Effects of location of production, nitrogenous fertilizer rates and plucking intervals on tea clone TRFK 6/8 tea in East Africa: I. yields

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ABSTRACT: The tea growing areas in East Africa fall in agro-ecological regions, differing in elevation and climatic factors but favourable growing conditions. Despite of these differences in elevation and climate, agronomic recommendations are uniform. Clone TRFK 6/8 is the most widely cultivated tea cultivar in East Africa, while nitrogen fertilizer and harvesting are the most expensive agronomic inputs in tea production. Trials were initiated to establish the optimal nitrogen fertilizer rates and plucking intervals to optimise yields within East Africa using clone TRFK 6/8. Experiments were set up at three sites in Kenya; two sites in Rwanda and three sites in Tanzania. At each site the plot was demarcated and the experimental trials were analysed by the 5 by 3 factorial split design for all the 8 locations with nitrogen rates as main treatment and plucking frequencies as sub treatment and the result yield from 2008 to 2010 was analysed. There were significant ($P<0.05$) yield difference due to sites, suggesting clone TRFK 6/8 is not adapting equally at the different sites. Although 225 and 300 kg N ha-1 year-1 fertiliser rates yielded higher than 150 kg N ha-1 year-1 rate, there was no yield difference between the two N-rates. During the whole experimental period, 150 to 225 kg N/ha/year produced yields considered optimal. The extend and rate of yield response to nitrogen fertilizer varied with location of production. Yields variations to plucking intervals were insignificant. For the whole experimental period, short plucking intervals (7 days) produced highest yields. However, differences in the pattern of response changed with sites leading to significant interactions effects.

KEYWORDS: Clonal tea; Yield; Nitrogen fertilizer; Plucking intervals; Kenya; Tanzania; Rwanda

INTRODUCTION

Tea (*Camellia sinensis* (L) O. Kuntze) is an important economic commodity crop in East Africa, earning foreign exchange and creating employment opportunities. The growing areas fall in several agro-ecological regions differing widely in climatic factors including elevation, temperatures and rainfall distribution. The favourable conditions for growing tea in the East African highlands include a suitable temperature (15–25°C), high relative humidity (80–90%), medium to high annual and well distributed rainfall (1200–2000 mm), and acid soils (pH 4.0–5.6).[1, 2] These conditions are met in Kenya, in the highlands west of the Great Rift Valley on the foothills of Mau Ranges, Nandi, Kisii and Kakamega Hills including Trans Nzoia; in Tanzania, in the southern highlands, (Mufindi, Lupende, Iringa and Tikuyu districts), northern Tanzania (Usambaras), Bukoba are on the Lake Victoria; and in Uganda around Lake Victoria in Mityana, Lugazi, Fort Portal and Masaka areas, Kigezi, Ankole, Toro, Mubende and Zeu in the western highlands and in Rwanda, the conditions are met in the provinces of Byumba, Cyangugu, Gikomgoro, Gisenyi and Kibaye.[3]

Application of agronomic inputs in farm production enhances yields, improves plant health and influences the product quality. Consequently, use of inappropriate agronomic practices leads to uneconomic returns. In tea production, nitrogen fertilizer and harvesting are the most expensive agronomic inputs.[4] The policies on the use of these two inputs influence tea yields.[5] Indeed, economic benefits of applying nitrogenous fertiliser are well documented in Kenya.[6, 7] But very high rates impair black tea quality.[8-14] In East Africa, the recommended

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nitrogenous fertiliser rates vary between 100 and 225 kg N/ha/year. This recommendation was adopted from Kenya.[1,2] There is no information on the suitability of the recommended rates in all tea producing areas of East Africa. One agronomic practice recommended across borders is plucking intervals. Harvesting the young tender shoots to make tea beverages is labour intensive and costly.[15] In India, for example, plucking constitutes up to 70% of the total costs of field operations.[16,17] Similar high costs are being recorded in other tea growing countries. When incorrectly practiced, plucking reduces tea yields[5,8,9,18,19] and/or quality.[8,13,20,21] Tea grows at different rates in different regions. For, example, while it takes only 40-45 days from bud break to pluckable shoot of two and a bud in Malawi,[22-24] in Kenya the same process takes 60 to 100 days depending on altitude and season.[25-27] Such variations require that plucking intervals are varied as plucking standard is set at two leaves and a bud in all locations.[2] It is not known if there are variations in the plucking intervals for tea grown in different parts of the Lake Victoria basin.

Within East Africa, different tea yields are realised in the different regions. These yield differences could result from variations in environmental factors, management and/or agronomic inputs. Possibly, the uniform agronomic recommendations[1] currently used in tea production in the region may be limiting yields in some of the regions. Optimising agronomic practices in the different environments for maximum economic returns is therefore necessary. There is need to evaluate optimal nitrogen rates and plucking intervals in a single cultivar under uniform management in different regions within East Africa. Clone TRFK 6/8 is the most widely grown tea cultivar in East Africa, accounting for about 80% Rwanda tea, 60% of clonal tea in Kenya,[28] and 35% to 40% in Tanzania. The objective of this trial was to establish the effect of nitrogen rates and plucking frequency on the yields of clone TRFK 6/8 tea plants grown in different regions within East Africa.

Methodology

The trials were set up in three sites in Kenya (Timbilil Estate (Upper Kericho); Changoi Estate (Lower Kericho), and Sotik Tea Company (Arroket); two sites in Rwanda (Kitabi and Mulindi Estates); and three sites in Tanzania (Katoke Tea Estate and Maruku Agricultural Research Institute (Kagera Region), Ngwazi Tea Estate (Mufindi District) all in the Lake Victoria basin, except for the trial in Ngwazi Tea Estate which in southern Tanzania, the main tea growing region in Tanzania. The details of the sites are presented in Table 1.

The sites for the trial were carefully selected such that although the plants were at different ages, all the sites had mature tea of clone TRFK 6/8. Pruning cycle time affects both yields and quality.[29-32] Tea at each site was pruned between April and August 2008 so that all plants were in same pruning cycle life. Subsequently the plots were demarcated and uniformity test recording were conducted between July and September. First experimental treatments commenced in September/October 2008, depending on when there was adequate soil moisture at different sites in the respective countries. In subsequent years, the trials received fertilisers in September/October in single annual dose.

At each site, a 5 by 3 factorial experiment is laid out in a randomized complete block design and replicated 3 times. The main treatments are the 8 sites with nitrogen rates (0, 75, 150, 225 and 300 kg N ha^{-1} $year^{1}$ as NPKS 25:5:5:5) as a sub treatment and plucking frequency (7, 14 and 21 days intervals) the sub-sub treatment. A sub-sub plot comprises of 30 bushes of clone TRFK 6/8. The trials are analysed as 5 by 3 factorial split design for the 8 locations.

Table 1: Study sites coordinates

Country	Site	Latitude	Longitude	Altitude
Kenya	Timbilil Estate (TRFK)	0° 22'S	35° 21'E	2180 m amsl
	Changoi	0° 30' S	35° 13' E	1860 m amsl
	Sotik Tea	0° 36' S	35° 04' E	1800 m amsl
Rwanda	Kitabi	2° 32' S	29° 26' E	2231 m amsl
	Mulindi	1° 27' S	30° 01' E	1800 m amsl
Tanzania	Maruku Tea Estate (MTE);	1° 23′ S	31° 45′ E	1,488m amsl
	Katoke Tea Estate	1° 36′ S	31° 41′ E	1,217m amsl
	Ngwazi Tea Research station (NTRS)	8° 32′ S	35 ° 10′ E	1,840m amsl

Results and Discussion

The yield responses in 2008 are presented in Table 2. The Timbilil site was affected by poor recovery from prune following severe drought and hail damage after recovery between October and December 2008. As a result, there were no proper yield records. However, the responses of the clone TRFK 6/8 to NPKS 25:5:5:5 fertiliser rates and plucking intervals at the other seven sites during the period October to December 2008 are presented in Table 2.

Yields data for 2009, 2010 and mean annual yields for the two years are presented in Tables 3, 4 and 5, respectively. Despite the short recording period in 2008, there were significant ($P \leq 0.05$) yield differences arising from the sites of production. Nitrogen fertiliser rates only influenced ($P \leq 0.05$) yields in Ngwazi, Kitabi and Arroket. In previous studies, in Kenya,[33,34] there were no yields responses to nitrogenous fertiliser application in the first years after prune. Such lack of responses was observed in the other areas apart from the three. The variations in the responses demonstrated that even when one cultivar is subjected to same agronomic inputs, yields responses vary depending on location of production. Similarly, plucking intervals caused significant ($P \leq 0.05$) yield variations in Ngwazi, Maruku and Changoi. For the mean of the seven sites, the area of production and nitrogenous fertiliser rates caused significant ($P \leq 0.05$) yield variations. The patterns of the variations in response to plucking intervals changed with locations leading to significant ($P \leq 0.05$) interactions effects. However, the data was collected for only four months in 2008 due to pruning and may not warrant much emphasis. Indeed, in the year of prune, responses to agronomic inputs can be irregular.[21,33,34]

In 2009 and 2010, data were collected from all sites for twelve months. During 2009, the yields significantly ($P \leq 0.05$) varied with geographical area of production (Table 3). Significant ($P \leq 0.05$) responses were recorded due to rates of nitrogenous fertiliser at all sites except Maruku and Mulindi. Peak yields were recorded at different fertiliser rates and different sites, but generally best yields were obtained at the 225 kg N ha^{-1} $year^{1}$ rate The patterns of the variations in yield responses to nitrogenous fertiliser rates changed with location causing significant ($P \leq 0.05$) site and nitrogen rates interaction effects. There were also significant ($P \leq 0.05$) variations in yields due to plucking intervals in Kitabi, Arroket and Changoi, such that in Kitabi, highest yield was obtained at 7 days plucking intervals, while at Arroket and Changoi, maximum yields were realised at 21 days plucking intervals. These variations in responses patterns with locations caused significant $P \leq 0.05$) site by plucking interval interaction effects. For mean of all sites increasing nitrogenous fertiliser rates increased ($P \leq 0.05$) yields up to the 225 kg N ha^{-1} $year^{-1}$ rate, while, the 7 days plucking intervals produced the highest ($P \leq 0.05$) tea yields. Overall, the rates and extent of the responses to the nitrogenous fertiliser rates and plucking intervals varied with locations causing significant ($P \leq 0.05$) interaction effects between nitrogen fertiliser rates and plucking intervals.

In 2010 (Table 4), yields were significantly ($P \leq 0.05$) different depending on location of production. Sotik (Arroket), Changoi, and Kitabi realised very high yields while Mulindi and Katoke produced very low yields. During the year, significant ($P \leq 0.05$) yields responses were recorded for nitrogenous fertiliser rates at Katoke, Kitabi, Timbilil, Arroket and Changoi, and plucking intervals at Kitabi, Mulindi, and Changoi. Thus, all the three variables tested significantly changed. The magnitudes of the changes due to nitrogen fertiliser rates and plucking intervals varied with location consequently causing location of production and nitrogenous fertiliser rates and location of production and plucking intervals showed significant ($P \leq 0.05$) interaction effects. This demonstrates that the patterns and extents of responses to these agronomic inputs are not constant or uniform and change with environmental conditions of tea production. Changes similar to those observed in year 2009 and 2010 yields were observed in the mean data (Table 5) over the experimental period.

In all years, the sites produced different ($P \leq 0.05$) (Tables 2-5, Fig. 1) yields. Although farmers generally use cultivars with proven yields at the site of selection in the hope that such yields would be replicated in the new areas, the data presented herein demonstrate that the responses vary widely with locations. Using different clones[28,35] and clone BBK 35,[10,11,36] similar observations had been recorded in Kenya. Thus despite the belief that the geographical areas within which tea is grown in East Africa close to the equator (Table 1) where tea grows almost uniformly throughout the environmental conditions differences are large enough to cause significant differences in yields. These results suggest that it is necessary to re-evaluate tea clones in areas of intended production to establish clones which are adaptable to that environment before widespread cultivation. Tea is a perennial crop that once planted can have economic life of over 100 years. Use of wrong cultivar in a location therefore subjects the grower to perpetual low production. The data also reveal that

Table 2: Effects of nitrogen fertilizer rates, plucking frequencies and sites on mean yields (kg mt/ ha) 2008, Tanzania, Rwanda and Kenya

Site	Plucking Frequency	N-rates (KgN/ha/yr)					Pluck. Freq Mean	Site mean
		0	75	150	225	300		
Ngwazi	7	796	835	960	979	1050	924	1064
	14	1026	1184	1109	1161	1107	1117	
	21	960	1159	1266	1111	1254	1150	
	N-rates mean	927	1060	1112	1083	1137		
	C.V. (%)			14.2				
	LSD ($P \leq 0.05$)			198			237	
Maruku	7	990	1017	752	949	1079	957	797
	14	657	773	769	874	673	947	
	21	606	788	723	774	637	686	
	N-rates mean	750	826	748	865	796		
	C.V. (%)			22.93				
	LSD ($P \leq 0.05$)			NS			287	
Katoke	7	1076	949	1144	956	1247	1075	1115
	14	1076	1196	1171	1081	1275	1160	
	21	964	1198	1188	1100	1098	1109	
	N-rates mean	1039	1115	1168	1046	1207		
	C.V. (%)			18.81				
	LSD ($P \leq 0.05$)			NS			NS	
Kitabi	7	1089	1066	1200	1486	1415	1251	1329
	14	1120	1412	1351	1607	1489	1396	
	21	930	1143	1698	1597	1328	1339	
	N-rates mean	1046	1207	1416	1563	1411		
	C.V. (%)			17.97				
	LSD ($P \leq 0.05$)			313			NS	
Mulindi	7	777	884	1213	817	955	929	887
	14	1204	706	1029	676	800	883	
	21	767	864	625	888	1099	849	
	N-rates mean	916	818	956	793	951		
	C.V. (%)			39.97				
	LSD ($P \leq 0.05$)			NS			NS	
Arroket	7	2476	2620	2713	2704	2677	2634	2717
	14	2575	2702	2688	2941	2762	2734	
	21	2601	2796	2727	2958	2817	2780	
	N-rates mean	2551	2706	2709	2868	2852		
	C.V. (%)			7.01				
	LSD ($P \leq 0.05$)			249			NS	
Changoi	7	1566	1649	1673	1718	1758	1672	1644
	14	1749	1820	2018	1782	1801	1834	
	21	1546	1467	1179	1300	1631	1425	
	N-rates mean	1620	1645	1623	1600	1730		
	C.V. (%)			8.51				
	LSD ($P \leq 0.05$)			NS			219	
All 7 sites	7	1253	1289	1379	1373	1454	1349	1363
	14	1344	1399	1448	1446	1415	1439	
	21	1196	1345	1344	1390	1409	1334	
	N-rates means	1264	1340	1390	1403	1426		
	C.V. (%)			17.48				
	LSD , $P \leq 0.05$			98			NS	123

Interactions: SxN = NS, SxP = 190, NxP = NS, SxNxP = NS

Table 3: Effects of nitrogen fertilizer rates, plucking frequencies and sites on mean yields (kg mt/ha) 2009, Tanzania, Rwanda and Kenya

Site	Plucking Frequency	N-rates (KgN/ha/yr)					Pluck. Freq Mean	Site Mean
		0	75	150	225	300		
Ngwazi	7	3961	3403	3166	3689	4288	3702	3736
	14	3432	3876	3488	3481	3881	3632	
	21	3154	4071	3711	4145	4297	3876	
	N-rates mean	3516	3784	3455	3772	4155	-	
	C.V. (%)			13.3			13.3	
	LSD (P ≤ 0.05)			340			NS	
Maruku	7	2334	2493	1898	2758	2928	2482	2300
	14	1865	2183	2260	2580	2287	2235	
	21	1803	2373	2082	2630	2021	2182	
	N-rates mean	2001	2349	2080	2656	2412	-	
	C.V. (%)			19.2			19.2	
	LSD (P ≤ 0.05)			302			NS	
Katoke	7	4954	4486	5174	5912	5583	5222	5023
	14	4796	5292	4877	5451	5503	5184	
	21	4058	4352	5037	5315	4549	4662	
	N-rates mean	4603	4710	5029	5559	5212	-	
	C.V. (%)			14.4			14.4	
	LSD (P ≤ 0.05)			NS			NS	
Kitabi	7	4659	4384	4777	5965	5923	5142	4799
	14	3339	4328	4217	5409	4846	4428	
	21	4013	3369	5968	5892	4898	4828	
	N-rates mean	4003	4027	4987	5755	5223	-	
	C.V. (%)			14.5			13.9	
	LSD (P ≤ 0.05)			474			367	
Mulindi	7	2828	2963	3352	3012	3235	3078	2195
	14	2421	1848	2338	1810	2025	2089	
	21	1091	1605	1063	1414	1925	1420	
	N-rates mean	2113	2139	2251	2079	2395	-	
	C.V. (%)			26.3			26.3	
	LSD (P ≤ 0.05)			NS			305	
Timbilil	7	4803	5018	5444	5294	5470	5206	5069
	14	4469	4819	5059	5193	4969	4902	
	21	4742	5133	4887	5258	5482	5101	
	N-rates mean	4672	4990	5130	5248	5307	-	
	C.V. (%)			7.62			7.62	
	LSD (P ≤ 0.05)			264			NS	
Sotik	7	4674	5155	5171	5243	5666	5182	5382
(Arroket)	14	4906	5108	5563	5623	4917	5224	
	21	5162	5507	5615	6195	6229	5742	
	N-rates mean	4914	5257	5450	5687	5604	-	
	C.V. (%)			5.53			5.53	
	LSD (P ≤ 0.05)			203			157	
Changoi	7	5033	5430	5634	5141	5872	5422	5695
	14	4995	5350	5473	6059	5473	5470	
	21	5145	6060	5995	6891	6873	6193	
	N-rates mean	5058	5614	5700	6030	6073		
	C.V. (%)			10.2			10.2	
	LSD (P ≤ 0.05)			396			306	
All 8 sites	7	4156	4167	4327	4627	4871	4430	
	14	3778	4101	4159	4451	4238	4146	
	21	3646	4059	4295	4718	4534	4251	
	N-rates means	3860	4109	4260	4598	4548		
	C.V. (%)			13.72				
	LSD, P ≤ 0.05			136			105	172

Interactions: SxN =385, SxP = 298, NxP = NS, SxNXP = NS

Table 4: Effects of nitrogen fertilizer rates, plucking frequencies and sites on mean yields (kg mt/ha) in 2010, Tanzania, Rwanda and Kenya

Site	Plucking frequency	N-rates (KgN/ha/yr)					Pluck. Freq Mean	Site Mean
		0	75	150	225	300		
Ngwazi	7	3843	3606	3625	3676	3727	3695	3799
	14	3585	3982	3650	4041	3774	3806	
	21	3564	3923	4226	3753	4007	3894	
	N-rates mean	3664	3837	3834	3823	3836	-	
	C.V. (%)			9.52			9.08	
	LSD (P ≤ 0.05)			NS			NS	
Maruku	7	2370	2830	3180	2669	2661	2742	2677
	14	2589	2582	2943	2891	2554	2712	
	21	2494	2403	2402	3038	2548	2577	
	N-rates mean	2484	2605	2812	2866	2588	-	
	C.V. (%)			17.4			17.4	
	LSD (P ≤ 0.05)			NS			NS	
Katoke	7	1776	1685	1998	1979	1919	1871	1844
	14	1709	1618	1884	1864	1896	1794	
	21	1639	1775	1956	1942	2016	1866	
	N-rates mean	1708	1693	1946	1928	1944	-	
	C.V. (%)			10.4			10.4	
	LSD (P ≤ 0.05)			131			NS	
Kitabi	7	3920	4013	4644	5217	4926	4544	4315
	14	3089	4308	5051	4995	4780	4445	
	21	2949	2859	4912	4822	4243	3957	
	N-rates mean	3319	3726	4869	5011	4650	-	
	C.V. (%)			13.9			13.9	
	LSD (P ≤ 0.05)			411			318	
Mulindi	7	1563	1626	2078	1841	1810	1784	1354
	14	1188	1310	1327	1226	1379	1286	
	21	802	1032	924	938	1272	993	
	N-rates mean	1185	1322	1443	1335	1487	-	
	C.V. (%)			19.5			19.5	
	LSD (P ≤ 0.05)			NS			140	
Timbilil	7	3089	3355	3586	3631	3666	3466	3427
	14	2819	3237	3373	3573	3456	3292	
	21	3019	3097	3710	3859	3936	3524	
	N-rates mean	2976	3230	3556	3688	3686	-	
	C.V. (%)			7.7			7.7	
	LSD (P ≤ 0.05)			180			NS	
Sotik	7	5141	6038	6330	5878	6428	5963	6102
(Arroket)	14	5448	5566	6400	6924	6562	6180	
	21	5241	5916	5770	6587	7303	6163	
	N-rates mean	5277	5840	6167	6463	6764	-	
	C.V. (%)			6.77			5.53	
	LSD (P ≤ 0.05)			282			NS	
Changoi	7	4088	4559	4606	4832	4974	4612	4727
	14	4588	4678	5357	5438	5431	5098	
	21	3983	4138	4422	4761	5045	4470	
	N-rates mean	4220	4458	4795	5010	5150	-	
	C.V. (%)			10.5			10.5	
	LSD (P ≤ 0.05)			339			263	
All 8 sites	7	3224	3464	3756	3715	3764	3585	
	14	3127	3410	3748	3869	3729	3577	
	21	2961	3143	3540	3713	3796	3431	
	N-rates means	3104	3339	3681	3766	3763		
	C.V. (%)			13.65				
	LSD, P ≤ 0.05			112			87	141

Interactions: SxN = 316, SxP = 245, NxP =NS, SxNxP =NS

Table 5: Effects of nitrogen fertilizer rates, plucking frequencies and sites on mean yields (kg mt/ ha) Tanzania, Rwanda and Kenya

Site	Plucking frequency	N-rates (KgN/ha/yr)					Pluck. Freq Mean	Site Mean
		0	75	150	225	300		
Ngwazi	7	3686	3362	3326	3613	3885	3575	3686
	14	3448	3875	3534	3721	3755	3667	
	21	3291	3923	3944	3824	4096	3816	
	N-rates mean	3475	3720	3602	3719	3912		
	C.V. (%)			8.48			8.48	
	LSD (P ≤ 0.05)			NS			NS	
Maruku	7	2440	2717	2351	2799	2858	2633	2476
	14	2190	2402	2706	2812	2363	2494	
	21	2101	2441	2232	2602	2231	2301	
	N-rates mean	2244	2487	2430	2738	2484		
	C.V. (%)			13.4			522	
	LSD (P ≤ 0.05)			NS				
Katoke	7	3346	3052	3564	3693	3750	3481	3420
	14	3249	3474	3400	3598	3718	3488	
	21	2854	3139	3506	3680	3284	3292	
	N-rates mean	3150	3222	3490	3657	3584		
	C.V. (%)			10.94			NS	
	LSD (P ≤ 0.05)			490				
Kitabi	7	4143	4089	4552	5429	5256	4694	4467
	14	3234	4306	4551	5148	4764	4401	
	21	3382	2994	5391	5276	4487	4306	
	N-rates mean	3587	3796	4831	5284	4836		
	C.V. (%)			13.06				
	LSD (P ≤ 0.05)			763			NS	
Mulindi	7	2229	2346	2847	2430	2572	2485	1902
	14	2063	1656	2012	1591	1802	1825	
	21	1140	1500	1120	1388	1841	1399	
	N-rates mean	1811	1834	1993	1803	2072		
	C.V. (%)			25.23				
	LSD (P ≤ 0.05)			NS			754	
Timbilil	7	3946	4187	4515	4463	4569	4336	4249
	14	3645	4028	4216	4383	4213	4097	
	21	3881	4115	4298	4559	4709	4313	
	N-rates mean	3824	4110	4343	4468	4497		
	C.V. (%)			5.79				
	LSD (P ≤ 0.05)			322			387	
Sotik (Arroket)	7	5421	6038	6291	5882	6419	6010	6219
	14	5580	5837	6240	6825	6342	6165	
	21	5537	6331	6211	7044	7283	6481	
	N-rates mean	5513	6068	6247	6584	6681		
	C.V. (%)			6.83				
	LSD (P ≤ 0.05)			256			367	
Changoi	7	4426	4870	4907	5054	5313	4914	5037
	14	4818	4974	5545	5505	5207	5210	
	21	4582	4762	4807	5253	5531	4986	
	N-rates mean	4609	4869	5086	5270	5350		
	C.V. (%)			5.74				
	LSD (P=0.05)			378			454	
All 8 sites	7	3705	3833	4044	4170	4328	4016	
	14	3528	3819	4026	4198	4021	3918	
	21	3346	3651	3939	4203	4183	3862	
	N-rates means	3526	3763	4003	4191	4177		
	All sites mean	3932						
	C.V. (%)			11.7				
	LSD (P ≤ 0.05)			191			230	223

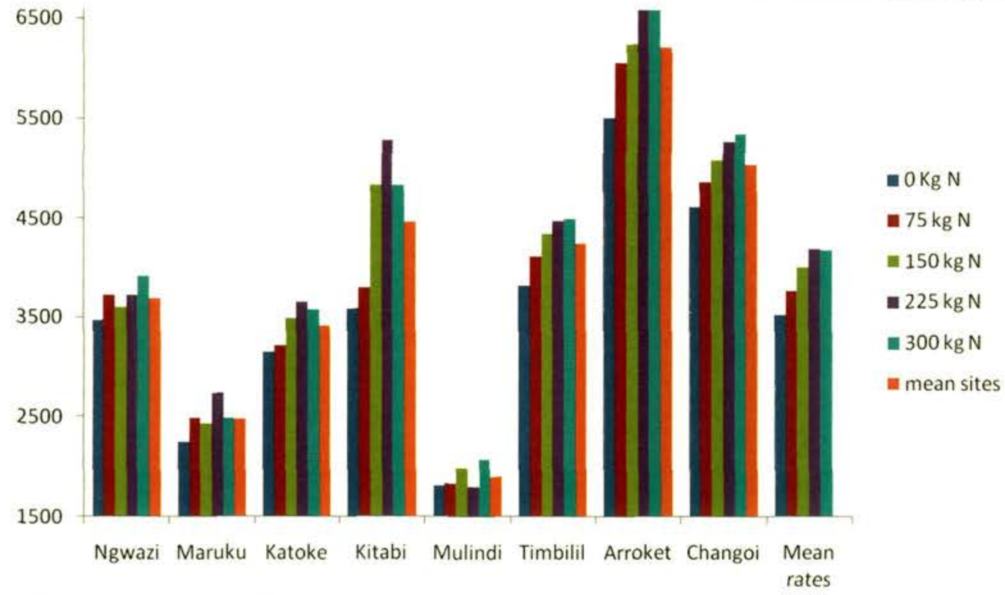

Fig. 1: Yields (kg made tea/ha/year) response nitrogenous fertiliser rates at different locations.

although some areas are suitable for growing tea within East Africa, due to variations in local climatic factors, yields can be variable. This is particularly when the tea is grown under rain fed conditions. Several sites in East Africa are prone to varying intensities of droughts, hail storms and temperatures. These factors can cause massive yield differences.[24] Indeed, although all tea growing areas met the minimum rainfall requirements of 1500 mm per annum,[1] the distribution is usually variable. Areas like Ngwazi in Southern Tanzania suffers prolonged droughts necessitating irrigation.[37,38]

Nitrogen is the most critical nutrient in tea production and several studies have demonstrated yield responses[4] even in Kenya.[20,21,39] Despite the short plucking duration in 2008, overall there was yield ($P \leq 0.05$) response to nitrogen fertiliser rates. Except for Mulindi where there was no significant response, clone TRFK 6/8 responded to nitrogen application in all locations, and intermittently in Ngwazi (Tables 2-5, Fig. 1). The recommended nitrogen fertiliser rates in Kenya vary from 100 to 250 kg nitrogen per hectare per year depending on yields.[2] This rate is adapted for use in most East Africa tea growing areas. Compared to the control, in this study, within this range there was significant ($P \leq 0.05$) response nitrogen all most areas except Mulindi. The 150 to 225 kg nitrogen per hectare per year appeared to be most suitable rates for application. However, the actual rates will vary from location to location since the extent of the response varied with locations. This range is within the recommended rate of nitrogen application. Thus although, the recommendation[1,2] was adopted without testing in different regions, it is nevertheless appropriate. However, the economic optimal level is expected to vary with location. Indeed, the actual appropriate rate for the different regions can only be determined upon performing economic analysis.

Contradicting yield responses to plucking intervals as those observed at different sites had been recorded in past studies using different cultivars at single locations. For example, with data recording of one year, yields were higher with longer plucking intervals in Malawi.[40,41] However, when recording was done for longer durations, yields declined with long plucking intervals in Kenya.[12,13,21,42,43] The observed differences between Kenya and Malawi could also have been due to variations in growing environmental conditions or differences in the cultivars used. However, data presented here demonstrate that when recording duration is similar, yield responses in the same cultivar under similar management changed from location to location. Thus, within East Africa different locations have different optimal plucking interval. The current uniform recommended plucking interval[1,2] may be subjecting some locations to low production. Although on the average short plucking interval produced highest ($P \leq 0.05$) (Fig. 2, Table 5), it is necessary to develop region specific plucking intervals for the realisation of high yields. These results suggest that growth rates at the various sites are different, and that the different regions need different plucking intervals to optimize the productivity. There were no significant interaction effects between plucking intervals and nitrogen fertilizer rates (Tables 2-5) suggesting that nitrogen fertilizer rates did not change the patterns of responses to plucking intervals.

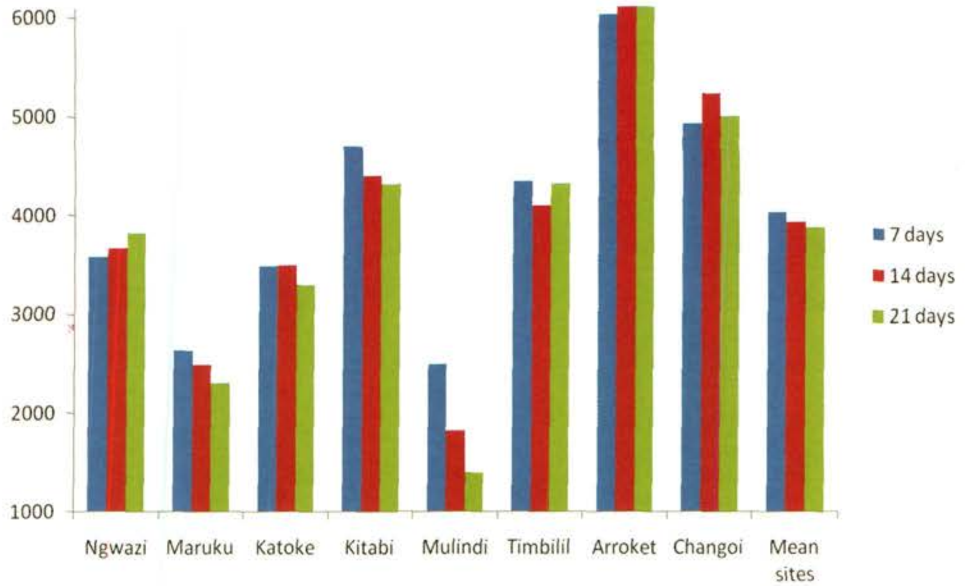

Fig. 2: Yields (kg made tea/ha/year) response toplucking intervals at different locations.

Generally, short term tea yield data can be misleading due to seasonal variations in growth rates. [25,26] Tea crop therefore needs a longer period of yield data recording for the results to be evaluated correctly. Indeed it requires long experimentation period of at least one pruning cycle (4 years) to get definitive yield results. These preliminary results presented here therefore may only show some trends and may only act as guides but cannot be used to formulate long term policy. These results need to be confirmed with longer experimental periods. However, it is usually very difficult to conduct long term trials in three different countries at sites far away from each other.

In conclusion, there were significant ($P \leq 0.05$) yield variations in one genotype subjected to similar management in different regions, implying genotypes should be tested in the intended areas of production before extensive planting. Significant interactions effects were recorded between rates of nitrogenous fertiliser and geographical area of production, demonstrating that extent of yield responses to nitrogenous fertilisers varied with location of production within East Africa. The blanket rate currently recommended for tea in Kenya and adopted in eastern African tea growing areas is inappropriate for all the growing areas. More trials are needed to develop location specific fertiliser use recommendations. There is a need to develop location specific agronomic recommendations to realise high yields and production of high quality black teas. Generally, short plucking intervals of 7 days produced high yields. But this also varied with location of production. Apart from yield benefits, improvement in tea quality have been demonstrated to arise from short plucking intervals,[11-13,36,44] even in clone TRFK 6/8 grown in a single location.[43] The data on yields alone may therefore not be the sole requirement for fixing a plucking interval. Area specific plucking intervals may help optimise production in different regions. Adoption of technologies in new areas without re-testing may be subjecting tea growers to low yields or inferior quality black teas with little profit margins. While cross border collaboration may be useful, production technologies developed in different countries need validation in the countries importing the technologies before they are adopted for general use.

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