TEA RESEARCH FOUNDATION OF CENTRAL AFRICA

Twin N as a source of nitrogen in tea

A project report for 2009/10 season

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Introduction

The industry spends considerable amounts of money on fertilizers each year because their cost prices are high. Transportation and application costs further increase the costs of utilising fertilisers.

Nitrogen is the main nutrient of all major elements required for tea production. It is usually applied three times per season and at higher rates than any other nutrients.

In Malawi and Zimbabwe, the cost of fertilizer has been increasing over the years. As prices of fertilizers continue to increase along with costs of transportation and application, growers may be faced with a hard choice of reducing the amount of fertilizer they buy and apply per unit area of a tea crop. This would reduce in the short and long term the health and productivity of tea bushes, which will threaten the viability of the tea industry and sustainability of tea production.

TWIN N has been reported a potentially less expensive source of nitrogen compared to the traditional sources of nitrogen. It supplies crop plants with natural form of nitrogen through the activity of endophytic and soil nitrogen fixing microorganisms. These interact with the plant metabolism system to fix atmospheric nitrogen in a form available to plants. Twin N is also reported to increase root growth, assist in solubilisation of phosphorus, increases production of photosynthetic sugar and improves efficiency of plant water use.. Twin N is further reported to increase the number of pseudomonad bacteria and manganese reducing bacteria which are important in increasing plant available manganese and other micronutrients (Mapleton International Pty ltd; 2008). Twin N can easily be applied through fertigation, overhead irrigation or as a foliar spray. When sprayed onto the leaf surface, or root zone, Twin N microbes are effectively absorbed by the plant via leaf stomata, leaf abrasions and lateral root cracks, diluting and multiplying through the plant via the vascular system.

A randomised block experiment with four replicates was set up in January 2010 at Nsuwadzi Tea Research Station and Makandi tea estate in order to test the effect of five combination of TWIN N with varying levels of urea on the yield and made tea quality of a mature SFS 204 cultivar bush and determine the optimum combination. The combinations were one application of TWIN with 0% (T1), 25% (T2), 50% (T3), 75% (T4) and 100% (T5) of the recommended nitrogen from urea, respectively, and zero TWIN N and 0% nitrogen from Urea (T6).The experimental plot size was 7.1m x 6.3m.

While Urea was applied in the traditional manner, TWIN N was prepared and applied as follows: a one TWIN N package that contained one vial of freeze dried microbes and a rehydration container of microbe food was filled with 50ml of clean water from a borehole and shaken to ensure a thorough microbes food and water mix. The vial used was enough for 1 hectare. The borehole water was assumed non-chlorinated as recommended. The mixture was thoroughly mixed with the freeze-dried microbes in the vial, allowed to stand for 4 hours at room temperature and emptied in a metal drum. 200 litres of water was added to the drum in order to have adequate volume of the mixture for spraying onto the plant foliage using a knapsack sprayer. The applications were done on 4 and 17 February 2010 at Makandi and Nsuwadzi respectively.

Yield, shoot-density, shoot-dry mass and made tea quality data were collected to measure the treatment effects. Before applying the treatments, two representative soil samples at 0-15 cm and 30-45 cm soil depths were collected and analysed for nutrients content at a laboratory in South Africa.

To monitor changes in the nutrient status in the leaves, third-leaf samples from 20 shoots were collected from each plot and analysed for the nutrient status at the same laboratory in South Africa.

Results

<u>Yield and yield components</u>

Made tea yield results at each treatment at Makandi and Nsuwadzi are presented in Table 11. 6

Yield did not significantly vary among combinations of TWIN N and Urea at Makandi and Nsuwadzi. One application of TWIN N combined with 75% of recommended N from Urea, equivalent to 206.25 kg/ha N, registered the highest yield compared with other combinations and the control, which registered the lowest yield at both sites.

Likewise, average shoot dry mass and shoot density was not affected by the fertiliser treatments at both sites

Table 11.6: Effect of TWIN N and Urea as nitrogen sources on made tea yield (kg ha^{-1}) of SFS 204 at Makandi and Nsuwadzi estates

Treatment	Makandi	Nsuwadzi
1 application of TWIN N + 0% recommended N from Urea	**1327**	**3333**
1 application of TWIN N + 25 % (68.75 kg N ha^{-1}) from Urea	**1407**	**3585**
1 application of TWIN N + 50% (137.5kg N ha^{-1}) from Urea	**1429**	**3585**
1 application of TWIN N + 75% (206.25 kg N ha^{-1}**) from** Urea	**1644**	**3791**
1 application of TWIN N + 100% (275kg N ha^{-1}) from Urea	**1535**	**3374**
No TWIN N + No Urea (control)	**1222**	**3135**
$LSD^{0.05}$	**409.7**	**639.9**
CV%	**19.0**	**12.4**

Made tea quality

Results of total taster's scores for the made tea and its valuation of six TWIN N and Urea fertiliser combinations at Makandi and Nsuwadzi are presented in Table 11.7.

There were neither significant differences in total scores and valuation of the made tea between different combinations of Twin N and Urea at both sites. Individual black tea quality parameters that contributed to the total score were brightness, briskness, colour of infusion, colour of liquor, colour with milk and strength of liquor. These did not differ among the treatments.

Table 11.7: Effect of TWIN N and Urea combination on total score and valuation by Tea Tasters of SFS 204 made tea at Makandi and Nsuwadzi in 2009/10 season

	Makandi		**Nsuwadzi**	
Treatment	**Total score**	**Valuation (US$$kg^{-1}$**	**Total score**	**Valuation (US$$kg^{-1}$**
1 application of TWIN N + 0% recommended N from Urea	19.98	189.8	19.84	183.9
1 application of TWIN N + 25 % (68.75 kg	19.89	189.7	19.27	183.0

N ha^{-1}) from Urea				
1 application of TWIN N + 50% (137.5kg N ha^{-1}) from Urea	20.78	190.3	19.66	188.3
1 application of TWIN N + 75% ((206.25 kg N ha^{-1}**) from** Urea	20.34	194.4	19.25	185.6
1 application of TWIN N + 100% (275kg N ha^{-1}) from Urea	20.69	197.5	18.73	185.2
No TWIN N + No Urea (control)	19.93	190.8	19.78	191.2
Mean	20.27	192.1	19.42	186.2
LSD $_{0.05}$	1.637	14.17	1.276	10.16
CV %	15.3	14.0	13.3	11.1

Table 11.8: Effect of TWIN N and Urea combination on brightness, briskness, colour of infusion, colour of liquor, colour with milk and strength of liquor of SFS 204 made tea at Makandi in 2009/10 season

Treatment	**Brightness**	**Briskness**	**Colour of infusion**	**Colour of liquor**	**Colour with milk**	**Strength of liquor**
1 application of TWIN N + 0% recommended N from Urea	1.731	**1.847**	4.535	4.000	**3.800**	**4.072**
1 application of TWIN N + 25 % (68.75 kg N ha^{-1}) from Urea	1.747	**1.893**	4.453	4.042	**3.752**	**4.005**
1 application of TWIN N + 50% (137.5kg N ha^{-1}) from Urea	2.063	**1.911**	4.524	4.067	**3.988**	**4.185**
1 application of TWIN N + 75% ((206.25 kg N ha^{-1}**) from** Urea	1.796	**1.991**	4.604	4.029	**3.838**	**4.078**
1 application of TWIN N + 100% (275kg N ha^{-1}) from Urea	1.639	**2.231**	4.454	4.227	**4.042**	**4.095**
No TWIN N + No Urea (control)	1.732	**1.865**	4.342	4.082	**3.865**	**4.044**
Mean	1.784	**1.956**	4.485	4.070	**3.881**	4.080
LSD $_{0.05}$	0.3793	0.3681	0.3532	0.3363	0.4139	0.2671
CV %	40.2	35.6	14.9	15.6	20.2	12.4

Table 11.8: Effect of TWIN N and Urea combination on brightness, briskness, colour of infusion, colour of liquor, colour with milk and strength of liquor of SFS 204 made tea at Nsuwadzi in 2009/10 season

Treatment	**Brightness**	**Briskness**	**Colour of infusion**	**Colour of liquor**	**Colour with milk**	**Strength of liquor**
1 application of TWIN N + 0% recommended N from Urea	1.813	**1.844**	4.281	4.000	**3.844**	**3.969**
1 application of TWIN N + 25 % (68.75 kg N ha^{-1}) from Urea	1.623	**1.719**	4.196	3.907	**3.849**	**3.971**
1 application of TWIN N + 50% (137.5kg N ha^{-1}) from Urea	1.641	**1.868**	4.225	3.934	**3.996**	**3.997**
1 application of TWIN N + 75% ((206.25 kg N ha^{-1}) **from** Urea	1.656	**1.750**	4.094	3.875	**3.844**	**4.031**
1 application of TWIN N + 100% (275kg N ha^{-1}) from Urea	1.364	**1.815**	4.029	3.889	**3.638**	**3.959**
No TWIN N + No Urea (control)	1.812	**1.813**	4.188	3.938	**4.094**	**3.938**
Mean	1.652	**1.801**	4.169	3.924	**3.877**	3.977
LSD $_{0.05}$	0.3469	0.2988	0.2973	0.2326	0.3641	0.1903
CV %	42.6	33.6	14.5	12.0	19.0	9.7

Soil properties at Makandi estate

There were no significant differences between treatments in most of the soil properties before treatment application in January 2010 except for sodium (Na) content, which ranged from 0.09 cmol/kg to 0.14 cmol/kg). Plots that received 1 application of TWIN N + 75% of the recommended N from Urea ((206.25 kg N ha^{-1}**)** had the highest content. Plots that received 1 application of TWIN N + 25 % of the recommended N from Urea (68.75 kg N ha^{-1}) had the lowest. This was not significantly different in other TWIN + Urea combinations.

Among the soil properties that were evaluated, significant differences were noted in carbon, calcium, potassium, and magnesium contents, and soil pH levels after treatment application. Results are presented in Figures 11.1a to 11.1e.

The soil pH levels were generally below the recommended level (i.e. below 4.5 -5.5) before treatment application and decreased after treatment application at this site (Fig. 11. 1.1a). The decrease was significantly different between treatments. The soil pH after application of No TWIN N + No Urea (control) (P= 0.032) was higher than the rest of the treatments.

Figure 11.1.1a-1r: **Soil properties at Makandi estate in 2009/10 season**

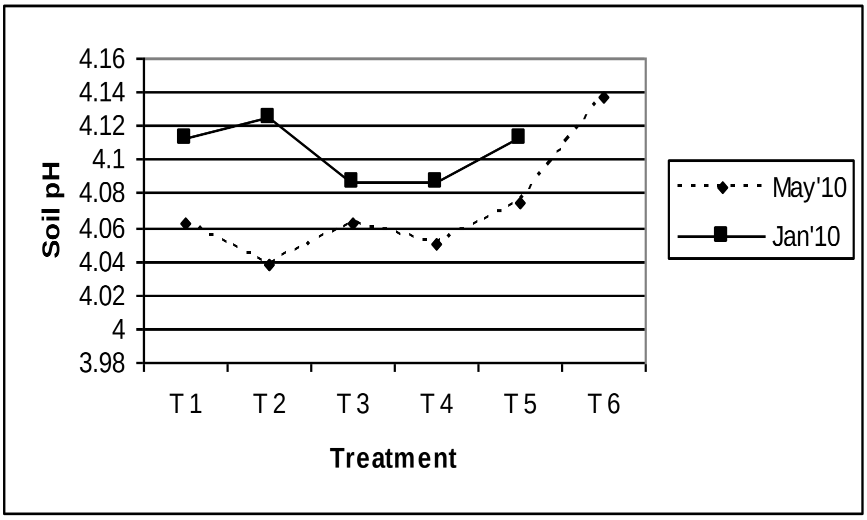

Figure 11.1.1a: Soil pH

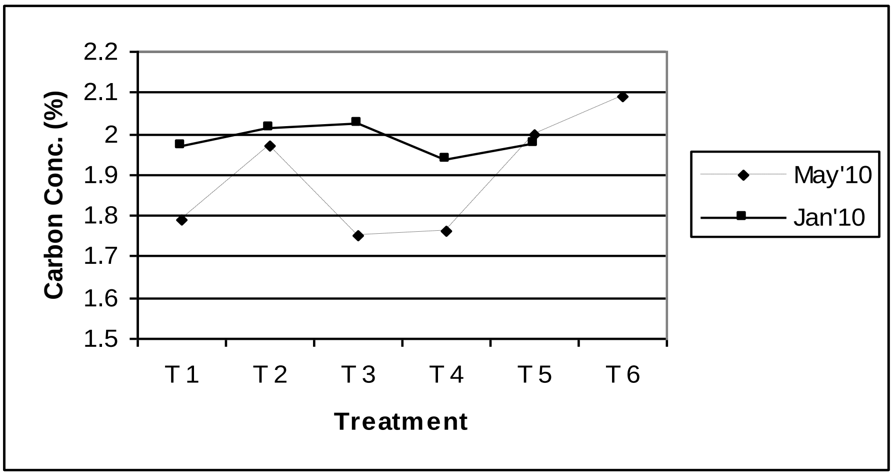

Figure 11.1.1b: Carbon

In the zero TWIN N and zero N from Urea treatment, carbon content was higher than in plots that received TWIN + Urea combination three and four (Figure 11.1.1b) suggesting the high inherent soil content of carbon.

Among the major nutrient elements N, P and K, only potassium was statistically different among treatments (P=0.015). Soils from the control treatments had the highest concentration similar to combination six had the highest content. Soils from treatment combination one had the lowest potassium concentration, comparable with combination three and four (Figure 11.1.1c).

Soil available forms of nitrogen, namely nitrate and ammonium, did not significantly vary with treatments. There was however some reduction in the level of ammonium in all treatments after applying the fertilizers while that of nitrate increased (results not presented).

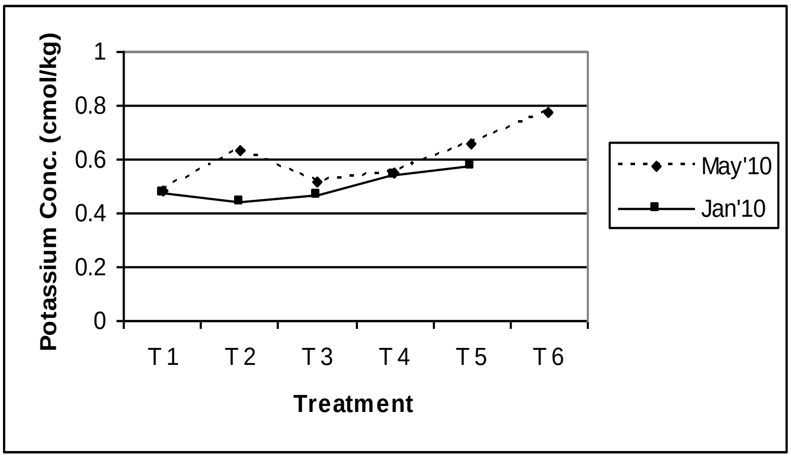

Figure 11.1.1c: Potassium

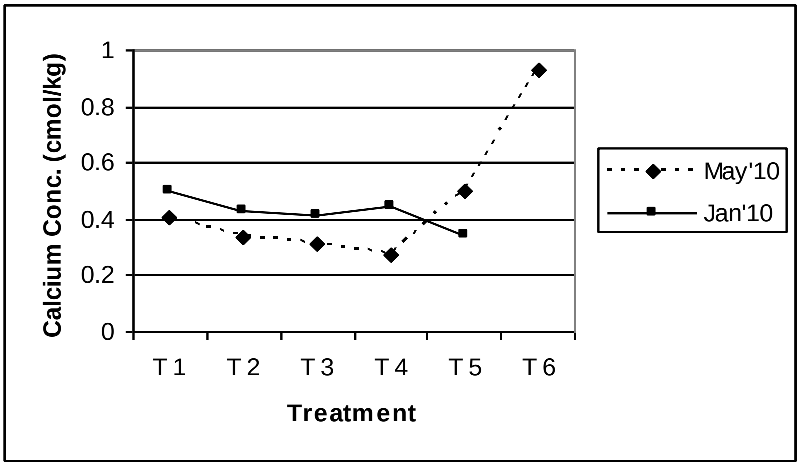

Figure 11.1.1d Calcium

Concentration of calcium and magnesium varied significantly among TWIN N and Urea treatment combinations (P <0.001 (Fig 11.1.1d and 11.1.1e). Soil content of the two elements was higher in combination six treatment than in others.

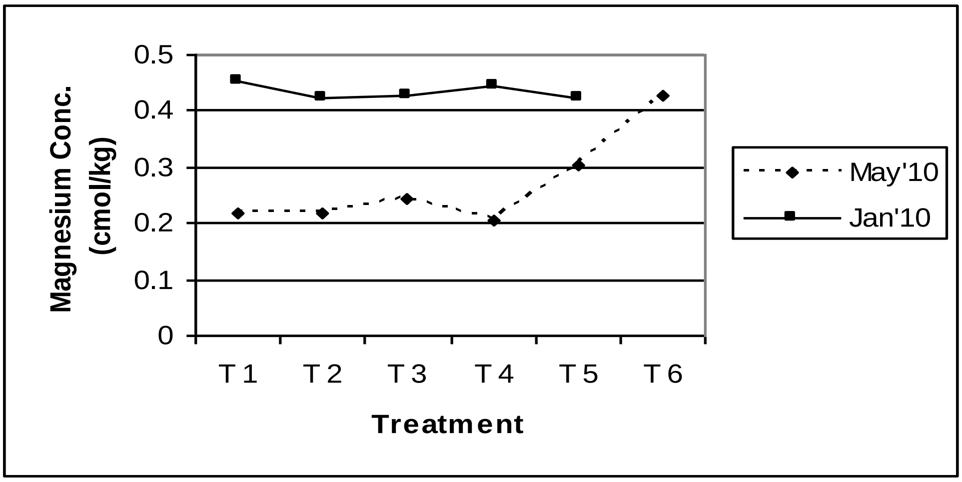

Figure: 11.1.1e Magnesium

Soil properties at Nsuwadzi Tea Research Station

Before treatments were applied, soil magnesium and calcium varied while the other elements were similar. Calcium and Magnesium soil contents were highest in treatment combination 3 (Figs 11.1.2 a and 11.1.2b).

Four months after treatments were applied (May 2010), there were differences in boron (P= 0.002) and magnesium (P= 0.048) (Figures 11.1.2d, 11.1.2b respectively). The rest of the soil properties remained the same across treatments Soil resistance also varied significantly across treatments (P= 0.004) (Fig. 11.1.2c). Differences in magnesium content after application of treatments were attributed to differences that already existed at the beginning of the trials.

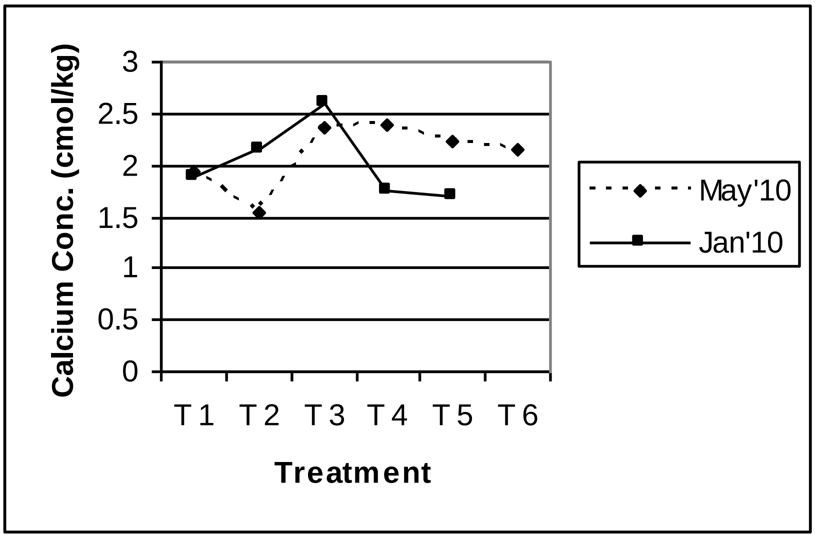

Figure 11.1.2 a Calcium

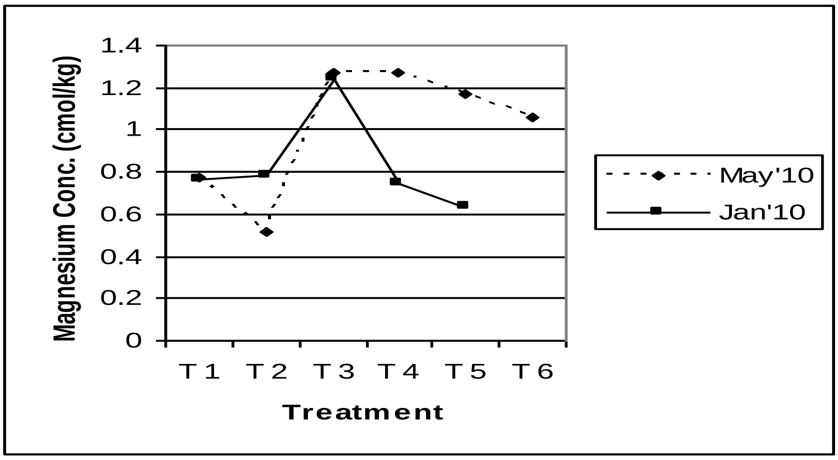

Figure 11.1.2b. Magnesium

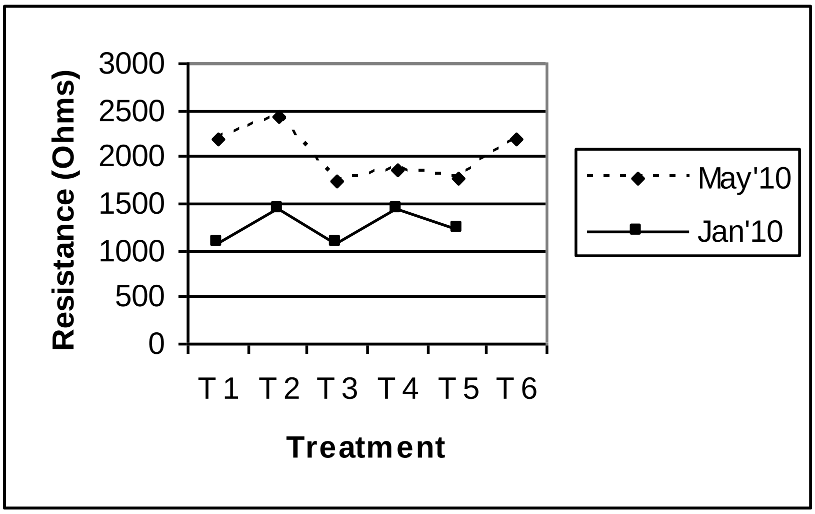

Figure 11.1:2c: Resistance

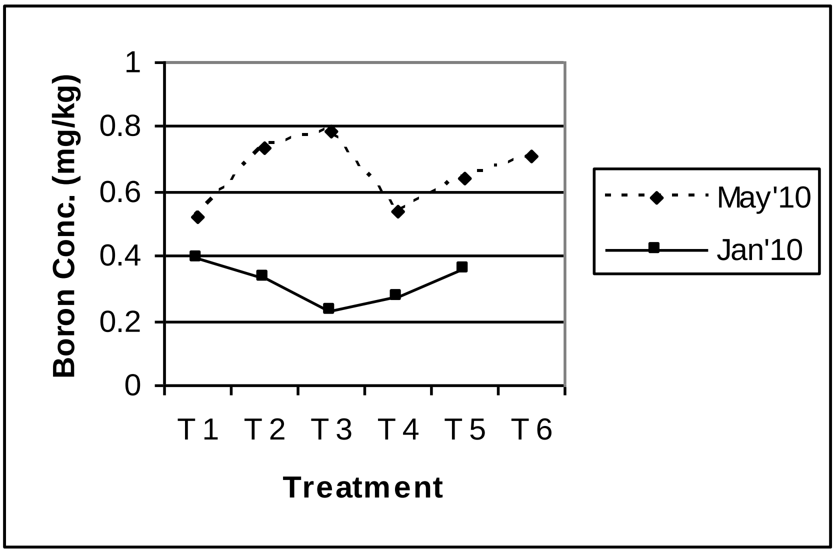

Figure 11.1:2d: Boron

N, P, K, S, Ca and Mg in tea leaves at Makandi tea estate

There were no significant differences in the concentration of N, P, K, S, Ca and Mg in tealeaves at Makandi estate. This indicates that these elements were not affected by the combinations of TWIN N and urea (Figure 11.1.3).

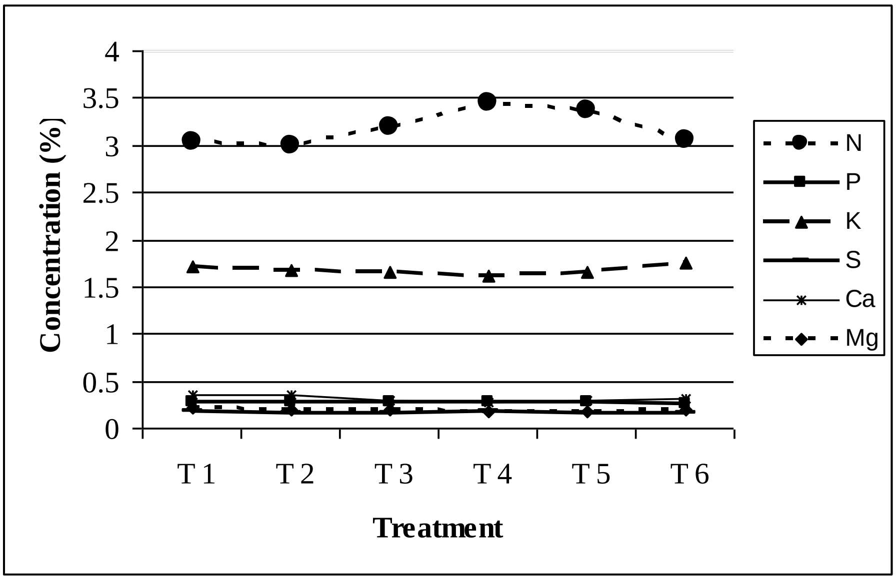

Figure 11.1.3: Concentration of N, P, K, S, Ca, and Mg in leaves of tea receiving different combinations of TWIN N and inorganic N at Makandi estate in 2009/11 season

At Nsuwadzi Research Station, nitrogen levels varied significantly (P=0.033) between treatments while levels of P, K, S, Mg, and Ca did not (Figure 11.1.2.2). Where TWIN N and 75% of the recommended N as Urea (T4) and where TWIN N and 100% of the recommended N as Urea (T5) were applied, respectively, N levels edged over the other combinations i.e. 3.7 % and 3.8 %, respectively. Where only TWIN N (T1) and where no TWIN N and no urea (T6) were applied, respectively, N levels were lowest i.e. 3.3% (Figure 11.1.4). Differences in leaf nitrogen levels between sites could have been due to differences in inherent characteristics of the two sites.

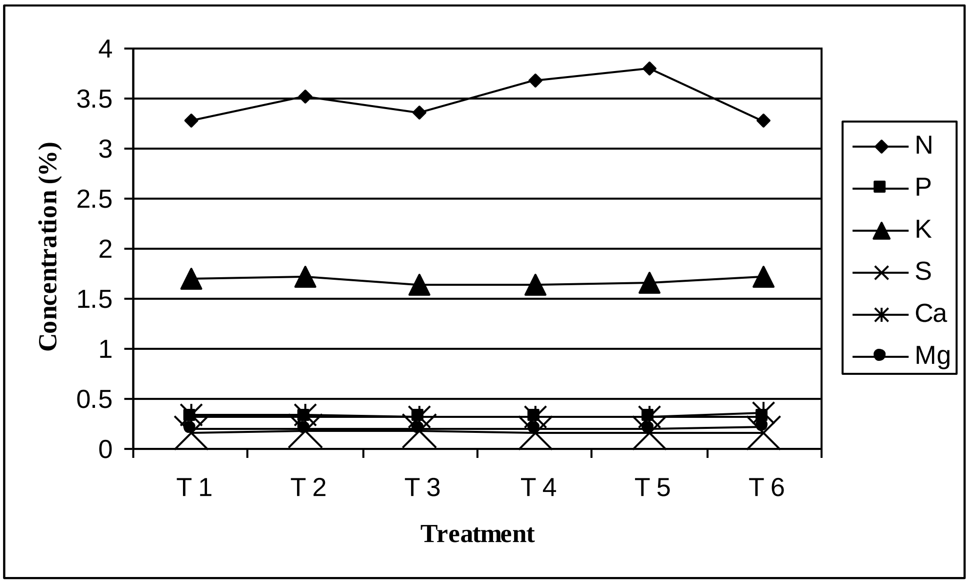

Figure 11.1.4: Concentration of N, P, K, S, Ca, and Mg in leaves of tea receiving different combinations of TWIN N and inorganic N at Nsuwadzi estate in 2009/11 season

Levels of molybdenum and sodium varied significantly among treatments at Makandi estate (Table 11.8) but not at Nsuwadzi (Table 11.9). Leaves from treatment 4 had the highest concentration of molybdenum while treatment 6 had the highest level of sodium. Other nutrient elements namely boron, chloride, copper, manganese, iron and zinc in the leaves did not differ at both sites.

Table 11.8: Levels of other nutrient elements in the leaves treated with different combinations of TWIN N and inorganic N at Makandi

	T 1	T 2	T 3	T 4	T 5	T 6	LSD $_{0.05}$	CV

								%
B mg/kg	28.5	30.8	27.5	28	28	27.3	2.477	5.8
Cl %	0.1	0.2	0.2	0.1	0.1	0.1	0.071	39.9
Cu mg/kg	10.8	10.8	11.5	12	12	11.8	1.336	7.7
Fe mg/kg	308	256	289	289	262	307	221.5	51.5
Mn mg/kg	972	996	792	866	810	729	247.0	19
Mo mg/kg	398	253	397	**549**	486	257	204.2	34.7
Na mg/kg	98.8	91	87	84	83.2	**135.5**	32.13	22.1
Zn mg/kg	22.5	19.8	21.8	20	22	19.5	6.699	21.2

Note: ns means not significant and N A means not applicable

Table 11.9: Levels of other nutrient elements in the leaves treated with different combinations of TWIN N and inorganic N at Nsuwadzi

	T 1	**T 2**	**T 3**	**T 4**	**T 5**	**T 6**	**LSD $_{0.05}$**	**CV%**
B mg/kg	33.8	33.2	29.3	33.8	32.5	36.0	7.51	15.1
Cl %	0.10	0.14	0.10	0.10	0.14	0.12	0.0808	46.3
Cu mg/kg	12.5	12.5	14.0	21.0	12.8	15.0	9.0	40.8
Fe mg/kg	289	167	703	789	204	467	705.6	106.9
Mn mg/kg	560	584	536	565	541	630	99.7	11.6
Mo mg/kg	1029	745	682	786	1134	787	655.3	50.5
Na mg/kg	49.5	49.8	38.5	40.5	37.8	54.8	21.3	31.3
Zn mg/kg	41	30	202	49	64	31	197.6	188.2

Note: ns means not significant

Cost benefit analysis

The cost benefit analysis was based on the assumption that all other factors of production were the same across treatments except the cost of procuring the fertilizers and that of application. Results on profit realized from the treatments are presented in Table 11.10.

Table 11.10: Profit realized from teas that received different combinations of TWIN N and urea

Treatment	Location	T1	T2	T3	T4	T5	T6
Yield (kg/ha)	Makandi	1,327	1,407	1,429	1,644	1,535	1,222
	Nsuwadzi	3,333	3,585	3,285	3,791	3,374	3,135
Valuation (Usc/kg)	Makandi	189.80	189.70	190.30	194.40	197.50	190.80
	Nsuwadzi	183.90	183.00	188.30	185.60	185.20	191.20
Income/ha Usc	Makandi	251,864.60	266,907.90	271,938.70	319,593.60	303,162.50	233,157.60
	Nsuwadzi	612,938.70	656,055.00	618,565.50	703,609.60	624,864.80	599,412.00
Income/ha (USD)	Makandi	2,518.65	2,669.08	2,719.39	3,195.94	3,031.63	2,331.58
	Nsuwadzi	6,129.39	6,560.55	6,185.66	7,036.10	6,248.65	5,994.12
Expenditure on fertilisers /ha (USD)	Makandi	58.00	153.80	243.80	333.80	423.80	-
	Nsuwadzi	58.00	153.80	243.80	333.80	423.80	-
profit (USD)	Makandi	2,460.65	2,515.28	2,475.59	**2,862.14**	2,607.83	2,331.58
	Nsuwadzi	6,071.39	6,406.75	5,941.86	**6,702.30**	5,824.85	5,994.12

Note: Calculations provided for in Appendix 1.

This analysis shows that Treatment 4, whereby a single application of TWIN N plus 75% of recommended N applied as urea, was more profitable than the rest of the treatments at Makandi and Nsuwadzi estates with a profit of US$ 2,862.14 and US$6,702.30 respectively.

Conclusion

Combining TWIN N and Urea as nitrogen sources did not affect made tea yield and made tea quality and valuation. Nevertheless, the benefit cost analysis suggested that a combination of TWIN N plus 75% of the recommended nitrogen from urea could be more profitable than any other combination thus maybe the optimum combination.

Soil properties that were affected by the fertiliser combinations include potassium, carbon content, calcium, magnesium, and boron and soil resistance. There was a preferential uptake of nitrogen at Nsuwadzi where TWIN N was applied with 75% and 100% of required nitrogen. These results will be followed up in the next two years of the experiment.