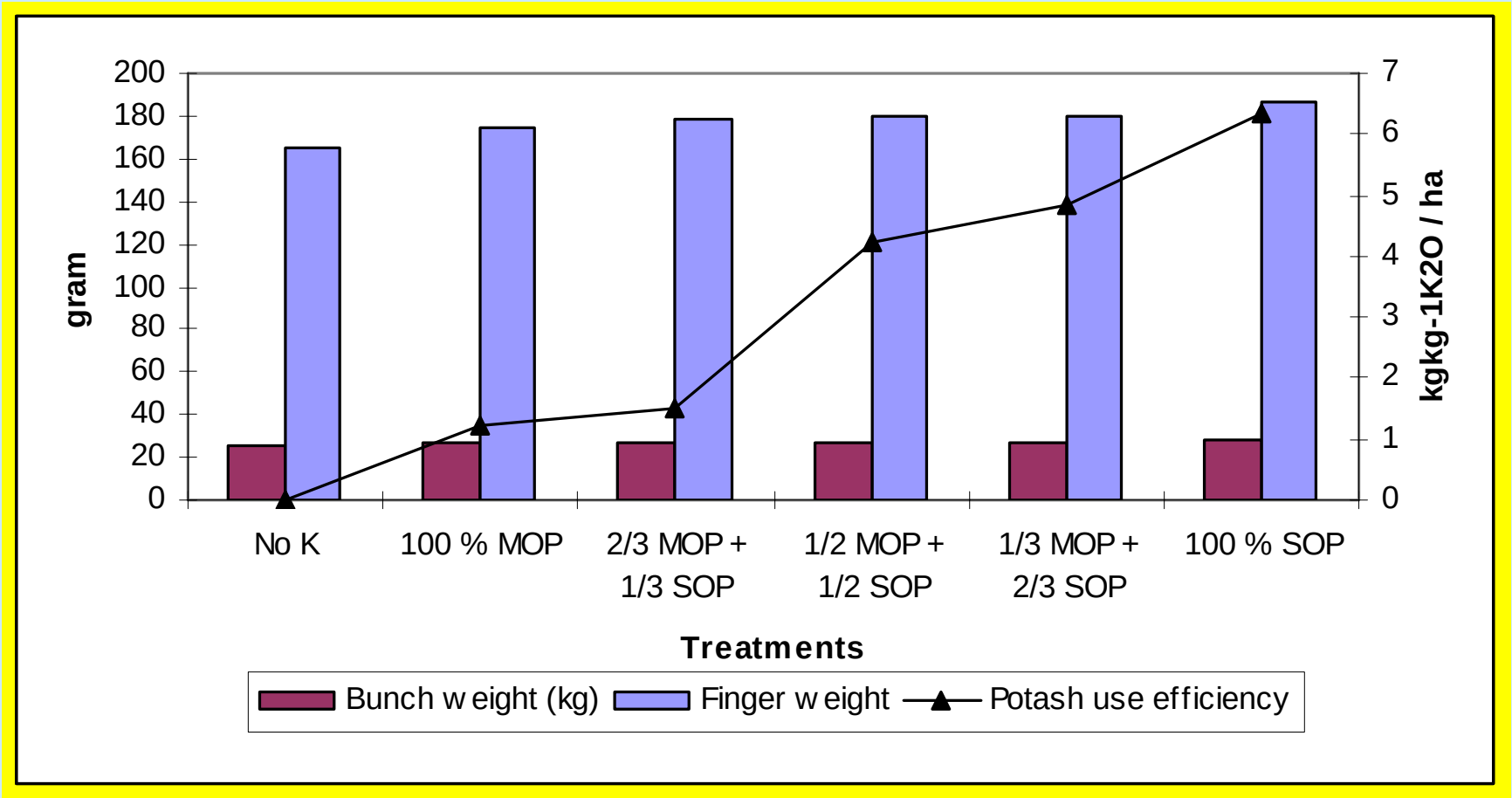
Kavino *et al.* (2004)

Effect of fertigation level in banana cv. Red banana

Treatments	Bunch Weight (Kg)	Total number of roots	Leaf Nutrient Status (%) at shooting stage		
			N	P	K
T1 – 100% RDF (110:330 g N and K g/plant)	18.19	535.23	2.90	0.32	2.38
T2 – 75 % RDF	16.05	519.85	2.82	0.30	2.30
T3 – 50% RDF	14.02	507.54	2.73	0.29	2.20
CD (P= 0.05)	0.65	0.94	0.031	NS	NS

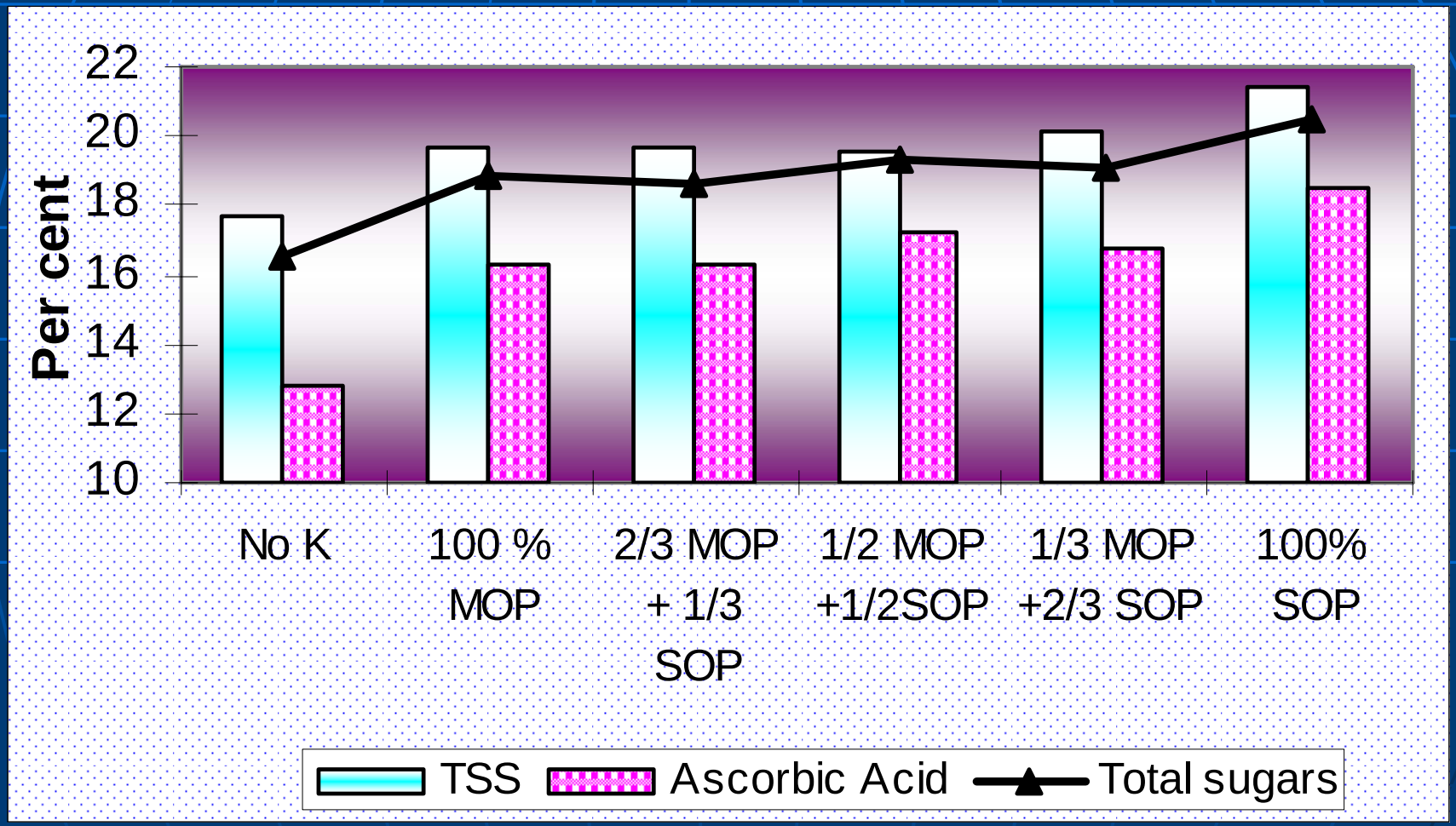
Suganthi, 2002

Influence of sources of potassium (SOP *vs* MOP) on bunch and finger weight in banana



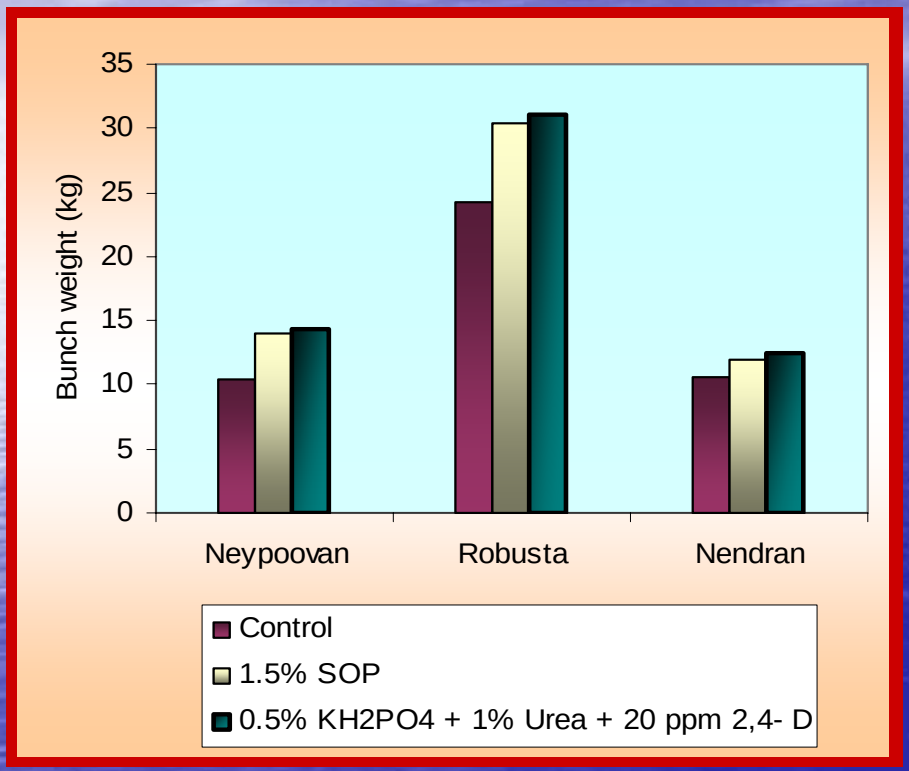
Ramesh Kumar, 2004

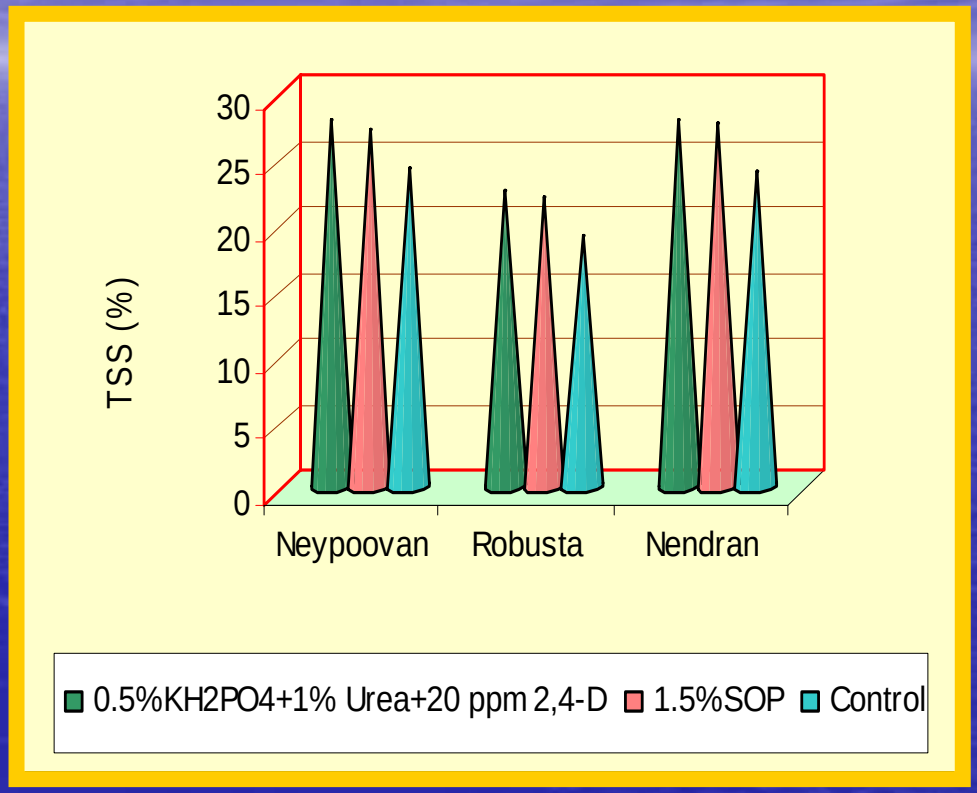
Influence of sources of potassium (SOP *vs* MOP) on quality traits in banana



Ramesh Kumar, 2004

Effect of post shooting spray of certain nutrients on bunch weight & quality in banana cultivars





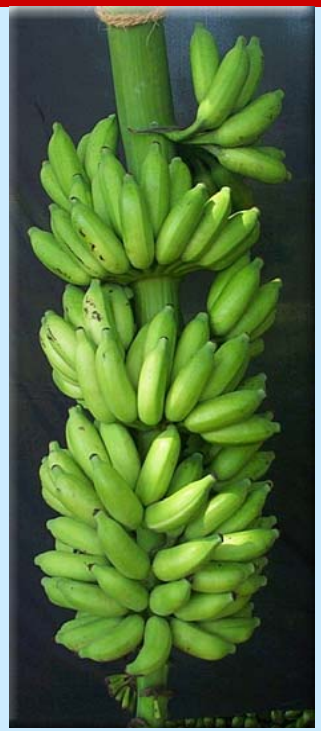
Ramesh Kumar (2004)

Bunches from post shooting spray of SOP cv. Rasthali (AAB)

1.5 % spray

Control

Bunches from post shooting spray of certain nutrients cv. Ney poovan (AB)



1.5% SOP

Control

Bunches from post shooting spray of certain nutrients cv. Robusta (AAA)

1.5% SOP

Control

STANDARDISATION OF FERTILIZER REQUIREMENT FOR TISSUE CULTURED BANANA CV. ROBUSTA

FERTILIZER RECOMMENDATION FOR TISSUE CULTURED BANANA CV. ROBUSTA (AAA)

MERITS OF TISSUE CULTURED BANANA

- Uniformity
- Higher vigour
- High yielding

FERTILIZER RECOMMENDATION

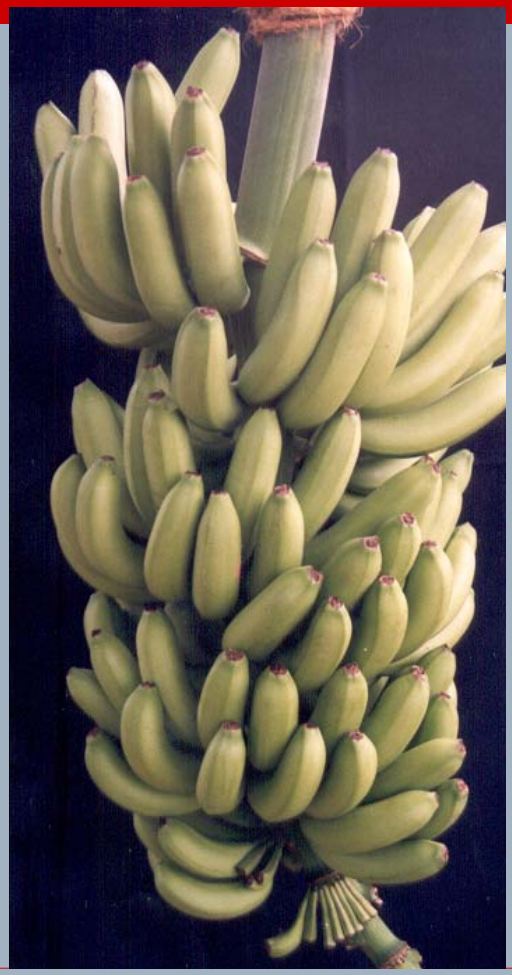
- 165 : 52.5 : 495 g N: P_2O_5 : K_2O / plant / year
- Apply 2, 4, 6 & 8 months after planting

Effect of nutrient levels and split application on TC banana cv. Robusta

Treatment ($N:P_2O_5:K_2O$ g/plant)		No. of splits	Bunch weight (kg)		
			Plant crop	1st ratoon crop	2nd ratoon crop
T1	110:35:330	3	26.87	30.00	17.50
T2	110:35:495	4	30.03	32.60	20.77
T3	165:52.5:495	3	33.54	35.42	23.33
T4	165:52.5:495	4	35.18	37.00	25.28
T5	220:70:660	3	23.13	27.00	14.12
T6	220:70:660	4	20.51	30.40	16.11
	CD		1.09	1.22	1.55

Nalina *et al*., 2002

BUNCHES FROM DIFFERENT TREATMENTS OF PLANT CROP

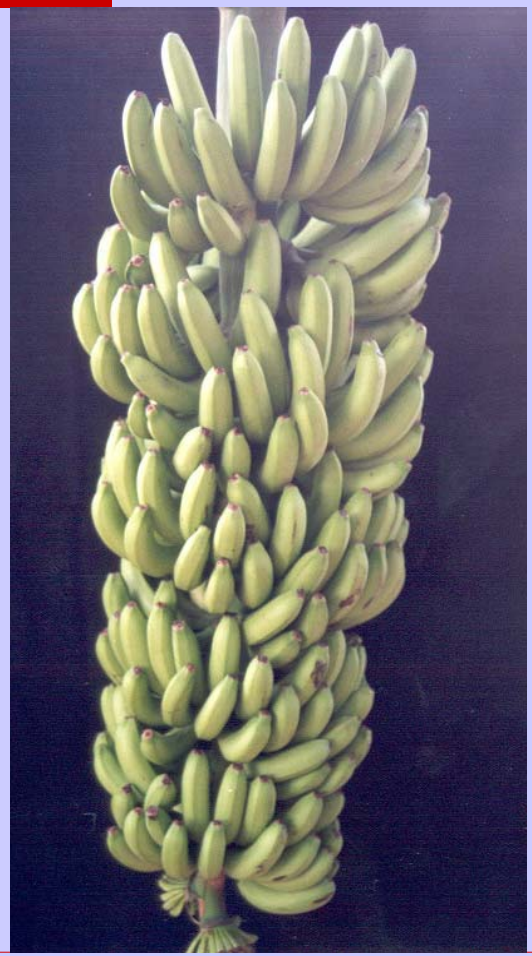


3 splits

4 splits

BUNCHES FROM DIFFERENT TREATMENTS OF RATOON CROP (R)

3 splits

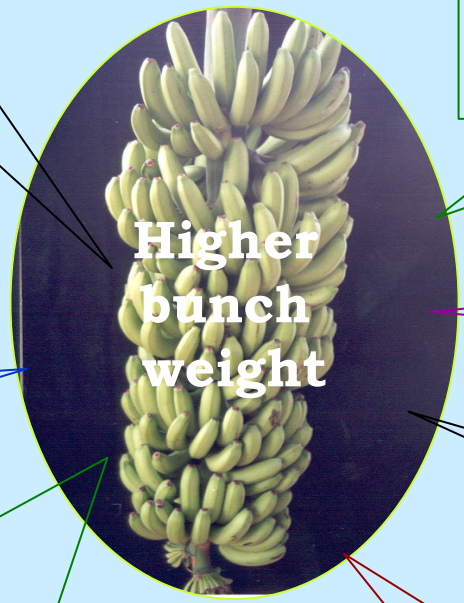


4 splits

Factors contributed for the maximum yield in TC Plants

Vegetative parameters
- More height
- More girth
- More No. of leaves
- More Leaf area
- More Leaf area index
- Shorter phyllocron

Higher dry matter in
- Root
- Corm
- Pseudostem
- Petiole
- Leaf



- More no. of roots
- Higher root volume
- Higher corm volume

Higher N P K content in leaves

Better uptake of NPK
Better availability of nutrients

Higher physiological activity
- Chlorophyll content
- Soluble protein/ photosynthetic activity/
- Nitrate reductase activity photosynthetic yield

More no. of hands
More no. of fingers
More finger weight

CITRUS

Citrus

- The importance of nutrients for citrus has been well established in India.
- Improper and inadequate nutrition is one of the major causes of citrus decline in India .
- Studies on the decline of mandarins in Kerala showed that poor nutrient status of soil and neglect and lack of manuring are the main causal factors.

30 MT of citrus fruits remove 270 kg N, 60 kg P_2O_5, 350 kg K_2O, 40 kg MgO and 15 kg S from the soil.

(Tandon and Kemmler, 1986)

- Different states recommend different amounts of NPK for mandarin and other important citrus species in India.
- It varies from 300-400 g of N, 200 to 375 g of P_2O_5 and 100 to 600 g of K_2O per plant per year.
- Recently, integrated nutrient management (INM) is being advocated in citrus.

Effect of different coating treatments on the efficiency of urea fertilizer on fruit yield and leaf nutrient status in Nagpur mandarin budded on Rangpur lime

Coating Treatments	Levels of nitrogen (g / plant / year)					
	Fruit yield (Kg/plant)			Leaf Nitrogen content(%)		
	300	450	600	300	450	600
Uncoated urea	11.99	13.54	31.66	1.92	2.12	2.20
Coaltar coated urea	13.34	17.66	31.44	2.10	2.20	2.32
Sulphur coated urea	21.54	30.45	21.95	2.20	2.40	2.32
FYM coated urea	20.08	10.77	16.27	2.10	2.15	2.28
Gypsum coated urea	31.98	34.15	28.36	2.26	2.61	2.62
Neem cake coated urea	9.00	35.34	22.25	2.08	2.16	2.24
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Source : NRC, Citrus

Effect of organic and inorganic nutrition on yield and quality of Khasi mandarin

Treatments	No of fruits / plant	Yield (kg / plant)	Juice (%)	Ascorbic acid (mg / 100g)	TSS (°Brix)
T_1 (600:300:600g NPK /plant)	805	118.01	46.33	48.27	14.35
T_2 (600:300:600g NPK / plant + Neem cake @7.5 kg/plant)	**1072**	**203.55**	**55.66**	**57.26**	**15.26**
T3 (Neem cake @7.5 kg/plant + 75 % T_1)	912	169.82	53.85	54.35	14.95
T4 (Neem cake @7.5 kg/plant + 50 % T_1)	895	161.40	54.95	52.12	14.45
CD (0.05)	19.66	10.45	1.05	3.50	0.21

(Source : AICRP Tropical Fruits, Biennial Report, 2006)

Effect of bioinoculants in combination with organic manure and inorganic fertilizers on yield and fruit quality of mandarin orange (TNAU)

Treatments	Fruit weight (g)	Number of fruits per tree	Yield per tree (kg)	TSS (^{O}Brix)	Ascorbic acid (mg/100 g)
Recommended dose of fertilizers (RDF) (600:200:400 g NPK plant^{-1})	91.50	100.97	9.00	8.89	21.80
100 per cent RDF + Bioinoculants*	84.50	147.95	12.90	9.44	23.13
75 per cent RDF + Bioinoculants *	86.00	140.95	12.00	9.51	22.47
CD (0.05)	01.75	8.06	00.08	0.26	00.62

** Arbuscular mycorrhiza (500 g plant-1) +Azospirillum lipoferum (100 g plant-1) + Phosphate solubilizing bacteria (100 g plant-1) + Pseudomonas fluorescens (100 g plant-1).*

Effect of organic and inorganic fertilizers on yield of sweet orange

Treatments	Fruit number / plant	Yield / plant (kg)	Weight of fruit (g)	Juice (%)	TSS (°Brix)
T_1 (Inorganic fertilizers @ 800:300:600g NPK / plant / year)	1960	296.27	160.76	42.04	12.86
T_2 (Castor cake @ 7.5 kg/plant/year)	2210	353.39	167.74	41.58	13.23
T3 (Castor cake @ 7.5 kg/plant/year + 75 % of T_1)	1801	321.82	170.40	41.25	12.85
T4 (Castor cake @ 7.5 kg / plant / year + 50 % of T_1)	2539	399.87	170.71	41.68	13.28
F Value	NS	NS	-	-	-

(Source : AICRP Tropical Fruits, Biennial Report, 2006)

Effect of organic and inorganic nutrients on yield and quality of acid lime fruits

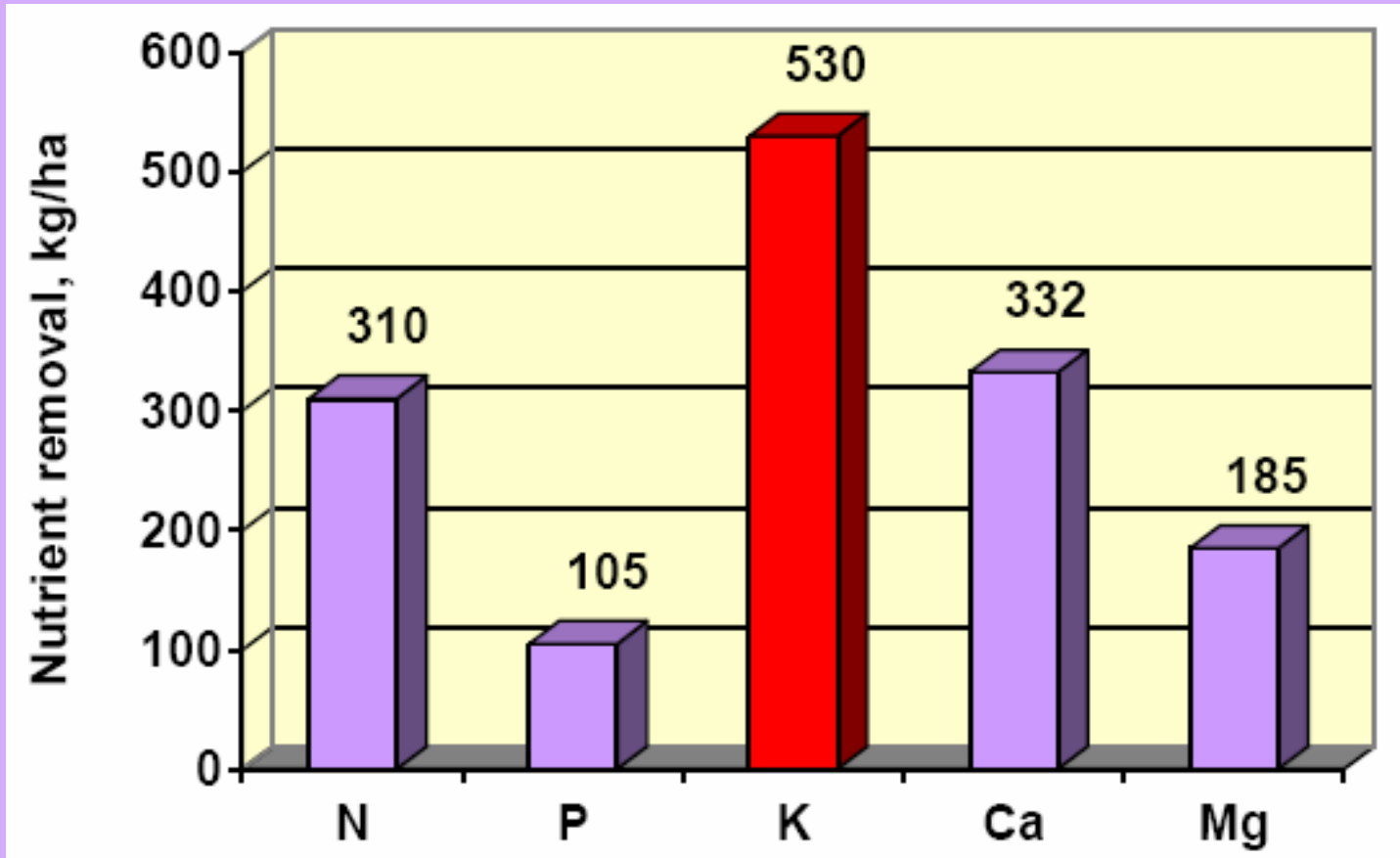
Treatment	Number of fruits / plant	Weight of fruits/ plant (kg)	Average weight of fruit (g)	Juice (%)	TSS (%)	Cost / Benefit ratio
T_1(600:300:300 g N, P_2O_5 and K_2O)	857	27.31	31.10	52.22	7.18	1: 9.70
T_2Neem cake 7.5 kg alone	722	21.26	28.75	52.82	7.15	1: 7.92
T_3(Neem cake 7.5 kg + 50 % T_1)	822	26.21	31.51	50.55	7.85	1: 8.90
T_4(Neem cake 7.5 kg + 75 % T_1)	909	28.80	31.51	50.53	7.90	1: 8.75
CD (0.05)	73.04	2.043	2.09	0.396	0.138	-

(Source : AICRP Tropical Fruits, Biennial Report, 2006)

PAPAYA

Why papaya needs heavy feeding

- Indeterminate growth habit
- Continuous vegetative and reproductive growth phases
- Heavy yielder



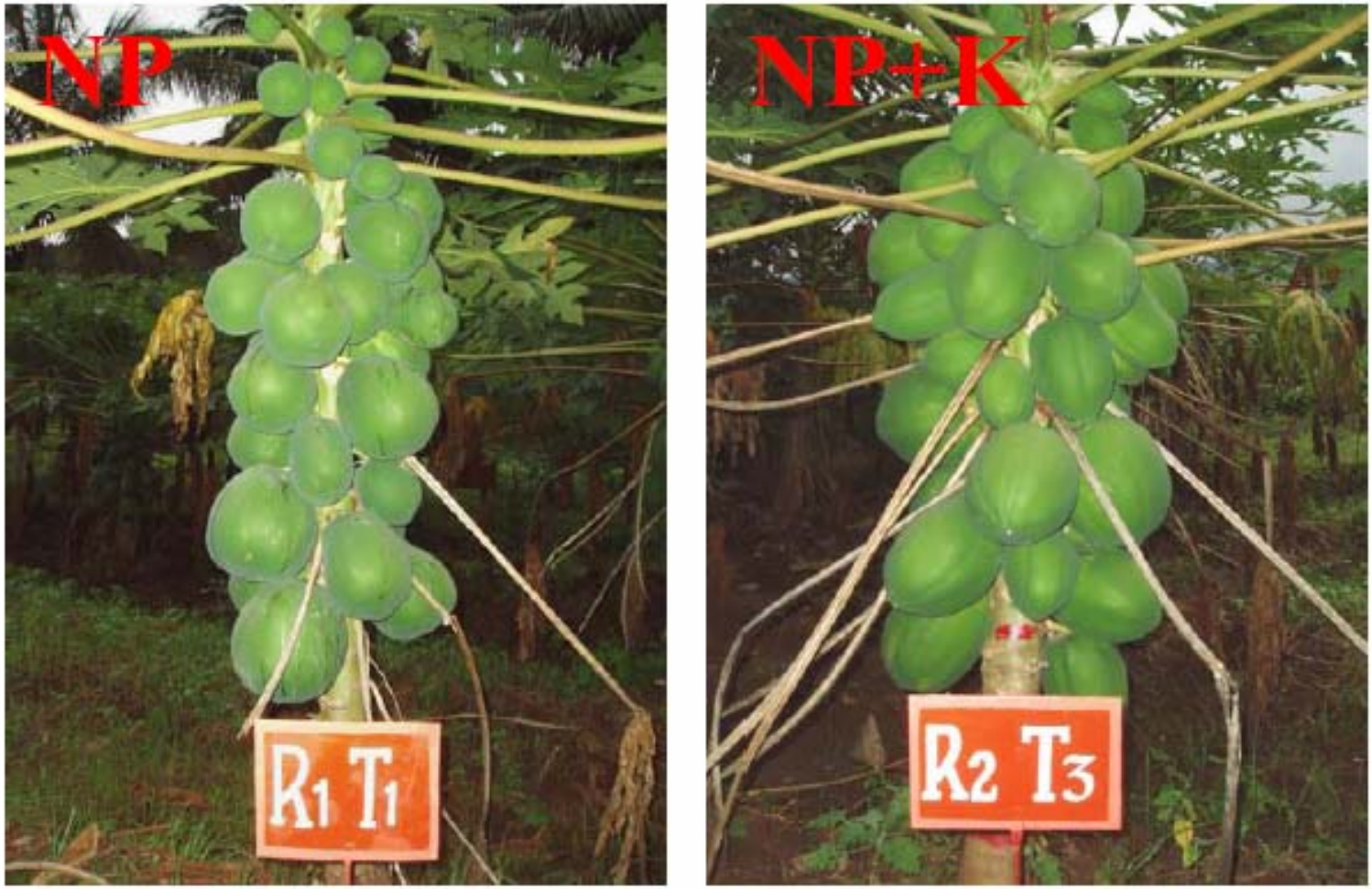
Total removal of nutrients by papaya plant

Effect of balanced fertilization on yield and quality of papaya

Treatment	Fruit yield (kg / plant*)	Fruit yield (t / ha*)	Fertilizer use efficiency (kg /kg of fertilizers ha^{-1})*	TSS (° Brix)
T_1 - N_{300g} + P_{300g} +K_0	99.9	249.7	-	10.8
T_2 - N_{300g} + P_{300g}+K_{150g}	115.5	288.7	104	11.7
T_3 - N_{300g} + P_{300g}+K_{300g}	146.0	365.3	154	12.0
T_4 - N_{300g} + P_{300g}+K_{450g}	113.3	283.3	30	12.8

* Mean of four locations

Kumar *et al.*, 2006

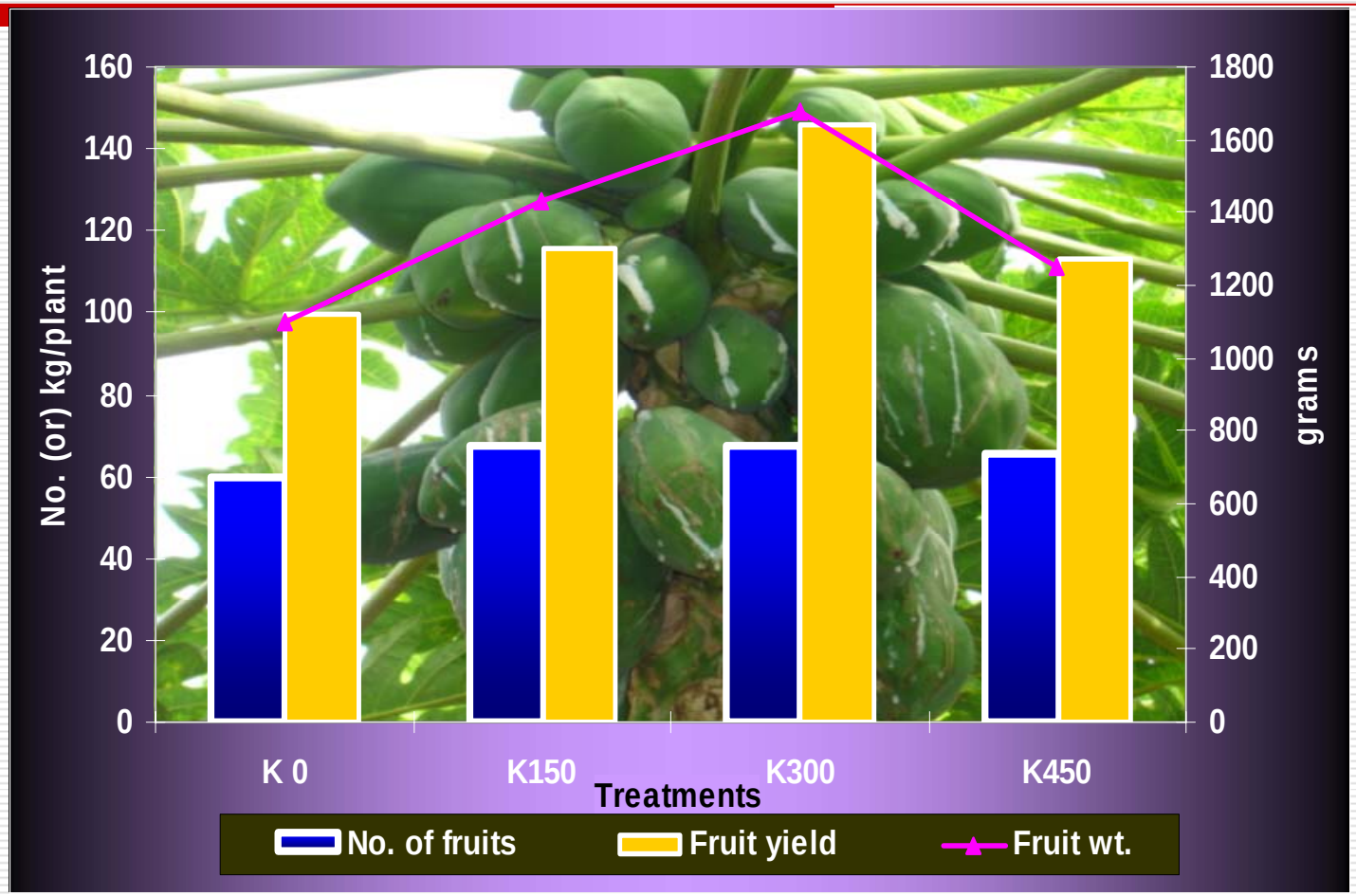


Papaya response to potash fertilizer at Vadipatti, Theni District, Tamil Nadu, India (2005)

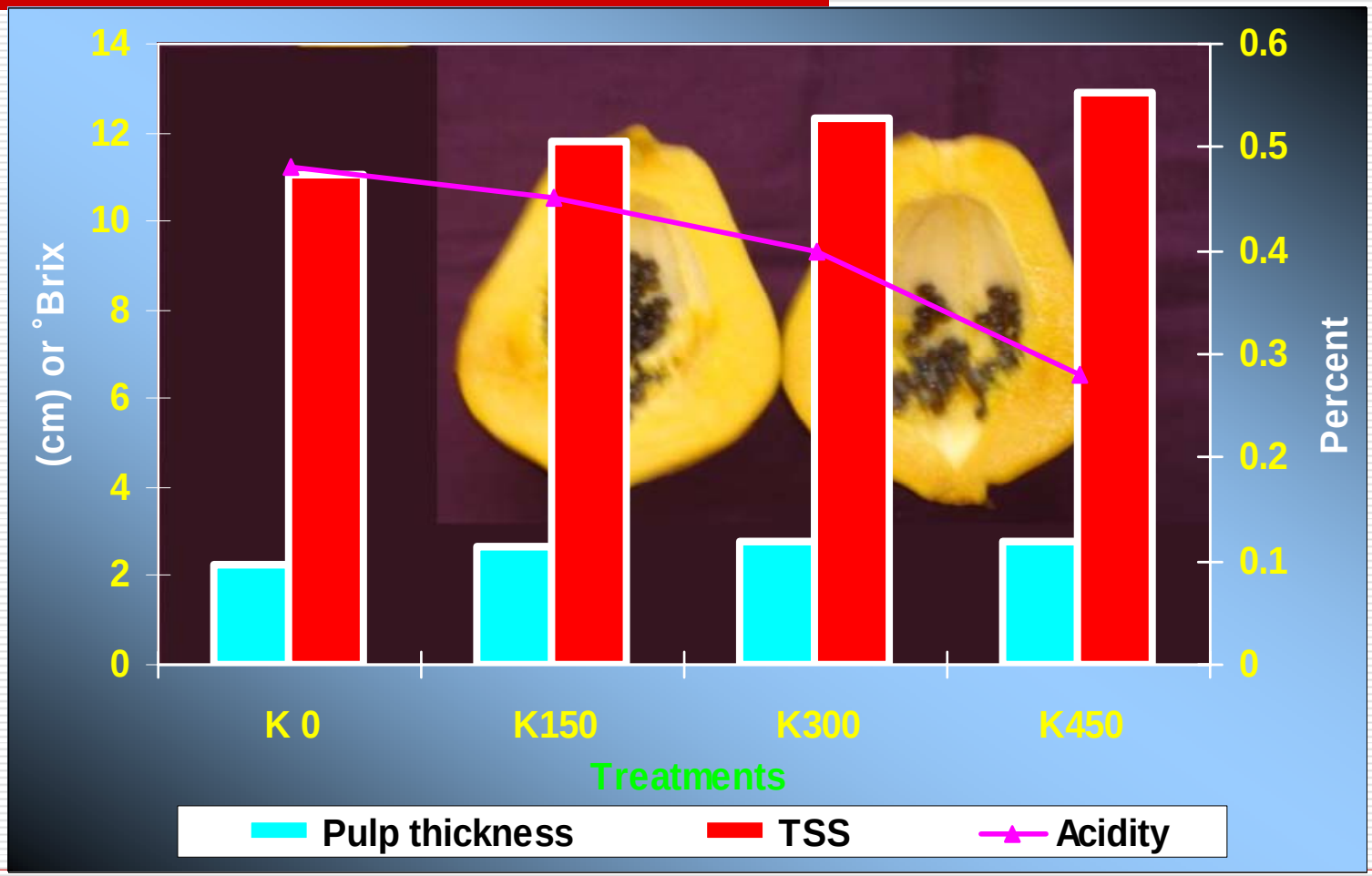
T_1 - N_{300} + P_{300} T3 - N_{300} + P_{300} + K_{300}

Kumar *et al.*, 2006

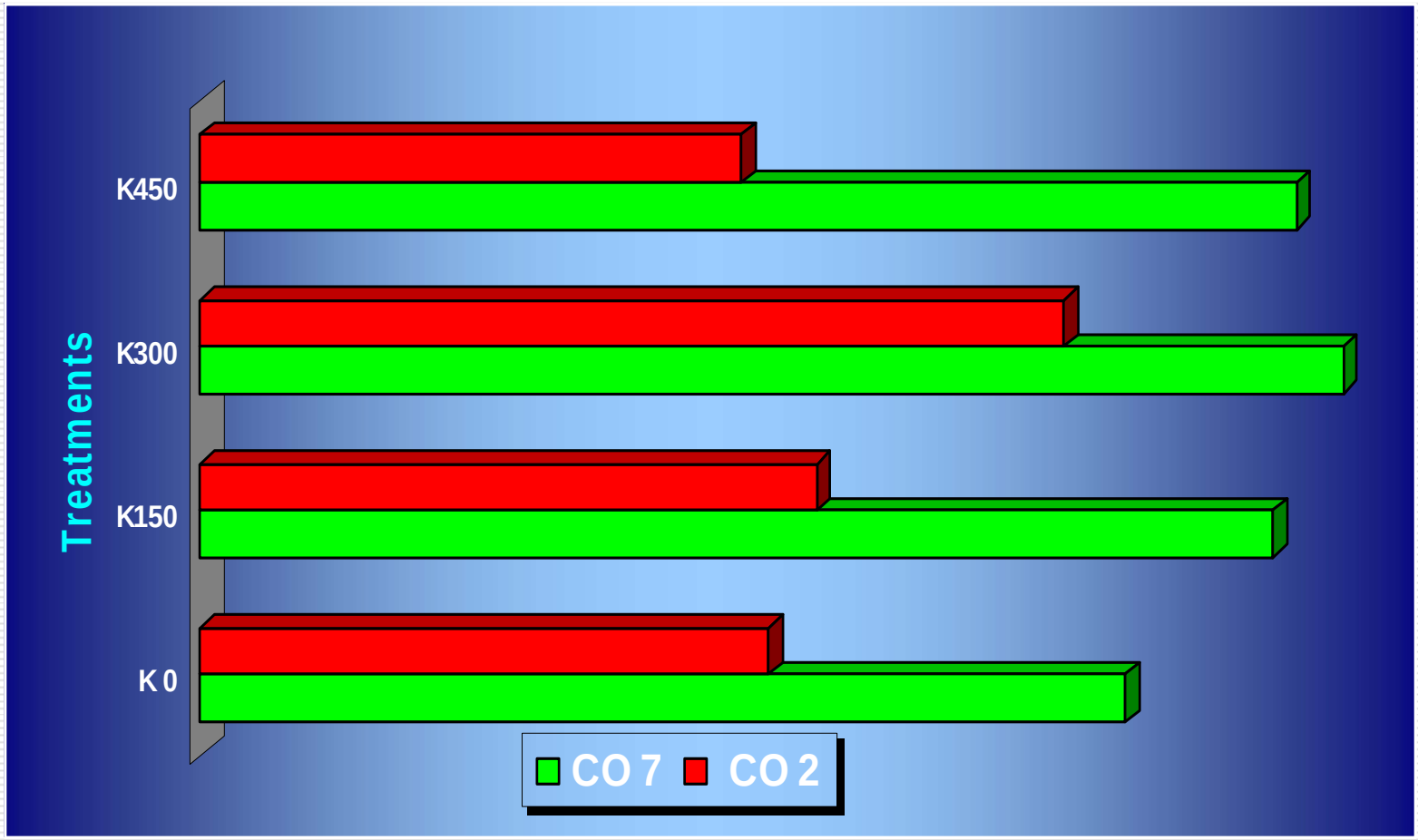
Effect of K nutrition on fruit yield and yield traits in papaya



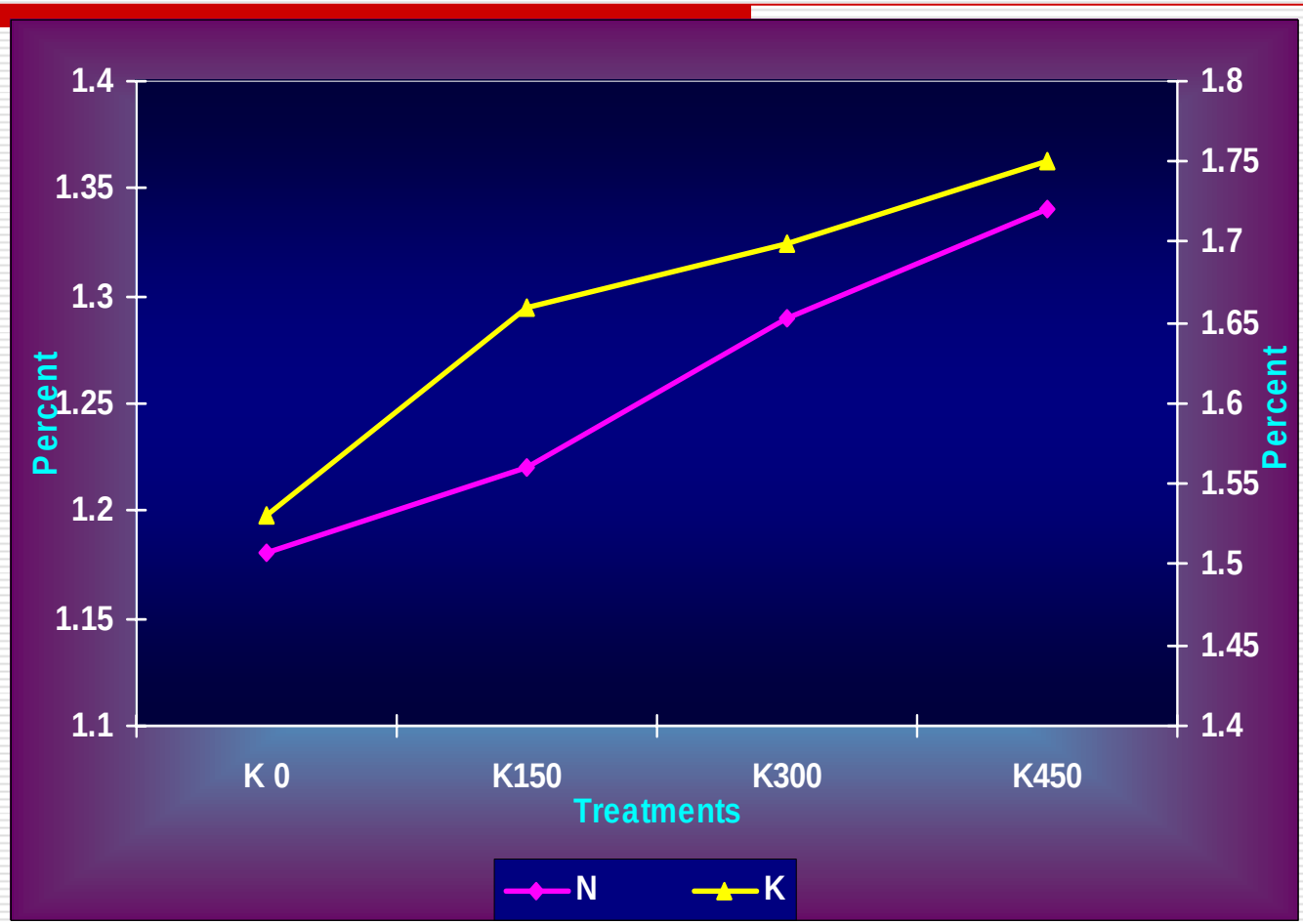
Effect of K nutrition on qualitative traits in papaya



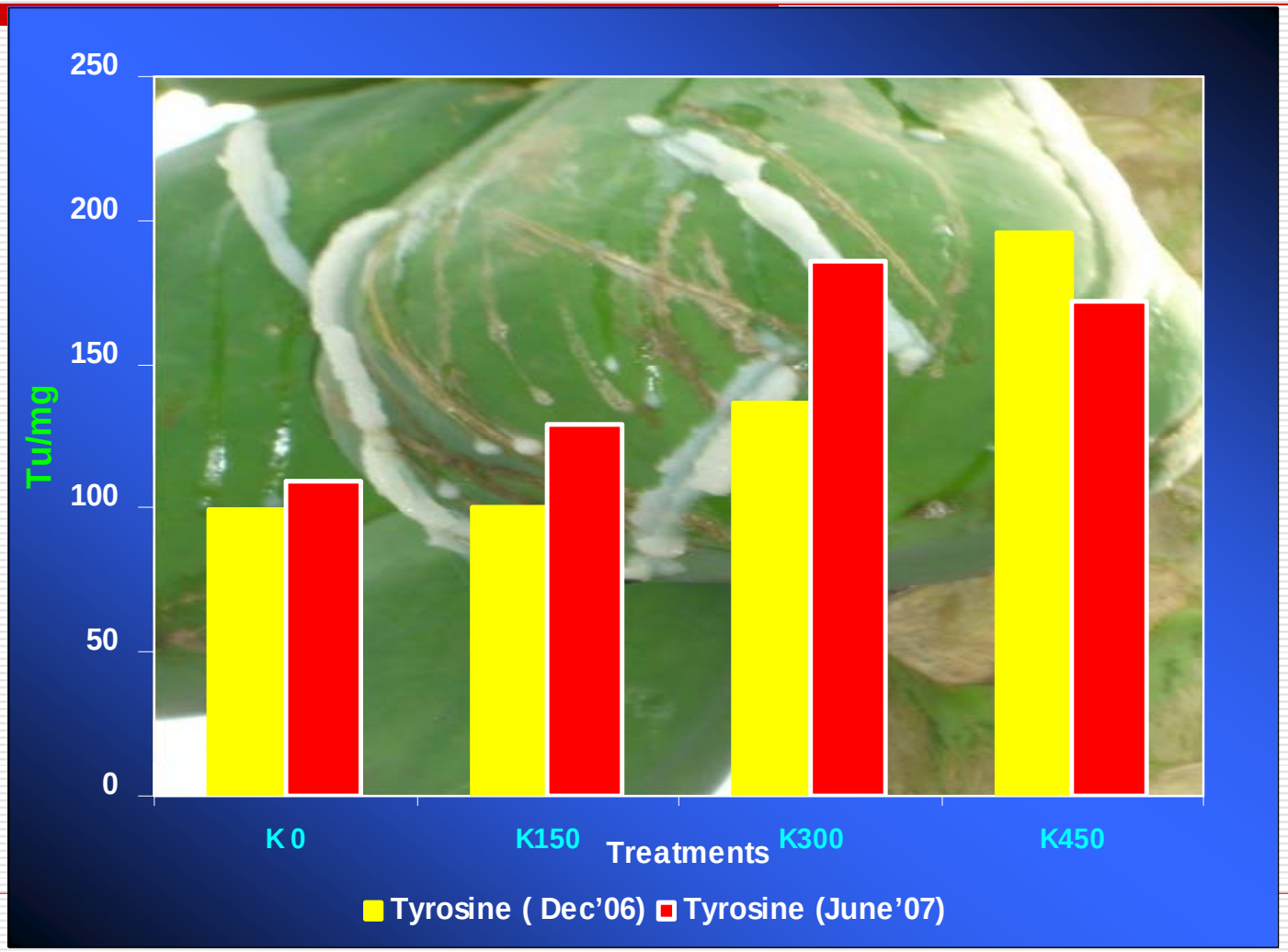
Effect of K nutrition on carotenoid content in papaya



Effect of K on nutrient content in papaya



Effect of K nutrition on Tyrosine content in papaya latex



Effect of nutrient levels and split application on the fruit yield of papaya cv. CO2

Nutrient level / Frequency of application	Yield of fruits / plant (kg)	
	12 splits / year	6 splits / year
200:200:200 g NPK per plant / year	113.4	97.5
300:300:300 g NPK per plant / year	202.9	167.0
400:400:400 g NPK per plant / year	213.6	175.4
SEd - 8.14	CD(0.05) – 16.55	

Ravichandranae *et al.* (2002)

Final Recommendation

Papaya can be balance fertilized with

N 300

P_2O_5 300 and

K_2O 300 kg/ha/year

in six equal split doses to get higher yield with quality fruits / latex.

PINEAPPLE

PINEAPPLE

Nutrient uptake of pineapple fruits

Yield (t/ha)	Source	Uptake or removal	kg/ha				
			N	P_2O_5	K_2O	MgO	CaO
100	Cowie, 1951	uptake	123	34	308	-	-
81	Stewart and Py, 1956	uptake	574	126	1631	-	-
55	Martin-Prével, 1961	uptake	205	58	393	42	121

Fertilizer recommendation for optimum productivity of pineapple grown in some states of India

India official recommendations in 5 states					
State	Plants/ha (spacing)	N	P_2O_5	K_2O	FYM t/ha
		kg/ha			
Assam	44 000	530	90	530	15
Karnataka	(0.6 x 0.3 m)	350	130	440	30
Kerala	40 000	320	160	320	25
Tamil Nadu*	(0.6 x 0.3 m)	500	40	660	40-50
West Bengal	40 000	400	200	400	20
* ZnSO4 and FeSO4 spray where required Source : Tandon, 1987					

Effect of Sources of K on Pineapple

(Devadas & Kuriakose, 2006)

Fertilizers	Yield (t/ha)	Fruit size (kg)
4 g N+4 g P_2O_5+16 g K_2O (Kcl)	67.0	1.47
4 g N + 4 g P_2O_5 + 16 g K_2O (SOP)	70.9	1.60
4 g N + 4 g P_2O_5 + 0 g K_2O	50.7	1.21
CD at 5 %	9.0	0.20


SAPOTA
SAPOTA

- ☹ **No systematic studies on the nutrient uptake or removal in sapota.**
- ☹ **1.69 kg K_2O, 1.16 kg N, 1.12 kg Ca, 0.17 kg P_2O_5 and 0.14 kg MgO to produce 1000 kg of fruits (Avilon *et al., 1982)***

Fertilizer recommendations for sapota in certain states of India

States	Age	N	P_2O_5	K_2O	Farm Yard Manure (kg/tree)
		Kg/ha			
Andra Pradesh	1-3 year	50	20	75	50
	11 & above	400	160	450	--
Karnataka	1-3 year	50	20	75	50
	11 & above	400	160	450	50

Cont…

Maharashtra	**1-10 year**	**50 g /yr**	**--**	**--**	**--**
	10th year	**500**	**--**	**--**	**10-15**
Orissa	**Adult**	**45**	**150**	**--**	**15 kg farm yard manure + 250g Stearameal**
Tamil Nadu	**Annual increase**	**30**	**30**	**50**	**10**
	I year	**30**	**30**	**50**	**10**
	Adult	**150**	**150**	**250**	**50**


AONLA
Emblica officinalis
(Euphorbiaceae)

- Area : 50,000 ha
- Production : 1,50,000 tonnes
- Cultivable area increases every year.
- Two flowering seasons : February- March and June – July
- Existing recommendation :
- 800 g N, 640 g P_2O_5, 750 g K_2O and 30- 40 kg FYM
- Balanced fertilization need to be done

Future thrust

- Systematic long term experiments need to be taken up to **assess the individual effect of these major nutrients** & their interaction on yield and quality in perennial fruit crops.

- **Research on INM**
  - ✓ organic manures,
  - ✓ organic cakes
  - ✓ biofertilizers including mycorrhiza.

- More emphasis on Nutrient recycling.
- Research on fertigation in perennial fruit crops like mango, sapota, citrus is totally lacking.
- Standardization of liquid bio fertilizers for all the fruit crops.


Thank you