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A special schedule of foliar application of nutrients for the tea fields under extensive mechanized harvesting

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Abstract

To overcome the problem of acute shortage of work force faced by the south Indian tea industry, UPASI Tea Research Institute recommends mechanized harvesting to cover large areas with high worker productivity. While adopting extensive mechanized harvesting, total leaf area of the maintenance foliage on the plucking surface is reduced. As a result growth of the crop shoots has been adversely affected leading to reduction in productivity. Excessive banji shoot formation and nutrient deficiency symptoms were also noticed. To overcome all these adverse impacts of extensive mechanization, foliar application of primary, secondary and micro-nutrients has been attempted. The practical utility of foliar feeding of all these nutrients when applied as a mixture after every harvest, except during continuous heavy rainy months, showed an increase in yield up to 21% compared to the current recommended practice, in spite of extensive harvesting using shears and machines. The problem of dwarfing of crop shoots due to extensive shear/machine harvesting could be minimized due to increase in internodal length by 0.87 cm and the dry weight of the crop shoots increased by 0.09 g/shoot. Excessive production of banji shoots also came down from 65 to 52%.

Keywords: Camellia, foliar feeding, machine harvesting, shear harvesting

Introduction

South Indian tea industry is facing severe crisis of acute shortage of work force especially for harvesting, and a steep increase in labour wages and high cost of inputs (Mohan Kumar *et al*., 2008). In this context, mechanization of harvesting has become necessary to overcome these problems to reduce the cost of production. Integrated schedule of harvesting using shears and harvesting machines can help the tea growers to cover large area with high worker productivity (Victor J Ilango *et al*., 2001). Such a practice is also recommended in the tea growing countries in Africa (Peter Martin, 2000). Operational efficiency of various models of one man operated and two men operated machines were evaluated by the UPASI Tea Research Institute and found to be useful to increase the productivity of workers thereby reducing the requirement of workers for harvesting as well as cost of production. The UPASI TRF recommends the use of two men operated machines to harvest the clonal fields planted on gentle slopes of less than 15%. The one man operated machines can be used up to 30% slopes and hand operated shears can be used for very steep terrains of more than 30% slopes (Victor J Ilango *et al*., 2001). Many estates in south India have started using these machines in clonal fields on a large extent. However, when shear harvesting and machine harvesting are extensively followed to overcome the worker shortage, adverse impacts like excessive banji shoot formation, dwarfed crop shoot with reduced inter nodal length and leaf area leading to reduction in the weight of crop shoots and

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deficiency symptoms of zinc, magnesium and potassium were also noticed.

Foliar fertilization or foliar feeding is a popular method of feeding plants in several crops worldwide (Basavarajeshwari Patil *et al*., 2008; Vijaya *et al*., 2009; El-Fouly *et al*., 2011; Gul *et al.*, 2011). In tea, foliar application of micro-nutrients like Zn @ 2kg + Mn @ 500 ppm + Mg @ 2kg + B @ 100 ppm + NAA @ 10 ppm + KNO_3 @ 4kg/ha is recommended during the high cropping periods of April - May and September to November for higher productivity. Similarly N+K @ 2+2kg/ha and P @ 4.4 kg/ha is recommended during the dry season from December to March for alleviating drought (Verma and Palani, 1997). The practice of foliar feeding with a combination of several essential nutrients and plant growth promoters has been reported to give positive results in increasing the crop productivity in several crops (Dongre *et al*., 2000; Sasthri *et al*., 2000; Paikray *et al*., 2001; Kuruppaiah, 2005). Therefore, a study has been made to investigate the usefulness of foliar feeding of primary, secondary and micro-nutrients at various combinations to minimize the impact of extensive mechanization in tea.

Materials and methods

Field experiments were carried out in a clonal tea field (UPASI-9) in Valparai, Coimbatore district, Tamilnadu at an elevation of 1000 m above mean sea level. The tea was planted at a spacing of 120 x 60 x 75 cm in 1990 with a population of 12500 plants/ha. The crop received soil application of 325 kg of N, 240 kg of K, 80 kg of P and 200 kg of Mg/ha/year as per the recommendation of UPASI Tea Research Institute from the first after pruning. Experiments were initiated in the month of December 2009 when the crop was in the second year from pruning. An experiment with split plot design having six main treatments (method of harvesting) and six sub treatments (foliar application) with two replications was laid out. The treatment details are given below:

Main treatments

MT1 Machine harvesting*** (6 months) + Hand plucking (6 months)

MT2 Machine harvesting (9 months) + Hand plucking** (3 months)

MT3 Continual machine harvesting**** (12 months)

MT4 Shear harvesting (6 months) + Hand plucking* (6 months)

MT5 Shear harvesting (9 months) + Hand plucking** (3 months)

MT6 Continual shear harvesting**** (12 months)

* January to March (Mother leaf addition) and July to August (Plucking to the level)

** January to March (Mother leaf addition)

*** April to June and September to November (Harvesting to the level)

**** January to December (Harvesting to the level)

Sub-treatments (Dosage kg/round/ha using a spray volume of 600 L/ha):

ST1 Unsprayed control

ST2 Foliar application of nutrients as per current recommendation

(i) N+K @ 2+2 kg/ha*

(ii) P @ 4.4 kg/ha**

(iii) Zn @ 2kg + Mn @ 500 ppm + Mg @ 2kg + B @100 ppm + NAA @ 10 ppm + KNO_3 @ 4kg/ha***

ST3 Foliar application of

(i) N+K @ 2+2kg/ha + Zn @ 2kg+ Mn @ 500 ppm + Mg @ 2kg + B @100 ppm + NAA @ 10 ppm) + KNO_3 @ 4kg +GA @ 50ppm/ha****

(ii) P @ 4.4 kg/ha**

ST4 Foliar application of

(i) N+K @ 2+2 kg/ha + Zn @ 2kg + Mn @ 500 ppm+ Mg @ 2kg + B @ 100 ppm + NAA @ 10 ppm + KNO_3 @ 4kg + GA @ 100ppm/ha****

(ii) P @ 4.4 kg/ha**

ST5 Foliar application of

(i) N+K @ 2+2 kg/ha + Zn @ 2 kg + Mn @ 500 ppm + Mg @ 2 kg + B @ 100 ppm + NAA @ 10 ppm + KNO3 @ 4kg + Amino acid mixture (Kadostim) @ 300 ml/ha****

(ii) P @ 4.4 kg/ha**

ST6 Foliar application of

(i) N+K @ 2+2 kg/ha + Zn @ 2 kg + Mn @ 1 kg + Mg @ 2 kg+B @ 1 kg + NAA @ 10 ppm + KNO_3 @ 2 kg + GA @ 50 ppm (10g) + Amino acid mixture (Kadostim) @ 300 ml/ha****

(ii) P @ 4.4 kg/ha**

* N:K as urea:muriate of potash @ 2+2 kg/round/ha from December to March (five rounds of spray)

** P as di-ammonium phosphate @ 4.4 kg/round/ha from December to March (five rounds of spray)

*** Zinc sulphate @ 2 kg/round/ha + Manganese sulphate @ (500 ppm) 0.31 kg/round/ha + Magnesium sulphate @ 2 kg/round/ha + B as boric acid @ (100 ppm) 0.11 kg/round/ha + Naphthalene acetic acid as Agrona or Planofix @ (10 ppm) + 0.045 L/round/ha from April to June (three rounds of spray) and September to November (three rounds of spray)

**** N+K @ 2+2 kg/ha+ Zn @ 2 kg + Mn @ 1 kg + Mg @ 2 kg + B @ 1kg + NAA @ 10 ppm + KNO_3 @ 2 kg + GA @ 50 ppm (10g) + Amino acid mixture (Kadostim) @ 300ml/ha (nine rounds of spray after every harvest from January to May & September to December)

Nutrients listed in the six sub-treatments were sprayed through the high volume sprayer using a spray volume of 600 litres/ha within five days after harvesting the crop as per the standard practice. Boric acid was first dissolved in hot water and then diluted with normal water. Gibberellic acid was first dissolved in alcohol and then diluted with normal water. Muriate of potash was added at last.

Observations on yield (kg green leaf) were monitored in every harvesting round. Percentage of buds and banji shoots in the harvested crop was monitored in every plucking round. Crop shoots were collected and brought to the laboratory and dry weight recorded after oven drying at 80^0C for 48 hours. Inter nodal length of the crop shoots (between 2nd and 3rd leaf) were recorded in every harvesting round. Damage to the maintenance foliage (reduction in leaf area) was recorded once in a year by quantifying (on weight basis) the leaves and stem at the top 20 cm profile of the tea bush.

Results and discussion

Effect of main treatments: Shear harvesting as well as machine harvesting when extensively followed for more than six months in a year reduced the leaf area in the top 20 cm profile of the tea bush canopy leading to a reduction in the leaf:stem ratio. The leaf:stem ratio has come down to 0.91 under nine months shear/machine harvesting schedule when compared to a ratio of 0.98 under the six months shear/machine harvesting. When shear/machine harvesting was extended up to 12 months in a year the ratio came down drastically to 0.80. Reduced leaf area of the maintenance foliages was the main reason for the reduction in the weight of the crop shoots, leaf area and internodal length and more number of banji shoots. As a result productivity of the experimental plots under extensive shear/machine harvesting (9 months and 12 months of shear/machine harvesting) was low when compared to shear harvesting as well as machine harvesting for a period of six months (Tables 1 & 2).

Highest productivity was recorded in the plots harvested using both hand operated shear and harvesting machine following the integrated schedule that is currently recommended (six months of shear/machine harvesting during the two high cropping seasons) (Tables 1 & 2). Crop shoots harvested in these plots had more dry weight and inter nodal length (Tables 3 & 4). Similarly percentage of buds in the harvest was also more (Table 5). When harvesting using both shears and harvesters was extended for a period of 9 months and 12 months significant amount of reduction was recorded both in the weight of crop shoots and inter nodal length leading to lower productivity. Reduction in these parameters was more significant in the blocks harvested with machines than the plots harvested with shears (Tables 3 & 4).

Table 1. Effect of foliar feeding on productivity in the clonal tea field UPASI-9 (Yield in kg made tea/ha); annual yield from Jan - Dec, 2010

Sub-treatment	Main treatment						
	MT1	MT2	MT3	MT4	MT5	MT6	Mean
ST1	5188	4577	4215	6124	5195	4660	4993
ST2	5468	4732	4339	6261	5553	5100	5242
ST3	5728	5032	4368	6846	6153	5485	5602
ST4	5772	5115	4461	6859	6179	5446	5639
ST5	5584	4947	4468	6308	5672	4986	5327
ST6	6603	5653	5141	7718	6836	6122	6336
Mean	5724	5010	4499	6686	5931	5300	
	CD at P=0.05	CV (%)					
Sub treat:	90.36	2.56					
Main treat	90.36						
ST X MT	221.33						

Table 2. Effect of foliar feeding on productivity in the clonal tea field UPASI-9 (Yield in kg made tea/ha); cumulative yield from Dec, 09 - Sep, 2011

Sub-treatment	Main treatment						
	MT1	MT2	MT3	MT4	MT5	MT6	Mean
ST1	9778	8968	7840	11742	9967	8406	9450
ST2	10789	9418	8223	12572	10983	9048	10172
ST3	11560	9933	8538	13646	12078	9822	10930
ST4	11964	10293	8945	14326	12321	10109	11326
ST5	11007	9597	8435	13636	11105	9180	10493
ST6	13478	11509	9990	16063	13796	11333	12695
Mean	11429	9953	8662	13664	11708	9650	-
	CD at P=0.05	CV (%)					
Sub treat:	103.10	1.11					
Main treat:	103.10						
ST X MT	252.53						

Effect of sub treatments: Foliar feeding of the essential nutrients that is currently recommended minimized the adverse effects of extensive harvesting using both shears and tea harvesters when compared to unsprayed control. However, more significant increase in productivity was observed due to foliar feeding (sub-treatment 6) of all these nutrients (N, K, Zn, Mn, B, KNO_3, NAA, GA & Amino acids and P) as a mixture when compared to the other sub treatments. Irrespective of the type and duration of harvesting method, foliar feeding for nine times in a year gave a yield increase of about 21% when compared to the current recommendation. Usefulness of all these essential nutrients in increasing the yield when fed through foliar has already been proved in several other crops worldwide as indicated earlier.

Table 3. Effect of foliar feeding on dry weight of crop shoots (g/shoot)

Sub-treatment	Main treatment						
	MT1	MT2	MT3	MT4	MT5	MT6	Mean
ST1	0.17	0.14	0.13	0.18	0.17	0.15	0.16
ST2	0.18	0.16	0.15	0.20	0.19	0.17	0.18
ST3	0.23	0.21	0.19	0.26	0.25	0.22	0.23
ST4	0.26	0.24	0.21	0.29	0.26	0.24	0.25
ST5	0.21	0.19	0.17	0.24	0.22	0.20	0.21
ST6	0.28	0.26	0.23	0.32	0.29	0.26	0.27
Mean	0.22	0.20	0.18	0.25	0.23	0.21	-
	CD at P=0.05	CV (%)					
Sub treat:	0.003	2.30					
Main treat:	0.003						
ST X MT	0.008						

Table 4. Effect of foliar feeding on inter nodal length (cm) of crop shoots

Sub-treatment	Main treatment						
	MT1	MT2	MT3	MT4	MT5	MT6	Mean
ST1	2.52	2.26	1.98	2.64	2.40	2.31	2.35
ST2	2.70	2.51	2.21	2.81	2.57	2.38	2.53
ST3	3.07	2.88	2.67	3.27	2.95	2.76	2.93
ST4	3.12	2.87	2.68	3.28	3.00	2.84	2.97
ST5	2.72	2.60	2.43	2.95	2.71	2.54	2.66
ST6	3.58	3.27	3.03	3.83	3.41	3.28	3.40
Mean	2.95	2.73	2.50	3.13	2.84	2.69	-
	CD at P=0.05	CV (%)					
Sub treat:	0.01	0.85					
Main treat:	0.01						
ST X MT	0.04						

The problem of dwarfing of crop shoots due to extensive shear as well as machine harvesting was also minimized due to the application of all these nutrients. An increase of 0.87 cm in the inter nodal length was recorded in the crop shoots under the sub-treatment no. 6 when compared to the current recommendation (Table 4).

Extensive shear and machine harvesting leading to the reduction in the weight of crop shoots was overcome by the foliar feeding technique of all the essential nutrients. An average increase of 0.09 g/crop shoot was recorded in the experimental plots treated with the special nutrients mixture (sub treatment no 6) when compared to the current recommendation, irrespective of the type and duration of the harvesting methods (Table 3).

Excessive production of banji shoots due to extensive shear/machine harvesting methods also could be minimized by the application of the special foliar nutrition as per sub-treatment no. 6. Percentage of buds in the harvest increased to 48 from 35 compared to the current recommendation (Table 5).

Age of the leaf to which foliar feeding is targeted plays an important role in absorption in any cultivated crop (Sargent and Blackman, 1962; Turner and Begg, 1973). Therefore, it should be ensured that a new tier of leaves as maintenance foliage even as cut leaves is always maintained on the plucking surface of the tea fields irrespective of the method and duration of harvesting for effective absorption of nutrients through foliar feeding.

An analysis on cost economics (cost of chemicals only) of the various foliar schedule reveled that, though the number of spraying rounds are less, special foliar feeding technique (sub-treatment no. 6) is expensive than the current recommendation mainly due to inclusion of several nutrients than the current recommendation. However, due to high productivity of up to 1094 kg of made tea/ha/year in the clonal tea fields that were fed with the special foliar schedule, the savings were Rs. 4735/ha/year (Table 8).

Foliar feeding/spraying of all the essential nutrients listed in sub treatment no. 6 has been found

Table 5. Effect of foliar feeding on bud and banji shoots composition

Sub-treatments	Main treatments													
	MT1		MT2		MT3		MT4		MT5		MT6		Mean	
	Bud	Banji	Bud	Banji	Bud	Banji	Bud	Banji	Bud	Banji	Bud	Banji	Bud	Banji
ST1	33	67	28	72	24	76	35	65	31	69	28	72	30	70
ST2	36	64	33	67	30	70	41	59	36	64	33	67	35	65
ST3	45	55	37	63	33	67	47	53	41	59	39	61	40	60
ST4	44	56	38	62	36	64	47	53	42	58	40	60	41	59
ST5.	38	62	34	66	33	67	42	58	37	63	35	65	36	64
ST6	52	48	46	54	40	60	54	46	51	49	47	53	48	52
Mean	41	59	36	64	32	68	44	56	40	60	37	63	-	-

Table 6. Cost of application of various nutrients as per current recommendation

Nutrients	Source	Rs/kg*	Kg/ha/ round	Rs/ha/ round	Kg/ha/ year	Rs/ha/ year
N	Urea**	6.40	2.00	12.80	10.00	64.00
K	Muriate of potash**	12.30	2.00	24.60	10.00	123.00
P	Di ammonium phosphate**	20.00	4.40	88.00	22.00	440.00
Zn	Zinc sulphate***	45.00	2.00	90.00	12.00	540.00
Mn	Manganese sulphate***	100.00	0.31	31.00	1.86	186.00
Mg	Magnesium sulphate***	12.00	2.00	24.00	12.00	144.00
B	Boric acid***	120.00	0.11	13.20	0.66	79.20
NAA	Naphthalene acetic acid***	330.00	0.05	14.85	0.27	89.10
KNO_3	Potassium nitrate***	91.00	4.00	364.00	24.00	2184.00
Total	-	-	-	662.45	-	3849.30

* Price as on October, 2011;
** For five rounds/year (N:K2O-5 rounds and DAP-5rounds sprayed separately);
*** For six rounds/year; Total number of rounds: 16

Table 7. Cost of application of various nutrients as per the special foliar feeding schedule

Nutrients	Source	Rs/kg*	Kg/ha/round	Rs/ha/round	Kg/ha/year	Rs/ha/year
N	Urea***	6.40	2.00	12.80	18.00	115.20
K	Muriate of potash***	12.30	2.00	24.60	18.00	221.40
P	Di ammonium phosphate**	20.00	4.40	88.00	22.00	440.00
Zn	Zinc sulphate***	45.00	2.00	90.00	18.00	810.00
Mn	Manganese sulphate***	100.00	1.00	100.00	9.00	900.00
Mg	Magnesium sulphate***	12.00	2.00	24.00	18.00	216.00
B	Boric acid***	120.00	1.00	120.00	9.00	1080.00
NAA	Naphthalene acetic acid***	330.00	0.05	14.85	0.41	133.65
KNO_3	Potassium nitrate***	91.00	2.00	182.00	18.00	1638.00
GA	Ryzup	36500	0.01	365.00	0.09	3285.00
Amino Acid	Kadostim***	450	0.30	135.00	2.70	1215.00
Total	-	-	-	1156.25		10054.25

* Price as on October, 2011;
** For five rounds/year;
*** For nine rounds/year; Total number of rounds: 14

Table 8. Cost economics of special foliar schedule

Yield increase (kg made tea /ha/year) due to special foliar schedule (ST6) compared to current recommendation	+1094 (+20.86%)
Extra expenses (cost of chemicals only) due to special foliar schedule (Rs/ha/year) compared to current recommendation	+6204.95
Profit margin @Rs.10/kg	10940
Saving Rs/ha/year	4735.05

to be useful to neutralize all the adverse impacts of extended duration of machine/shear harvesting. The schedule is useful to extend the duration of machine/ shear harvesting to overcome the acute shortage of labour force faced by the south Indian tea industry.

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