Tea Research Foundation Central Africa

TwinN as source of nitrogen in tea

Abstract

Field experiments, which were set up in 2010 at Nsuwadzi tea research station in Mulanje and Makandi tea estate in Thyolo to establish yield and quality response of SFS 204 to application of TwinN and urea as sources of nitrogen and to determine the combination of TwinN and urea that would produce optimum yield and quality of tea, continued to be monitored. The trials were set up in January 2010 and the treatments were: Twin N, TwinN plus 25% of inorganic N, TwinN plus 50% of inorganic N, TwinN plus 75% of inorganic N, TwinN plus 100% of inorganic N, Zero N and 100% of inorganic N. TwinN was applied as a foliar spray and urea was used as the inorganic N source. In 2011/12, there were significant differences in yield among treatments at both sites. Yield was significantly higher when TwinN was applied in combination with inorganic N at 75% and 100%. TwinN applied alone produced significantly lower yield which was similar to yields obtained from the zero nitrogen treatment. In 2011/12 season, at Makandi, highest valuation was obtained from tea harvested from plots which received TwinN alone, TwinN plus 25% urea and TwinN plus 50% urea. Treatments that received nitrogen rates higher than 50% of the recommended N had a reduced value. Treatments that received no nitrogen also had a reduced value. When TwinN was applied alone, the value of made tea was significantly higher than where the standard application of nitrogen was done. At Nsuwadzi, there was a marginal difference in valuation of made tea but generally the value was significantly higher where TwinN and TwinN plus 25% of inorganic N were applied with the rest of the treatments similar to the standard N application. Net returns taking into account yields, tea values and fertiliser plus TwinN costs showed that TwinN plus 75%N gave the highest increases in net returns at both sites. At Makanda the increase was $352/ha (+11%) and at Nsuwadzi the increase in net return was $1125/ha (+21%), compared to the standard N program alone. These increases in net return were mainly due to increased yields.

Introduction

The industry spends a considerable sum of money on fertilizers each year. This is due to high prices of fertilizers, its transportation and application costs (Limwado, 1995). Of all the nutrients required by tea, nitrogen is the main nutrient and is usually applied at rates several times greater than any other nutrients required by tea. This suggests that use of efficient and cost-effective sources of N is essential for economic production. Limwado, (1995) suggested that in tea, when planning for fertilizer requirement, the aim should be to consider means of reducing the target cost by any suitable means available such as use of high analysis grades of fertilizer which are cheaper and adopting better and cost-effective methods of application.

In central Africa (Malawi and Zimbabwe), the cost of fertilizer has been increasing over the years. As the prices of fertilizers continue to skyrocket along with costs of transportation and application, growers may be faced with a hard choice of reducing the amount of fertilizer they buy thereby reducing nutrient input per unit area. This would have serious short- and long-term implications on the health and productivity of tea bushes and consequently viability and sustainability of tea production. In order to counter these challenges, there is need to identify and assess various sources of nitrogen and other nutrients that can be used economically and sustainably. An experiment was conducted on TwinN as a source of nitrogen in tea which started in January, 2010.

Objectives

The objectives of the experiment were to establish yield and quality responses of mature clonal tea to application of TwinN and urea as sources of nitrogen, and to determine the combination of TwinN and urea that would produce optimum yield and quality of tea.

Materials and Methods

Study sites

Two trials were set up at Makandi tea estate in Thyolo and Nsuwadzi Tea Research Station in Mulanje on mature SFS 204.

Experimental design and treatments

There were seven treatments and the description of the treatments is provided in Table 11.1.

Table 11.1 Details of fertilizer treatments at Makandi and Nsuwadzi

Trt. No	Description
T 1	1 application of TwinN + no Urea
T 2	1 application of TwinN + 25 % of recommended N (68.75 kg/ha N)
T 3	1 application of TwinN + 50% of recommended N (137.5kg/ha N)
T 4	1 application of TwinN + 75% of recommended N (206.25 kg/ha N)
T 5	1 application of TwinN + 100% of recommended N (275kg/ha N)
T 6	No TwinN applied + zero N
T 7	No TwinN + 100% of recommended N (275kg N /ha) (Standard practice)

The treatments were arranged in a Randomized Complete Block Design (RCBD) with four replicates. Each plot had an area 0.004473ha.

Application of TwinN and other fertilisers

Preparation and application of TwinN Mixture

One TwinN package, which contained 1 vial of freeze dried microbes and a rehydration container of microbe food, was used at each site. The rehydration container was filled with 50ml of clean water from a borehole (chlorinated water is unsuitable) and was shaken to ensure that the food for the microbes is thoroughly mixed with the water. The mixture of water and food for the microbes was thoroughly mixed with the freeze dried microbes in the vial. The mixture was then allowed to stand for 4 hours at room temperature. After 4 hours, 200litres of non-chlorine water was added to the mixture in a drum and the resultant mixture was applied on the plant foliage using a knapsack sprayer. The applications were done on 6 and 7 February, 2012 at Makandi and Nsuwadzi respectively.

Application of inorganic fertilisers

Required quantities of urea for each treatment were calculated and applied. Phosphorus and potassium were applied at recommended rates of 55kg ha^{-1} and 92kg ha^{-1}, respectively using Monoammonium phosphate and Muriate of potash as sources of P and K, respectively.

Application rates for P and K were the same for all treatments. These were applied to the plots on 6 and 7 February, 2012 at Makandi and Nsuwadzi respectively.

Soil and leaf sampling for nutrient analysis

Soil and leaf samples at Makandi and Nsuwadzi were collected in October 2011. Soil samples were randomly collected from the trial plots using a stainless steel soil auger as described by Grice (1990). Cores were taken from 0-15 cm and 30-45 cm depths. Both leaf and soil samples were not sent to ARET for analysis as ARET was still analyzing TRFCA samples that were collected during 2010/11 season.

Yield and yield components (made tea yield, shoot density and shoot dry mass)

Harvesting was done by hand plucking on every 10th or 11th day at both sites during the main growing season and plucking round was extended to 14 or 21 days during the lean periods depending on the shoot growth rate. On each plucking day, mass of plucked leaf from each plot was recorded and expressed as made tea yield by multiplying the green leaf yield by a factor of 0.22.

Shoot density was determined by using a 0.75 m by 1.2 m square grid, which was thrown randomly on the plucking table at three positions in each plot. Different shoot categories were counted at each position and the number of shoots per m^2 was calculated. This was performed once a month.

Once in a month, a sample of green leaf weighing 200g was collected from each treatment plot. From the sample, different shoot categories were separated as follows: 1L+bud, 2L+bud, 3L+bud, 4L+bud shoots. Number of shoots for each shoot category and their fresh masses were recorded and the shoots were placed in a labeled envelope for drying. The shoots were oven dried at temperatures between 65^{o}C and 85^{o}C for 48 hours after which their dry masses were recorded. Average shoot mass was then calculated for each category of shoots.

Determination of black tea quality by sensory evaluation

A sample weighing 300g of green leaf plucked from each of the trial plots was collected once a month from the seven treatments and four replicates. Each sample was processed separately into black tea in the Mini Processing Unit at Tea Research Foundation of Central Africa (TRFCA).

From each of the black tea samples, 50g black tea sample from each plot was sent to Tea Brokers of Central Africa (TBCA) for sensory evaluation by tea tasters. Black tea quality parameters assessed by tea tasters included: brightness, briskness, colour of liquor, colour of infusion, colour with milk and strength of liquor. A scoring scale of 1 to 10 is used by the tea tasters for each parameter, 1 being the lowest score and 10 the highest (Clowes&Mitini –Nkhoma, 1987).

Statistical analysis

All data was subjected to analysis of variance using GENSTAT statistical package. Treatment means were separated using the Duncan's Multiple Range Test (DMRT) at $p<0.05$ level of significance.

Results and Discussion

Yield, shoot dry mass and shoot density

During the season, there were highly significant differences in yield among treatments. Yield results for Makandi and Nsuwadzi are presented in Tables 11.2 and 11.3.

Table 11.2 Effect of TwinN and urea on made tea yield (kg ha^{-1}) at Makandi Estate

Trt	Details	2009/10 (Feb to Jun 2010)	2010/11	2011/12	2009/10- 2011/12
T 1	TwinN + zero Urea	1327	2700	1880	1969
T 2	TwinN + 25% N 68.75 kgN/ha	1407	2716	2026	2050
T 3	TwinN + 50% N 137.5kgN/ha	1429	2880	2165	2158
T 4	TwinN + 75% N 206.25 kgN/ha	1644	3653	2331	2543
T 5	TwinN + 100% N 275kgN /ha	1535	3537	2574	2548
T 6	No TwinN + zero urea	1222	2256	1626	1701
T 7	No TwinN + 100% N 275kg N/ha	-	2752	2009	2381
Mean		**1427**	**2928**	**2087**	**2193**
LSD		**409.7**	**556.4**	**256.1**	**324.5**
P value		**0.355**	**<0.001**	**<0.001**	**<0.001**
CV (%)		**19.0**	**12.8**	**8.3**	**10.0**

Table 11.3 Effect of TwinN and urea on made tea yield (kg ha^{-1}) at Nsuwadzi Research Station

Trt	Details	2009/10 (Feb to Jun 2010)	2010/11	2011/12	2009/10- 2011/12
T 1	TwinN + zero Urea	3333	2947	2594	2958
T 2	TwinN + 25% N 68.75 kgN/ha	3585	3889	3009	3494
T 3	TwinN + 50% N 137.5kgN/ha	3285	3643	3296	3408
T 4	TwinN + 75% N 206.25 kgN/ha	3791	4375	4093	4087
T 5	TwinN + 100% N 275kgN /ha	3374	4609	4202	4061
T 6	No TwinN + zero urea	3135	3150	2503	2929
T 7	No TwinN + 100% N 275kg N/ha	-	3316	3053	3185
Mean		**3417**	**3704**	**3250**	**3446**
LSD		**639.9**	**886.0**	**744.2**	**696.7**
P value		**0.349**	**0.007**	**<0.001**	**0.009**
CV (%)		**12.4**	**16.1**	**15.4**	**13.6**

There were highly significant differences in made tea yield among the treatments at Makandi and Nsuwadzi during the season. Applying a combination of TwinN plus 75% and 100% of the recommended nitrogen as urea gave the highest yields at both sites and significantly higher yields than those obtained from where urea was applied alone at the N recommended rate (275kg ha^{-1}). The lowest yields were obtained from where no nitrogen was applied signifying detrimental effects on the productivity of the tea bush when a complete withdrawal of nitrogen was done. Yields obtained from where TwinN was applied alone were not significantly different from where no nitrogen was applied. This also indicates that the microbes contained in TwinN when TwinN is used on its own, cannot supply enough nitrogen that would meet the requirements of the tea bush. Average yields for the three years also show similar trends in yield as obtained in 2010/11 and 2011/12 seasons. This signifies that TwinN should not be applied on its own.

Average shoot dry mass of 1L+b, 2L+b, 3L+b and 4L+b shoots was not significantly affected by the different treatments at both sites. Shoot density however was significantly affected by the treatments at Makandi (P= 0.007) as well as at Nsuwadzi (P= 0.018) (Figures 11.1 and 11.2).

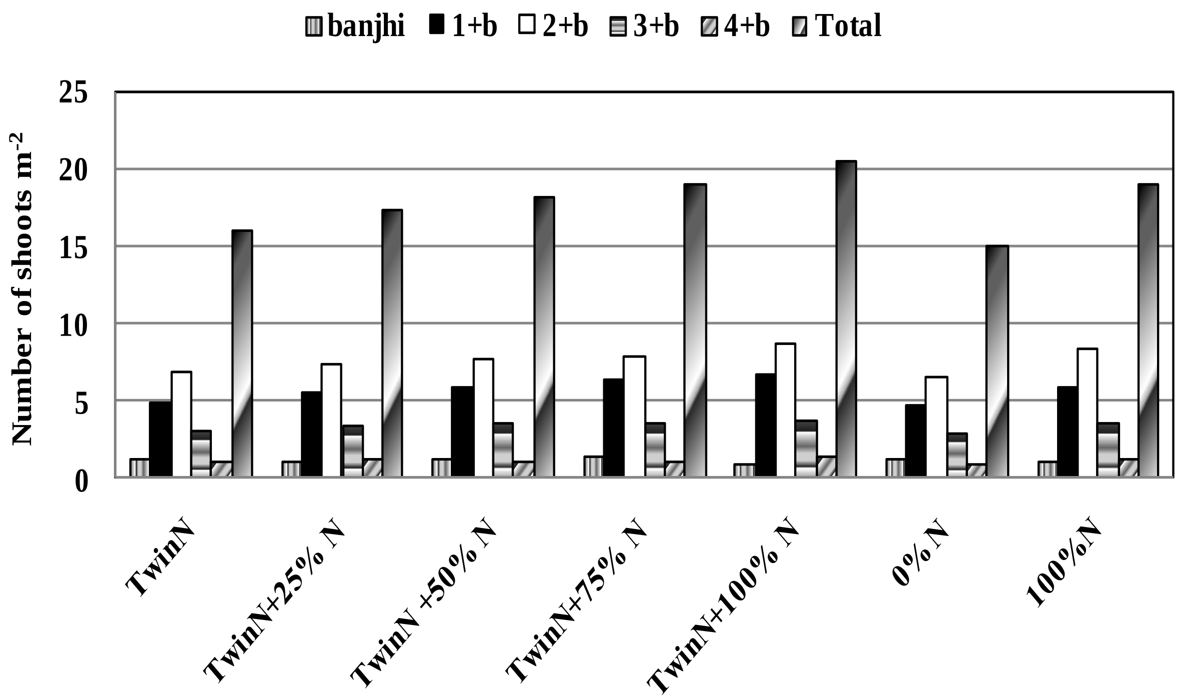


Figure 11.1 Effect of TwinN and Urea on shoot density at Makandi estate

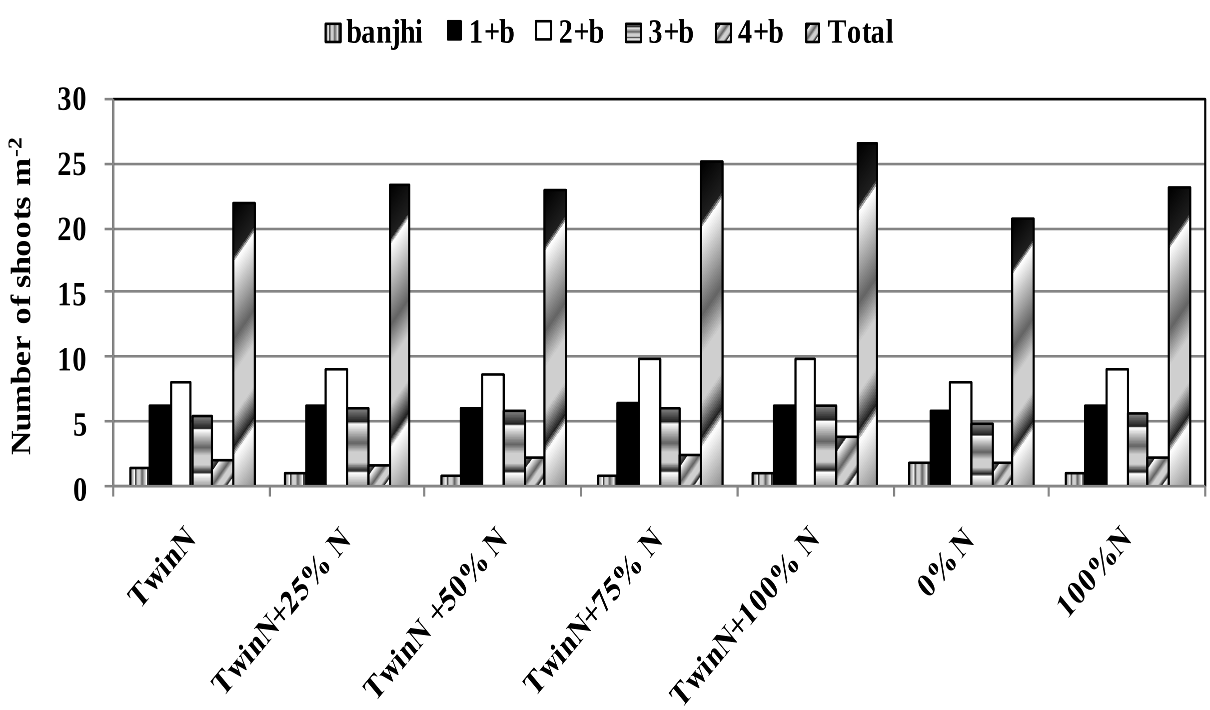


Figure 11.2 Effect of TwinN and Urea on shoot density at Nsuwadzi Research Station

Applying TwinN and 100% of inorganic nitrogen as urea produced the highest number of pluckable shoots m^{-2} both at Makandi and Nsuwadzi but was not significantly different from where TwinN was applied in combination with 75% of inorganic nitrogen as urea and where urea was applied alone at the standard nitrogen application rate. The lowest number of shoots m^{-2} was produced from where no nitrogen was applied which did not differ from where TwinN was applied alone. This suggests that applying TwinN alone in tea does not increase shoot density and hence yield i.e. application of TwinN alone is as good as not applying any nitrogen, as the amount of nitrogen supplied by TwinN does not meet the requirements of mature tea. Therefore, use of TwinN alone in tea as a source of nitrogen is not recommended as it leads to a significant yield loss.

Made Tea Quality

Results on made tea quality as affected by the different treatments at Makandi and Nsuwadzi are presented in Table 11.4.

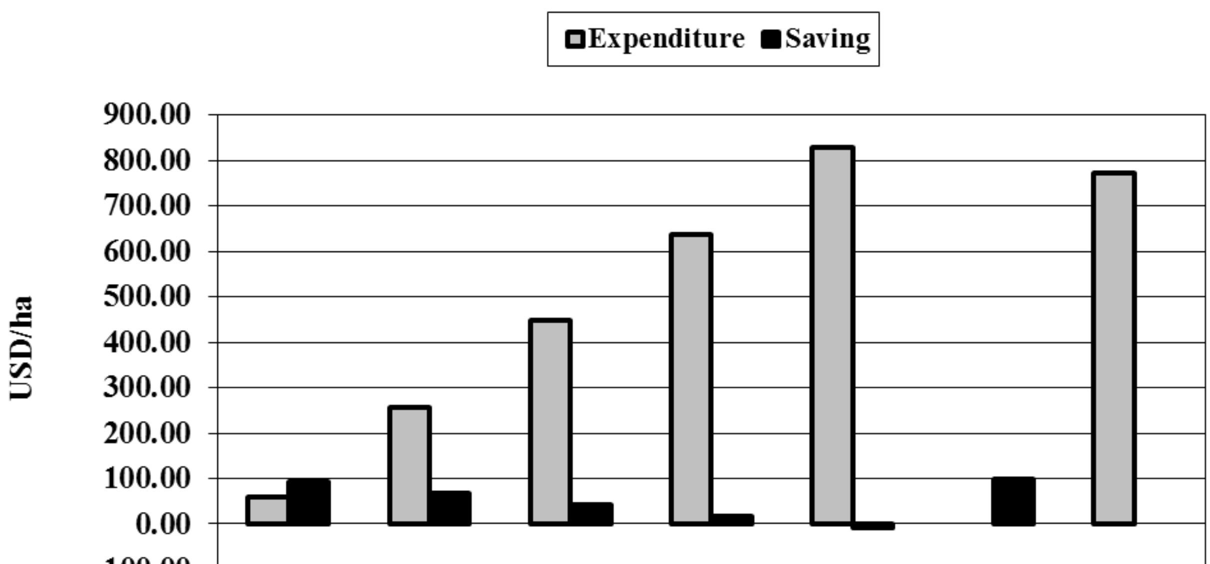
Table 11.4 Tasters' total scores and valuation at Makandi and Nsuwadzi

Trt. No	Description	Makandi		Nsuwadzi	
		Total score	Valuation (USc kg^{-1})	Total score	Valuation (USc kg^{-1})
T 1	TwinN + zero Urea	16.26	154.6	18.04	172.5
T 2	TwinN + 25% N 68.75 kgN/ha	16.04	153.2	17.86	172.1
T 3	TwinN + 50% N 137.5kgN/ha	15.50	148.6	17.39	166.8
T 4	TwinN + 75% N 206.25 kgN/ha	14.44	134.5	16.18	155.7
T 5	TwinN + 100% N 275kgN /ha	13.86	132.1	15.07	143.6
T 6	No TwinN + zero urea	14.21	128.9	16.08	158.3
T 7	No TwinN + 100% N 275kg N/ha	13.96	129.6	16.77	165.0
Mean		**14.90**	**140.2**	**16.77**	**162.0**
LSD		**1.094**	**12.79**	**1.804**	**18.83**
P value		**<0.001**	**<0.001**	**0.029**	**0.051**
CV (%)		**4.9**	**6.1**	**7.2**	**7.8**

Taster's total score and valuation were affected significantly by the treatments at Makandi while at Nsuwadzi total score was significantly affected by the treatments and there was a marginal significant difference in valuation among the treatments. At Makandi, highest valuation was obtained from tea harvested from plots which received TwinN alone, TwinN plus 25% urea and TwinN plus 50% urea. Treatments that received nitrogen rates higher than 50% of the recommended N had a reduced value. Treatments that received no nitrogen also had a reduced value. When TwinN was applied alone, the value of made tea was significantly higher than where the standard application of nitrogen was done. This may suggest that TwinN improves the quality of black tea while a complete withdrawal of nitrogen application in tea has detrimental effects on the value of made tea. It may also entail that the nitrogen supplied by TwinN is within the ranges not detrimental to the quality of black tea.

Expenditure incurred in different treatments

While holding all other factors constant (*Ceteris Paribas*), the cost of urea, TwinN and the application cost of each of these in the different treatments was calculated and results are presented in Figure 11.3.



	TwinN	TwinN+25%	TwinN+50%	TwinN+75%	TwinN+100%	No N	100%N
Expenditure	58.20	255.90	447.21	638.51	829.82	0.00	771.62
Saving	92.46	66.84	42.04	17.25	-7.54	100.00	0.00

Figure 11.3 Expenditure on fertilisers

Obviously, there was no expenditure on nitrogen incurred where nitrogen was not applied but due to the decline in yield observed when there was a complete withdrawal of nitrogen in tea, nitrogen application in tea is highly recommended.

The cost of buying and applying TwinN is generally lower than the cost of buying and applying Urea. There is a saving of 92% when TwinN is applied alone compared to the standard application. It has been observed that TwinN on its own cannot supply enough nitrogen to cause a significant yield increase in tea, therefore use of TwinN as a sole source of nitrogen may not be effective. Hence, the 92% saving may not be seen as a true saving on fertilizers.

The maximum expenditure on fertiliser is incurred when 100% of recommended nitrogen is applied as urea plus TwinN thus by adding TwinN to the standard application, there is an increase in cost of about 8%. However, there was a saving of 17% when 75 % of recommended nitrogen was applied as urea plus TwinN. Due to the fact that yield obtained from a combined application of TwinN and 75% of recommended nitrogen applied as urea was significantly higher than where a standard application of urea was made, and that there was actually a saving of 17%, this treatment may be recommended to growers.

Cost-benefit analysis

The tea industry faces challenges in maintaining profitability and all production technologies need to be assessed on their effects on net returns. The different treatments produced differences in yield, value per kg and costs of urea fertiliser/TwinN. The following two tables (Tables 11.4 and 11.5) summarise the effect of these changes on net cost-benefit from each treatment at both sites. At Makandi TwinN plus 75%N gave a $352/ha (11%) increased net return while TwinN plus 100%N gave a $273/ha (9%) increased net return. Removal of all urea and TwinN gave a decrease of $793/ha (-26%) in net return. At Nsuwadzi all the TwinN treatments gave increased net returns over the standard 100%N, with TwinN plus 75%N giving the largest gain of $1125/ha (21%). This was mainly achieved via increased yield.

Table 11.5 Cost-benefit analysis at Makandi

Treat No.	Treatment	2012 Yield Kg/ha [1]	Value US$/kg [2]	Value US$/ha [3]	Net saving on fertiliser & TwinN US$/ha [4]	**Net return $/ha [5]**	**Increased returns $/ha**
1	TwinN + zero Urea	1969	1.55	3044	92	**3137**	**51 (+2%)**
2	TwinN + 25% N 68.75 kgN/ha	2050	1.53	3141	67	**3207**	**122 (+4%)**
3	TwinN + 50% N 137.5kgN/ha	2158	1.49	3207	42	**3249**	**163 (+5%)**
4	TwinN + 75% N 206.25 kgN/ha	2543	1.35	3420	17	**3438**	**352 (+11%)**
5	TwinN + 100% N 275kg N /ha	2548	1.32	3366	-8	**3358**	**273 (+9%)**
6	No TwinN + zero urea	1701	1.29	2193	100	**2293**	**-793 (-26%)**
7	No TwinN + 100% N 275kg N/ha	2381	1.30	3086	0	**3086**	**0**

1. From Table 11.2 2. From Table 11.4 3. Yield by value/kg 4. From Fig 11.3

5. Yield value + saving on fertiliser

Table 11.5 Cost-benefit analysis at Nsuwadzi

Treat ment No.	Treatment	2012 Yield Kg/ha [1]	Value $/kg [2]	Value per ha $/ha [3]	Net saving on fertiliser & TwinN $/ha [4]	**Net return $/ha [5]**	**Increased returns $/ha**
1	TwinN + zero Urea	2958	1.73	5103	92	**5195**	**-60 (-1%)**
2	TwinN + 25% N 68.75 kgN/ha	3494	1.72	6013	67	**6080**	**825 (+16%)**
3	TwinN + 50% N 137.5kgN/ha	3408	1.67	5685	42	**5727**	**471 (+9%)**
4	TwinN + 75% N 206.25 kgN/ha	4087	1.56	6363	17	**6381**	**1125 (+21%)**
5	TwinN + 100% N 275kgN/ha N	4061	1.44	5832	-8	**5824**	**569 (+11%)**
6	No TwinN + zero urea	2929	1.58	4637	100	**4737**	**-519 (-10%)**
7	No TwinN + 100% N 275kgN /ha	3185	1.65	5255	0	**5255**	**0**

1. From Table 11.3 2. From Table 11.4 3. Yield by value/kg 4. From Fig 11.3

5. Yield value + saving on fertiliser

Summary

Yield was consistently high in treatments that received TwinN plus 75% of recommended nitrogen and TwinN plus 100% of recommended nitrogen applied as urea when considering results from 2010/2011 and 2011/12 seasons. A yield increase in these treatments was due to increase in shoot density on the plucking table while average shoot mass of different shoot categories remained unaffected.

There is an extra cost in applying TwinN and 100% of the recommended nitrogen as urea while a savings of 17% is made when TwinN is applied alongside 75% of the recommended nitrogen applied as urea, making this treatment (TwinN +75% of recommended nitrogen as urea) more cost effective than the other treatments when yield and expenditure incurred in each treatment are considered. TwinN plus 75%N have substantial increases in net returns compared to the standard urea rate with no TwinN. At Makandi and Nsuwadzi these increases were $352 (+11%) and $1125 (+21%) respectively.

Application of TwinN alone and combined applications of TwinN plus urea at 25 and 50% of the recommended nitrogen improves the quality of black tea. Nitrogen rates higher than 50% of the recommended inorganic nitrogen when applied as urea together with TwinN reduces the value of made tea. Although TwinN and combined application of TwinN and lower nitrogen rates than 50% of recommendation tends to improve the quality of made tea, yield in these treatments were significantly low thereby relegating the quality effect.

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