YIELD AND BLACK TEA QUALITY RESPONSES OF CLONE BBK 35 TEA TO NITROGEN FERTILIZER RATES AND HARVESTING INTERVALS IN THE LAKE VICTORIA BASIN OF KENYA

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Introduction

- Tea, *Camellia sinensis* (L.) O. Kuntze is cultivated from 49ºN, outer Carpathians to 30ºS, Natal, South Africa and from altitudes varying from sea level in Japan to above 2700m above mean sea level (amsl) in Olenguruone, Kenya and Gisovu, Rwanda.
- In Kenya, it is grown on the foothills of Abardare ranges and Mount Kenya in the East of the Great Rift Valley and the Mau ranges, Nandi, Kisii and Kakamega Hills in the West of the Great Rift Valley of Kenya.
- Tea is widely adaptable to geographical areas with large differences in climate and physical features which affect rates of growth, leading to yields and quality variations.
- Such variations may require different management strategies to maximise yields and quality.

Introduction Continues

- Previous studies demonstrated wide responses in yields of tea genotypes to different environments.
- Quality variations have also been recorded due to environmental factors and geographical area of production.
- Previous studies were confounded by use of different genotypes.
- Despite noted differences due to growth factors, agronomic recommendations are usually uniform within one country or region.

Important Agronomic Inputs

- Harvesting is the most expensive agronomic inputs in tea production.
- Nitrogen fertilizer application is the second most expensive agronomic inputs in tea production
- It is necessary to establish the optimal nitrogen rates and plucking intervals to optimise quality in different regions within Lake Victoria basin, using one tea cultivar

Some Problems of Plucking in Different Locations

- Previous studies to formulate plucking policies, especially intervals were conducted at single sites and the results from the Studies were assumed replicate in all tea growing regions.
- In 2002, Wachira *et al,* (2002) demonstrated large variations yield of tea genotypes within Kenya suggesting that the recommended production policies even within one country could be inappropriate for some tea growing areas.
- The recommended plucking interval in Kenya varies from 7 to 14 days.
- The variations in yields and plain tea quality parameters with area of production and harvesting intervals using one tea genotype under uniform management were evaluated in this presentation.

Need for Application of Nitrogenous Fertilizers and Consequences

Needs:

The application of nitrogen fertilizer is necessary as it increases yields.

Consequences:

Raises costs of production

High rates of nitrogen may lower resultant black tea quality.

May affect the environment and render productive lands moribund.

Nitrogenous Fertilizer Use on Tea Indifferent Countries

Country	N rate (Kg N/ha/year)		Country	N rate (Kg N/ha/year)
North India	100-200		South India	120-200
Sri Lanka	120-360		Malawi	180-300
Kenya	100-250		Queensland (Australia)	182
Malaysia	153-270		Indonesia	120-200
Vietnam	36-40		USSR	200-300
Turkey	112		Taiwan	150
Congo (Kivu)	45-150		Japan	800

Source: Owuor & Wanyoko, *Tea*, **17**, 53-59 (1996) and references therein

Amount of Nutrients Removed with Crops

Nitrogen	~ 4%
Phosphorous	~0.2%
Potassium	~ 2%

For tea Yielding 8000 kg mt/ha/year

Nitrogen (N)	320 kg mt
Phosphorous (P_2O_5)	36 kg mt
Potassium (K_2O)	193 kg m

For tea yielding 10,995 kg mt/ha/year

Nitrogen (N)	440 kg mt
Phosphorous (P_2O_5)	50 kg mt
Potassium (K_2O)	265 kg m

(Source: Oyamo, *Tea*, **13**, 1, (1992)

Study Sites

Location	Altitude	Latitude	Longitude
Karirana	2260m amsl	1^0 6’S	36^0 39’E
Timbilil	2180m amsl	0^0 22’S	35^0 21’E
Changoi	1860m amsl	0^0 29’S	35^0 14’E
Sotik Highlands	1800m amsl	0^0 35’S	35^0 5’E
Kipkebe	1800m amsl	0^0 41’S	35^0 5’E

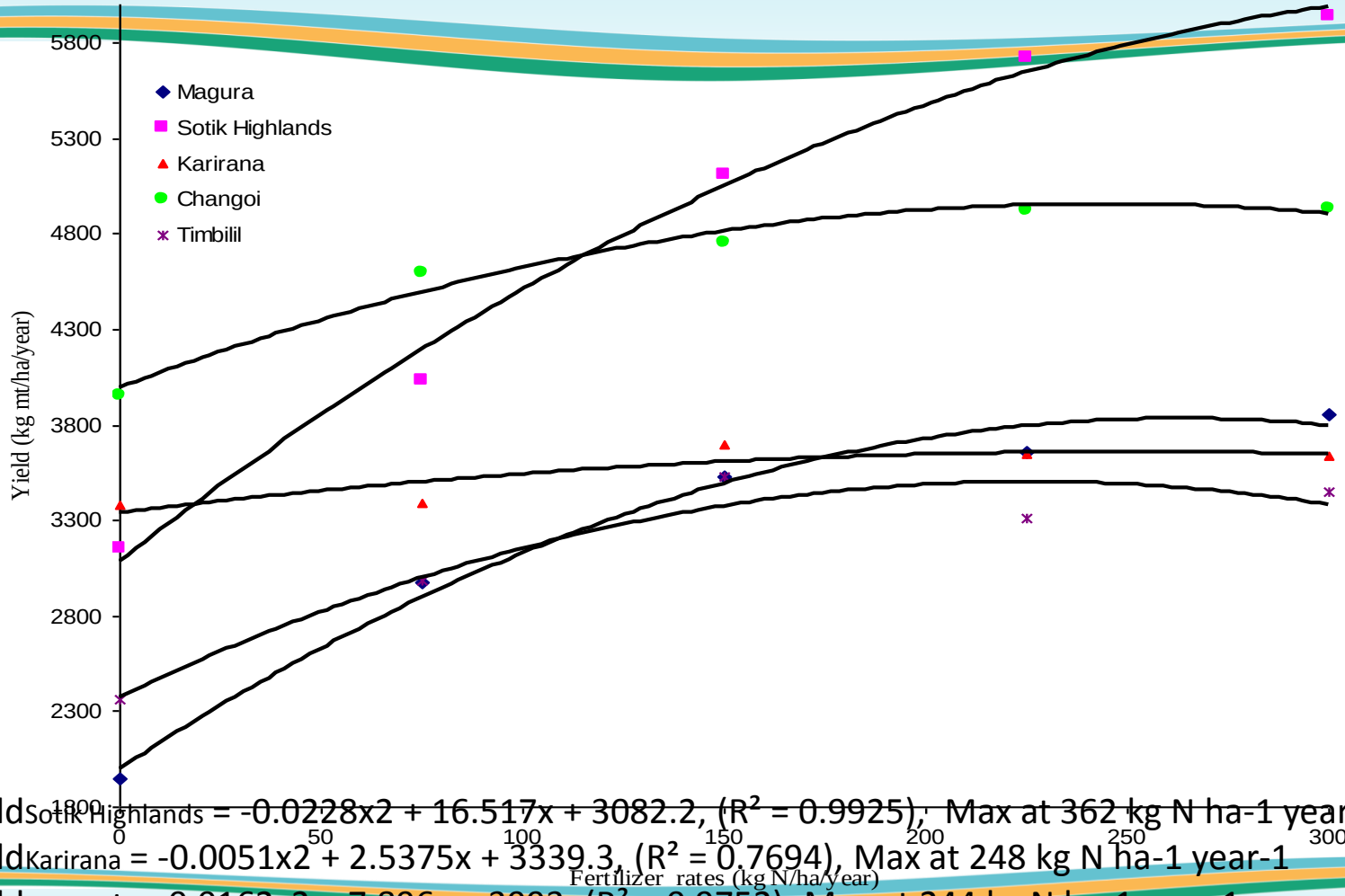
Effects of Geographical Area of Production and Nitrogenous Fertiliser Rates on the Yields of Clone BBK 35 in 2007 and Mean from 2003 to 2007

Year	Location	Rate of nitrogen (kg N ha^{-1} $year^{-1}$)					Mean location
		0	75	150	225	300	
2007	Kipkebe	1625	2829	3460	3534	3495	2989
	Sotik Highlands	3020	4393	5011	5403	5369	4639
	Karirana	3751	4098	4759	4831	4777	4443
	Changoi	3344	4377	4616	4357	4717	4282
	Timbilil	2194	3006	3313	3519	3721	3150
	Mean rate	2787	3741	4232	4329	4416	
	CV (%)			6.92			
	LSD, ($P \leq 0.05$)			274			274
	Interactions			467			
1998-2007	Kipkebe	1947	2977	3534	3657	3859	3194
	Sotik Highlands	3151	4034	5112	5720	5942	4792
	Karirana	3379	3393	3693	3647	3635	3549
	Changoi	3952	4595	4757	4925	4928	4632
	Timbilil	2359	2982	3532	3309	3451	3126
	Mean rate	2957	3595	4126	4252	4363	
	CV (%)			5.55			
	LSD, ($P \leq 0.05$)			217			217
	Interactions			371			

Effects of geographical area of production and plucking intervals on the yields of clone BBK 35 (2007 and mean 1998 to 2007)

Year	Plucking Round (days)	Site					Mean plucking round
		Kipkebe	Sotik Highlands	Karirana	Changoi	Timbilil	
2007	7	3460	5011	4759	4616	4646	4298
	14	3778	4527	4875	5150	3532	4372
	21	3421	4275	4870	5129	4499	4439
	Mean site	3553	4604	4835	4965	3892	
	CV (%)			7.22			
	LSD,(P ≤ 0.05)			413			NS
	Interactions			594			
Mean 1998 to 2007	7	3534	5112	3693	4757	3532	4126
	14	4033	4714	3241	5265	3223	4095
	21	3465	4697	2793	5365	3462	3957
	Mean site	3678	4841	3229	5129	3405	
	CV (%)			7.21			
	LSD,(P ≤ 0.05)			383			NS
	Interactions			511			

Annual Mean (Ten Years) Response of BBK 35 to Varying Rates of Nitrogenous Fertilizer at Different Sites



$Yield_{Sotik\ Highlands}$ = -0.0228x2 + 16.517x + 3082.2, (R^2 = 0.9925), Max at 362 kg N ha-1 year-1

$Yield_{Karirana}$ = -0.0051x2 + 2.5375x + 3339.3, (R^2 = 0.7694), Max at 248 kg N ha-1 year-1

$Yield_{Changoi}$ = -0.0162x2 + 7.896x + 3993, (R^2 = 0.9752), Max at 244 kg N ha-1 year-1

$Yield_{Kipkebe}$ = -0.0265x2 + 13.967x + 1995.4, (R^2 = 0.9858), Max at 263 kg N ha-1 year-1

$Yield_{Timbilil}$ = -0.022x2 + 9.9575x + 2376.5; (R^2 = 0.9261), Max at 226 kg N ha-1 year-1

Predicted Return (Kg Mt Kg N Ha^{-1} $Year^{-1}$) of Applying Various Rates of Nitrogen at Different Geographical Areas of Tea Production in Kenya

Rate of N (kg N ha^{-1} $year^{-1}$)	Kipkebe	Sotik Highlands	Karirana	Changoi	Timbilil
50	11.3	14.2	2.0	6.3	7.8
75	10.0	13.1	1.8	5.5	6.7
100	8.7	12.0	1.5	4.7	5.6
125	7.3	10.8	1.3	3.8	4.5
150	6.0	9.7	1.0	3.0	3.4
175	4.7	8.5	0.8	2.2	2.3
200	3.4	7.4	0.5	1.4	1.2
225	2.0	6.3	0.2	0.6	0.1
250	0.7	5.1	0.0	-0.2	-1.0
275	-0.6	4.0	-0.3	-1.0	-2.1
300	-1.9	2.8	-0.5	-1.8	-3.2

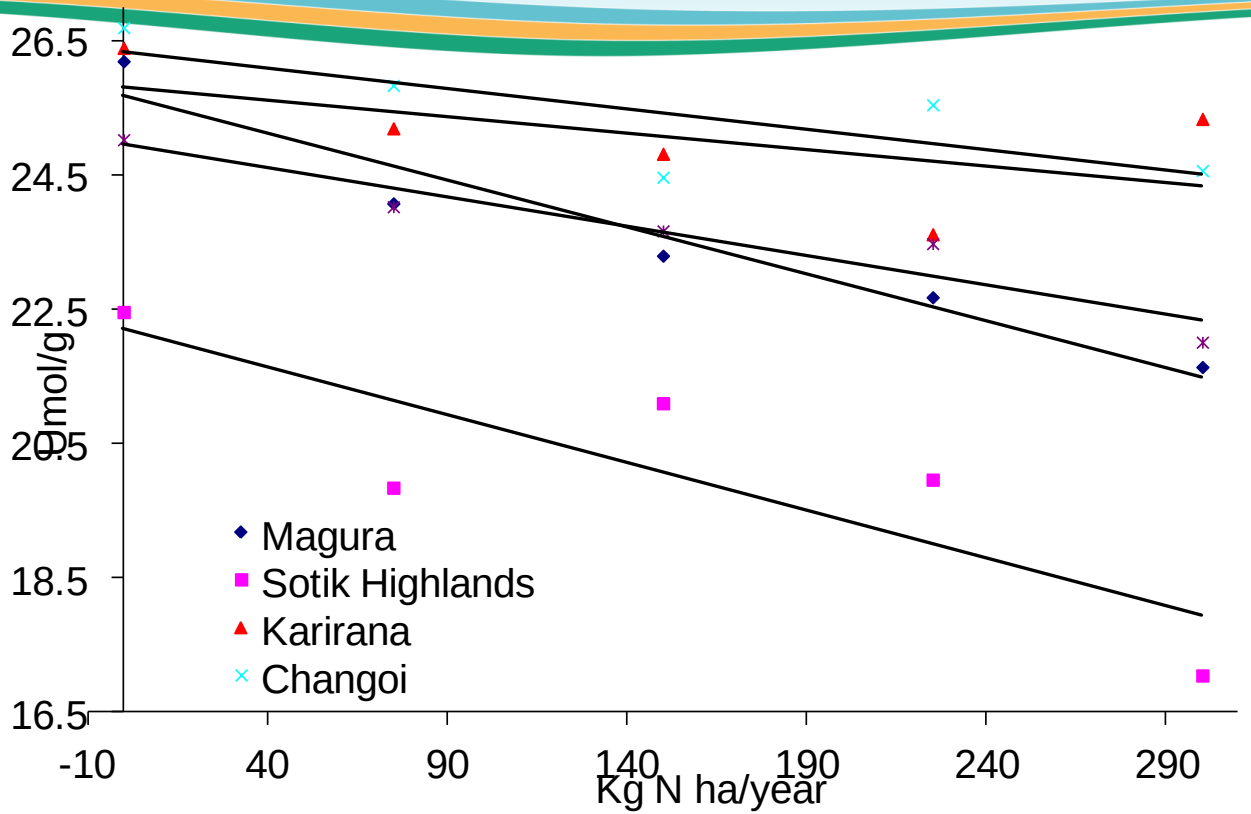
Effects of Geographical Area of Production and Nitrogenous Fertiliser Rates on Theaflavins and Thearubigins Levels of Clone BBK 35 Black Teas

Parameter	Location	Rate of nitrogen (kg N/ha/year					Mean location
		0	75	150	225	300	
Theaflavins (µmol/g)	Kipkebe	26.21	24.09	23.31	22.69	21.65	23.59
	Sotik Highlands	22.47	19.85	21.11	19.97	17.05	20.09
	Karirana	26.41	25.21	24.83	23.63	25.35	25.09
	Changoi	26.71	25.85	24.48	25.56	24.58	25.44
	Timbilil	25.04	24.04	23.68	23.49	22.02	23.66
	Mean rate	25.37	23.81	23.48	23.07	22.13	
	CV (%)			13.50			
	LSD, ($P \leq 0.05$)			3.23			3.23
Thearubigins (%)	Kipkebe	17.86	17.94	16.75	15.00	14.67	16.44
	Sotik Highlands	16.82	17.91	16.67	16.87	15.05	16.67
	Karirana	16.53	16.88	15.82	15.64	15.09	15.99
	Changoi	17.68	17.87	16.41	16.67	15.99	16.93
	Timbilil	18.38	16.23	15.82	15.44	14.46	16.07
	Mean rate	17.46	17.37	16.29	15.93	15.05	
	CV (%)			9.51			
	LSD, ($P \leq 0.05$)			1.58			NS

Effects of Geographical Area of Production and Plucking Intervals an Theaflavins and Thearubigins Levels of Clone BBK 35 Black Tea

Parameter	Plucking round	Site					Mean plucking round
		Kipkebe	Sotik Highlands	Kaririana	Changoi	Timbilil	
Theaflavins (umol/g)	7	23.31	21.11	24.83	25.62	23.69	23.71
	14	21.81	18.96	24.50	26.38	22.02	22.73
	21	21.04	17.54	21.92	23.75	20.55	20.96
	Mean site	22.06	19.20	23.75	25.25	22.09	
	CV (%)			5.69			
	LSD,(P ≤ 0.05)			4.73			2.01
Thearubigins (%)	7	16.75	16.67	15.82	16.92	15.82	16.40
	14	18.31	17.91	17.54	16.19	17.43	17.47
	21	18.53	17.92	18.58	17.22	18.64	18.18
	Mean site	17.86	17.50	17.31	16.78	17.30	
	CV (%)			5.58			
	LSD,(P ≤ 0.05)			NS			1.52

Changes in Theaflavins Levels Due to Nitrogen Rates at Various Sites



TFSotik Highlands= -0.0143x + 22.234, (R^2 = 0.7174)

TFKipkebe = -0.014x + 25.694, (R^2 = 0.9406)

TFTimbilil = -0.0088x + 24.972, (R^2 = 0.9109)

TFKarirana = -0.0049x + 25.826 (R^2 = 0.3402)

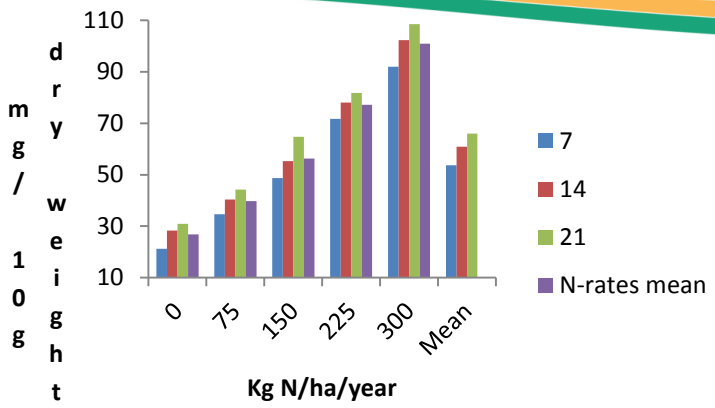
TFChangoi = -0.0061x + 26.346 (R^2 = 0.5989)

Effects of Geographical Area of Production and Plucking Intervals on Total Colour and Brightness of Clone BBK 35 Black Tea

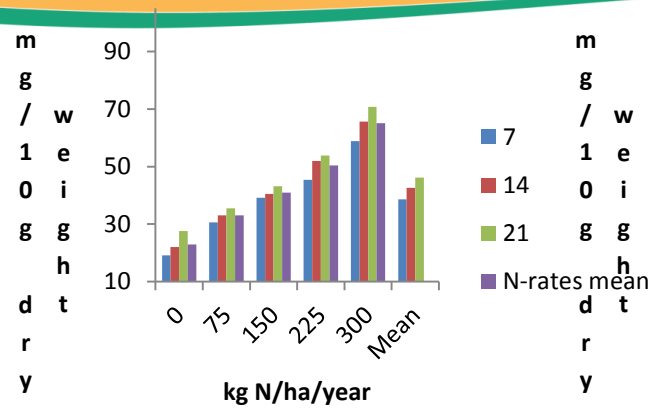
Parameter	Plucking round	Site					Mean plucking round
		Kipkebe	Sotik Highlands	Karirana	Changoi	Timbilil	
Total colour (Roberts) %	7	4.04	4.50	5.21	6.00	5.08	4.97
	14	4.44	4.71	5.52	5.57	5.40	5.13
	21	4.76	5.22	5.53	5.81	5.74	5.41
	Mean site	4.41	4.81	5.42	5.79	5.41	
	CV (%)			5.56			
	LSD,(P ≤ 0.05)			NS			0.45
Brightness (%)	7	27.64	22.84	29.08	25.49	25.29	26.07
	14	25.51	21.63	27.24	26.40	24.23	25.00
	21	22.94	18.34	24.55	24.48	20.44	22.15
	Mean site	25.36	20.94	26.96	25.46	23.32	
	CV (%)			6.14			
	LSD,(P ≤ 0.05)			NS			2.35

Changes in Unsaturated Fatty Acids Levels in Tea Leaves Due Nitrogen Rates and Plucking Intervals

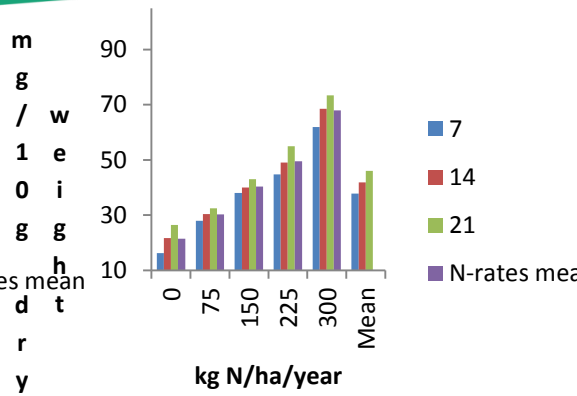
Karirana



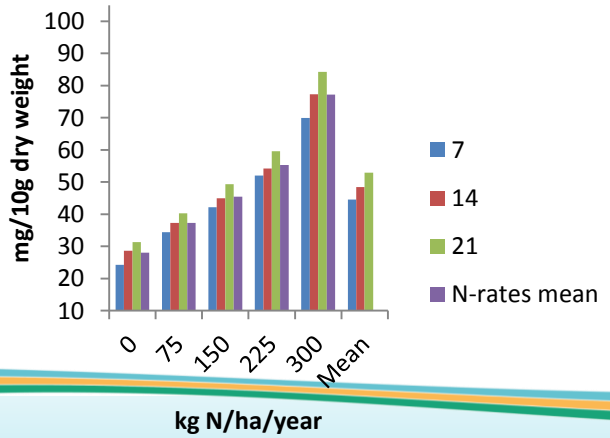
Sotik Highlands



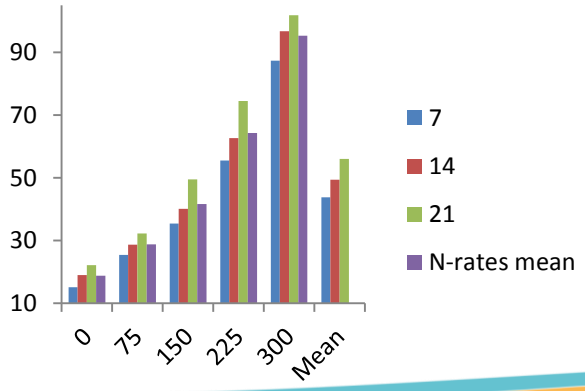
Kipkebe



Timbilil



Changoi



Conclusions

- Even when one genotype is subjected to similar management in different regions, yields at one site are not maintained or replicated in the other sites.
- To realise high production genotypes should be tested in the intended areas of production before extensive plantation.
- This will identify geographical areas for which genotypes are most suited for realisation of high yields.

Conclusions Continue

- **For the mean of the five sites, yields declined with long plucking intervals but this was not significant due to the conflicting responses as shown by the significant ($P \leq 0.05$) interaction effects between sites and plucking intervals**

Conclusions Continue

- Except for theaflavins levels which significantly ($P \leq 0.05$) varied with geographical area of production, the other plain tea quality parameters did not significantly change.
- It is possible to make black teas from BBK 35 with similar thearubigins, brightness and colour within tea growing regions of Kenya.
- Short plucking intervals improved black tea quality at all major tea producing areas in Kenya

Recommendations

- **Agronomic practices should be developed that are locational specific.**
- **All tea growing areas should practice short plucking intervals to enhance quality**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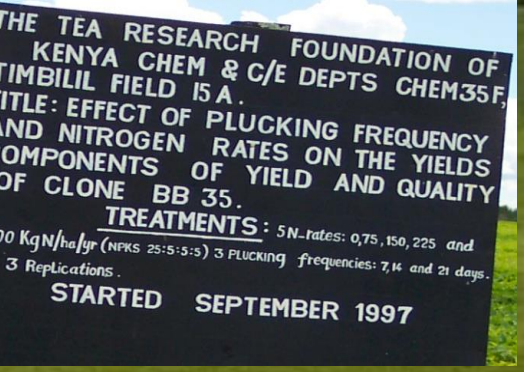

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