Development of a Package on Foliar Feeding for the Tea Fields under extensive Shear and Machine Harvesting*

R.Victor J Ilango, P.Mohan Kumar, R.Parthibaraj, B.Suresh Kumar, J.Mareeswaran, R.Govindaraj, K.Ranjith, M.Saravanan and R.Gunasundari
UPASI Tea Research Foundation, Valparai, Coimbatore

Introduction

South Indian tea industry is facing acute shortage of labour especially for harvesting, followed by a steep increase in worker 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. Operational efficiency of various models of one man and two men operated machines were evaluated by the UPASI Tea Research Institute and found to be useful to increase the productivity of labour thereby reducing the requirement of number of workers per unit area for harvesting as well as reduction in cost of production. The UPASI TRF recommends use of two men operated machines to harvest the clonal fields planted on gentle slopes of less than 15% while 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% gradient (Victor J Ilango *et al.*, 2001).

Many estates in south India have started using these machines in clonal fields on a large scale level. However, when shear and machine harvesting are extensively followed to overcome the labour shortage, adverse impacts like excessive banji shoots formation, dwarfing of crop shoots with reduced inter nodal length and leaf area leading to reduction in the weight of crop shoots, symptoms of zinc, magnesium and potassium deficiencies were noticed. Practice of foliar feeding with a combination of essential nutrients and plant growth promoters has been reported to give positive results in increasing the crop productivity in several crops (Suryanarayana Reddy *et al.*, 1985; Chandel *et al.*, 1989; Stoyanow and Gikov, 1990; Singh and Verma, 1991; Sivasankaran *et al.*, 1995; Dongre *et al.*, 2000; Sasthri *et al.*, 2000; Paikray *et al.*, 2001; Kuruppaiah, 2005). Therefore, a study has been made to minimize all the adverse impacts of extensive mechanization in tea by foliar feeding of various essential primary, secondary and micro nutrients.

Methodology

Prior to going in to the details of foliar application, importance of foliar feeding and role of each nutrient is essential for a better understanding. Foliar fertilization or foliar feeding is a popular method of feeding plants in several crops worldwide (Vijaya *et al.*, 2009; Mohamed M.El-Fouly *et al.*, 2011; Basavarajeshwari C.Patil *et al.*, 2008; Hasina Gul *et al.*, 2001). The term refers to feeding of plants through leaves supplementing ground application. This practice is considered as an additional management technique and not the primary means of nutrient

* *Paper presented at the Technical Session of 118th UPASI Annual Conference 2011*

delivery. In terms of nutrient absorption, foliar fertilization is 8 to 20 times as efficient as ground application.

Role of nutrients:

Sixteen nutrients are essential for proper growth of plants. Each one is equally important for plant growth but their requirement varies. Based on the requirement these essential elements are grouped into three categories viz., primary (macro), secondary and micronutrients.

Primary nutrients

Primary (macro) nutrients particularly, nitrogen (N), phosphorus (P) and potassium (K) are required in high quantity by the plants. Nitrogen is necessary for formation of amino acids, the building blocks of proteins. It is essential for plant cell division and directly involved in photosynthesis. It is a necessary component of vitamins and aids in production and use of carbohydrates. Phosphorus is involved in photosynthesis, respiration, energy storage and transfer, cell division, and enlargement. It promotes early root formation and its growth and improves quality of fruits, vegetables, and grains. It is vital for seed formation and helps plants to survive the harsh winter conditions, increases water use efficiency and hastens maturity. Potassium is involved in carbohydrate metabolism and the break down and translocation of starches, increases photosynthesis and water use efficiency. It is essential for protein synthesis, important in fruit formation. It activates enzymes and controls their reaction rates, improves quality of seeds and fruit, improves winter hardiness and increases disease resistance.

Secondary nutrients

Secondary nutrients include calcium (Ca) magnesium (Mg) and sulphur (S). These are required in lesser amounts than the primary nutrients. Calcium is utilized for continuous cell division and cell formation. It is involved in N metabolism, reduces plant respiration and aids translocation of photosynthesis from leaves to fruiting organs and increases fruit set. Magnesium is the key element of chlorophyll, improves utilization and mobility of phosphorus. It is an activator and component of many plant enzymes, increases iron utilization in plants and influences early and uniform maturity. Sulphur is an integral part of amino acids. It helps in syntheses of enzymes and vitamins, promotes nodule formation on legumes, aids in seed production and necessary in chlorophyll formation.

Micronutrients

Micronutrients are required by the plants in minor quantity which include boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zn). Boron is essential for seed and cell wall formation, promotes maturity and necessary for sugar translocation. Chlorine interferes with P uptake and enhances maturity. Copper catalyzes several plant processes and involved in major function in photosynthesis. It indirectly play a role in chlorophyll production, increases sugar content, intensifies color of plant organs. Iron promotes formation of chlorophyll, acts as an oxygen carrier and involved in cell division and growth. Manganese functions as a part of certain enzymes, aids in chlorophyll synthesis and increases the availability of P. Molybdenum is required to form certain enzymes and needed to convert inorganic phosphates to organic forms in plants. Zinc aids syntheses of endogenous plant growth hormones and enzymes, necessary for chlorophyll production, carbohydrate formation, starch formation and aids in seed formation. In addition to the above 13 nutrients, plants utilizes air and water for carbon, hydrogen and oxygen.

Plant growth promoters

Endogenous gibberellins regulate growth and development of plants. Gibberellic acid particularly promotes stem elongation. Composition of the commercial plant growth formulation, Kadostim 20 contained N 5.0%, organic matter 2.0%, soluble K_2O 6.0% and bioactive amino acids 3.75% which could facilitate effective water relations resulting in higher crop.

Multilocational field experiments were carried out in clonal as well as seedling tea fields to investigate the usefulness of foliar application of various essential micro and macronutrients and plant growth promoters in minimizing all the adverse impacts of extensive shear and machine harvesting. Initially, the field experiments were laid out in split plot design with six main treatments (MT) and fifteen sub treatments (ST). Main treatments were fixed on the basis of method and duration of harvesting. On the other hand, sub treatments were confined to foliar application of recommended nutrients/plant growth regulators and their combinations. All the treatments were replicated twice. After preliminary investigation, number of sub treatments was reduced to six. The treatment details are:

Main treatments: MT1: Six months hand plucking with mother leaf addition during December to March and level plucking between July and August and remaining 6 months machine harvesting; MT2: Nine months machine harvesting and 3 months hand plucking between January and March with mother leaf addition; MT3: Continuous machine harvesting (12 months) irrespective of the cropping period; MT4: Six months hand plucking with mother leaf addition during December to March and level plucking between July and August and remaining 6 months shear harvesting; in other words, shear harvesting 6 months + hand plucking 6 months; MT5: Nine months shear harvesting and 3 months hand plucking between January and March with mother leaf addition and MT6: Continuous shear harvesting through out the year. Two men operated machines were used for harvesting the crop in the MT1 to MT3.

Sub Treatments: Sub treatments are:

ST1: upsprayed control

ST2: Foliar application as per current recommendation, where a) N +K @ 2+2 kg each, b) DAP @ 4.4 kg and c) $ZnSO_4$ @ 2 kg + $MnSO_4$ @ 500 ppm + $MgSO_4$ @ 2 kg + B @ 100 ppm + NAA @ 10 ppm + KNO_3 @ 4 kg

ST3: Foliar feeding of a)N + K @ 2 + 2 kg each, b) DAP @ 4.4 kg and c) $ZnSO_4$ @ 2 kg + $MnSO_4$ @ 500 ppm + $MgSO_4$ @ 2 kg + B @ 100 ppm + NAA @ 10 ppm + KNO_3 @ 4 kg +GA_3 @ 50 ppm

ST4: Foliar feeding of a) N + K @ 2 + 2 kg each, b) DAP @ 4.4 kg and c) $ZnSO_4$ @ 2 kg + $MnSO_4$ @ 500 ppm + $MgSO_4$ @ 2 kg + B @ 100 ppm + NAA @ 100 ppm + KNO_3 @ 4 kg + GA_3 @ 100 ppm (enhanced level of GA_3 from ST3)

ST5: Foliar feeding of a) N + K @ 2 + 2 kg each, b) DAP @ 4.4 kg and c) $ZnSO_4$ @ 2 kg + $MnSO_4$ @ 500 ppm + $MgSO_4$ @ 2 kg + B @ 1.0 kg + NAA @ 10 ppm + KNO_3 @ 4 kg + Amino acid mixture (Kadostim) @ 300 ml/ha

ST6: Foliar feeding of a) N + K @ 2 + 2 kg each, b) DAP @ 4.4 kg and c) $ZnSO_4$ @ 2 kg + $MnSO_4$ @ 1 kg + $MgSO_4$ @ 2 kg + B @ 1 kg + NAA @ 10 ppm + KNO_3 @ 2 kg + GA_3 @ 50 ppm + Amino acid mixture (Kadostim) @ 300 ml/ha

Method of Application:

Nutrients listed in the six sub treatments were sprayed through the high volume sprayer using a spray volume of 600 litres per hectare for a thorough coverage of all the leaves within five days after harvesting the crop. Wherever DAP was included in the sub treatments, it was applied separately and scheduled five times in a year starting from November to March. All other macro and micro nutrients along with specified concentrations of plant growth regulators were applied at monthly interval, except the months between June and August. Nine rounds of foliar application was carried out in clonal fields in a year whereas in seedling tea only eight rounds per year was applied due to less number of plucking rounds. While preparing the tank mixture, boric acid was first dissolved in hot water and then diluted with cold water while gibberellic acid was first dissolved in alcohol and then diluted. Muriate of potash was added in the last to ensure the clear suspension of the spray fluid.

Observations on yield, percentage of buds and banji shoots in the harvest, dry weight of crop shoots and internodal length (between 2nd and 3rd leaf) were recorded periodically. Damage to the maintenance foliage (reduction in leaf area) was recorded once in a year.

Results and discussion

Effect of main treatments: Extensive shear/machine harvesting followed for a period of more than six months led to a reduction in canopy (top 20 cm profile) leaf; stem ratio.

Irrespective of the sub treatments, there was no substantial change in leaf:stem ratio (0.98:1.0) where six months shear/machine harvesting integrated with hand plucking. On the other hand, considerable reduction in leaf:stem ratio (0.91:1.0) was observed when shear/machine harvesting was extended to nine months. When shears/machines were continuously used through out the year, the ratio drastically came down to 0.80:1.0. Reduced leaf area of the maintenance foliage was the main reason for the reduction in the weight of the crop shoots, short internodes, more banji shoots and reduced leaf area.

Clonal tea blocks are more productive where its productivity level crossed >5000 kg, irrespective of the treatments while seedlings recorded the yield level between 3000 and 4000 kg/ha. Irrespective of the method of harvesting (shear/machine), extended duration of usage of these harvesting tools played an important role in productivity (Table 1 & 2). As a result, productivity of the experimental plots under extensive shear/machine harvesting (9 & 12 months) was significantly lowered when compared to that of integrated shear/machine harvesting for six months. Adverse impact of extensive shear/machine harvesting was comparatively higher in the seedling tea fields than the clonal blocks.

Table 1. Effect of foliar feeding on annual tea productivity

Sub Treatment*	Clone/Seedling	Main Treatment (MT)* Yield, made tea kg/ha (Jan-Dec 2010)						
		MT1	MT2	MT3	MT4	MT5	MT6	Mean (ST)
ST1	Clone	5188	4577	4215	6124	5195	4660	4993
	Seedling	3594	3447	2963	3997	3529	3376	3484
ST2	Clone	5468	4732	4339	6261	5553	5100	5242
	Seedling	3993	3648	3088	3794	3634	3534	3615
ST3	Clone	5728	5032	4368	6846	6153	5485	5602
	Seedling	4125	3853	3122	4158	3810	3681	3791
ST4	Clone	5722	5115	4461	6859	6179	5446	5639
	Seedling	4009	3638	3142	4188	3764	3611	3725
ST5	Clone	5584	4947	4468	6308	5672	4986	5327
	Seedling	3972	3544	2999	4043	3710	3599	3645
ST6	Clone	6603	5653	5141	7718	6836	6122	6336
	Seedling	4842	4347	3644	4635	4416	4210	4349
Mean (MT)	Clone	5724	5010	4499	6686	5931	5300	
	Seedling	4089	3746	3160	4136	3811	3669	

Critical difference at P=0.05:	Clone	Seedling
Main treatment (MT)	90.36	68.43
Sub treatment (ST)	90.36	68.43
Interaction (MT x ST)	221.33	167.63

*Main and sub treatments are as per the details presented in materials and methods

Considerably higher productivity was achieved both in the clonal and seedling tea fields when harvesting was followed using shears (MT4, MT5 & MT6). Adoption of machines in harvesting the crop reduced the yield substantially. This was reflected both in the yield presented for the calendar year (Table 1) and cumulative yield for the experimental period (Table 2). However, for the cost economics yield data for the calendar year was used. Irrespective of the main treatments, considering the subtreatment alone, tremendous increase in yield was observed when compared to that of absolute control (ST1) both in seedlings and clonal teas. Here again shear harvesting had an edge over machines in terms of crop productivity.

Table 2. Effect of foliar feeding on cumulative productivity of clonal and seedling teas

Sub Treatment	Clone/ Seedling	Main Treatment (MT) Yield,made tea kg/ha (Dec'09 – Sep'10)						
		MT1	MT2	MT3	MT4	MT5	MT6	Mean (ST)
ST1	Clone	9778	8968	7840	11742	9967	8406	9450
	Seedling	7122	6459	5499	8296	6861	6187	6734
ST2	Clone	10789	9418	8223	12572	10983	9048	10172
	Seedling	7762	6838	5730	8554	7286	6521	7129
ST3	Clone	11560	9933	8538	13646	12078	9822	10930
	Seedling	8260	7220	6035	9010	7664	6826	7503
ST4	Clone	11964	10293	8945	14326	12321	10109	11326
	Seedling	8454	7210	6196	9148	7764	7008	7630
ST5	Clone	11007	9597	8435	13636	11105	9180	10493
	Seedling	7957	6847	5782	8756	7451	6609	7234
ST6	Clone	13478	11509	9990	16063	13796	11333	12695
	Seedling	10143	8531	6969	11199	9073	7898	8702
Mean (MT)	Clone	11429	9953	8662	13664	11708	9650	
	Seedling	8283	7184	6035	9160	7683	6838	

Critical difference at P=0.05:	Clone	Seedling
Main treatment (MT)	103.10	141.51
Sub treatment (ST)	103.10	141.51
Interaction (MT x ST)	252.53	346.65

Crop shoots harvested from the experimental plots exhibited significant variations in terms of dry weight (Table 3), inter nodal length (Table 4) and banji proportion (Table 5) in the harvest. Dry weight of the shoot varied from 0.11 to 0.32 g, irrespective of the clone/jat, main and subtreatments (Table 3). Between the jats, clones had more unit weight than that of seedlings. Invariably extending the duration of machine or shear harvesting reduced the unit weight considerably. Both seedlings and clones responded positively towards foliar feeding and the degree of response varied with the nutrients/PGRs applied in the experimental plots.

Table 3. Effect of foliar feeding on dry weight of crop shoots in a clonal and seedling teas

Sub Treat-ment*	Clone/ Seedling	Main Treatment (MT)* Dry weight, g/shoot						
		MT1	MT2	MT3	MT4	MT5	MT6	Mean (ST)
ST1	Clone	0.17	0.14	0.13	0.18	0.17	0.15	0.16
	Seedling	0.13	0.12	0.11	0.14	0.13	0.11	0.12
ST2	Clone	0.18	0.16	0.15	0.20	0.19	0.17	0.18
	Seedling	0.15	0.14	0.12	0.16	0.15	0.13	0.14
ST3	Clone	0.23	0.21	0.19	0.26	0.25	0.22	0.23
	Seedling	0.16	0.15	0.15	0.18	0.16	0.16	0.16
ST4	Clone	0.26	0.24	0.21	0.29	0.26	0.24	0.25
	Seedling	0.19	0.17	0.17	0.20	0.18	0.17	0.18
ST5	Clone	0.26	0.19	0.17	0.24	0.22	0.20	0.21
	Seedling	0.21	0.15	0.14	0.16	0.15	0.15	0.15
ST6	Clone	0.28	0.26	0.23	0.32	0.29	0.26	0.27
	Seedling	0.21	0.20	0.19	0.22	0.21	0.20	0.21
Mean (MT)	Clone	0.22	0.20	0.18	0.25	0.23	0.21	
	Seedling	0.17	0.16	0.15	0.18	0.16	0.15	

Critical difference at P=0.05:	Clone	Seedling
Main treatment (MT)	0.003	0.002
Sub treatment (ST)	0.003	0.002
Interaction (MT x ST)	0.008	0.006

Inter nodal length between second and third leaves ranged from 1.98 to 3.83 cm, irrespective of the clone/jat, main and subtreatments (Table 4). Inter nodal length of clonal tea was significantly higher than that of seedlings, irrespective of the shear/machine harvesting or foliar application of nutrients/PGRs. Extended period of machine or shear harvesting reduced internodal length significantly. However, both the seedlings and clones responded favourably towards foliar applied nutrients/PGRs. It was interesting to note that inclusion of gibberellic acid in the spray schedule increased the internodal length. Among the three subtreatments (ST3, ST4 & ST6), order of increase in internodal length followed was ST3 > ST4 > ST6 substantiating the synergistic effect of foliar applied nutrients and plant growth regulators.

Table 4. Influence of foliar feeding on inter nodal length (cm) between second and third leaf of a crop shoots

Sub Treatment	Clone/ Seedling	Main Treatment (MT)Internodal length, cm						
		MT1	MT2	MT3	MT4	MT5	MT6	Mean (ST)
ST1	Clone	2.52	2.26	1.98	2.64	2.40	2.31	2.35
	Seedling	2.40	2.22	1.97	2.53	2.39	2.17	2.28
ST2	Clone	2.70	2.51	2.21	2.81	2.57	2.38	2.53
	Seedling	2.57	2.42	2.24	2.73	2.55	2.40	2.49
ST3	Clone	3.07	2.88	2.67	3.27	2.95	2.76	2.93
	Seedling	2.90	2.80	2.56	3.15	2.85	2.75	2.83
ST4	Clone	3.12	2.87	2.68	3.28	3.00	2.84	2.97
	Seedling	2.99	2.87	2.68	3.16	2.89	2.84	2.90
ST5	Clone	2.72	2.60	2.43	2.95	2.71	2.54	2.66
	Seedling	2.61	2.54	2.46	2.72	2.65	2.59	2.60
ST6	Clone	3.58	3.27	3.03	3.83	3.41	3.28	3.40
	Seedling	3.40	3.25	3.03	3.62	3.36	3.24	3.32
Mean (MT)	Clone	2.95	2.73	2.50	3.13	2.84	2.69S	
	Seedling	2.81	2.68	2.49	2.99	2.78	2.66	

Critical difference at P=0.05:	Clone	Seedling
Main treatment (MT)	0.01	0.02
Sub treatment (ST)	0.01	0.02
Interaction (MT x ST)	0.04	0.05

Irrespective of the clone/jat, main subtreatments, considering only the banji proportion in the harvest, it varied from 48 to 76% (Table 5). In integrated shear/machine harvesting extended from six to 12 months, there was a rapid banji bud production both in the seedling and clonal teas. There was a marginal variation between the clones (61.6%) and seedlings (62.2%) in terms of banji buds in the harvest irrespective of the main and subtreatments.

Table 5. Impact of foliar feeding on banji proportion (%) in the harvest

Sub Treatment	Clone/ Seedling	Main Treatment (MT) Banji proportion in %						
		MT1	MT2	MT3	MT4	MT5	MT6	Mean (ST)
ST1	Clone	67	72	76	65	69	72	70
	Seedling	69	72	75	68	69	72	71
ST2	Clone	64	67	70	59	64	67	65
	Seedling	64	68	71	63	64	69	66
ST3	Clone	55	63	67	53	59	61	60
	Seedling	58	62	65	58	59	63	60
ST4	Clone	56	62	64	53	58	60	59
	Seedling	58	61	62	56	59	62	60

ST5	**Clone**	62	66	67	58	63	65	64
	Seedling	62	64	67	62	63	67	64
ST6	**Clone**	48	54	60	46	49	53	52
	Seedling	52	53	58	48	52	54	53
Mean (MT)	**Clone**	59	64	68	56	60	63	
	Seedling	60	63	66	59	61	64	

There was a significant reduction in banji content than the absolute control, both in the seedlings and clones, when special package of nutrients/PGRs applied (ST6). In general, foliar application of nutrients/PGRs reduced the banji content and improved the growing bud's proportion in the harvest when compared to that of absolute control (ST1).

In a nut shell, when harvesting using shears and harvesters extended for a period of nine and twelve months significant quantum of reduction in weight of crop shoots and inter nodal length was noticed leading to lower productivity. Adverse impact in the above morphometric parameters was more pronounced in blocks harvested with machines than the plots harvested with shears.

Impact of foliar application

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 the unsprayed control. However, more significant increase in productivity of both clonal and seedling tea fields was observed due to foliar feeding of all these nutrients (N, K, $ZnSO_4$, $MnSO_4$, $MgSO_4$, B, KNO_3, NAA, GA_3, amino acid formulation and P) as a mixture. Irrespective of the type and duration of harvesting method, foliar feeding the clonal tea plants for nine times in a year gave a yield increase of 24.8% when compared to the current recommendation. Similarly foliar feeding of seedling tea field for eight times in a year gave a yield increase of 22.0% (Tables 1 & 2). Usefulness of all these essential nutrients in increasing the yield when fed through foliar has been proved in several other crops worldwide (Vijaya *et al.*, 2009; Mohamed M.El-Fouly *et al.*, 2011; Basavarajeshwari *et al.*, 2008; Hasina Gul *et al.*, 2011).

Extensive shear and machine harvesting leading to the reduction in the weight of crop shoots was overcome by the foliar feeding of all the essential nutrients. An average increase of 0.07 to 0.09 g/crop shoot was recorded in the experimental plots treated with the special nutrients mixture irrespective of the type and duration of the harvesting methods (Table 3). 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 especially gibberellic acid and zinc sulphate. An increase of 0.8 cm in the inter nodal length was recorded in the crop shoots (Table 4). Usefulness of gibberellic acid in improving growth of plants has been reported in other crops as well (Govinda and Basavaiah, 2006).

Excessive production of banji shoots due to extensive shear/machine harvesting methods also could be minimized by the application of the special foliar nutrition. Percentage of banji shoots in the harvest decreased to 65 to 52 in the clonal tea fields. In the seedling tea fields the decrease was 66 to 53% (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.

Cost economics

An analysis on cost economics (cost of chemicals only) of the various foliar schedule (subtreatments only) revealed that the special foliar feeding technique is expensive than the current recommendation mainly due to inclusion of several nutrients (Table 6). However, due to higher productivity recorded up to 1094 kg of made tea/ha/year in the clonal tea fields treated with special foliar schedule resulted in a savings of Rs.4735/ha/year. In the case of seedlings, productivity increased up to 734 kg of made tea/ha/year which resulted in a net savings of Rs.2203/ha/year.

Foliar feeding/spraying of all the essential nutrients that are required for the normal growth of crop shoots has been found to be useful to neutralize the adverse impact of extended duration of machine/shear harvesting. Dosage, spray interval, compatibility between the nutrients and cost economics of the special foliar schedule has been developed. 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.

Table 6. Cost of application of various nutrients as per current recommendation and special foliar package

Nutri-ent/ PGRs	Source	Rs./ kg	Kg/ha per round	Current recommen-dation (ST2)			Kg/ ha/ round	Special foliar package (ST6)		
				Rs./ round	Kg/ ha/ year	Rs./ ha/ year		Rs./ round	Kg/ ha/ year	Rs./ha/ Year
N	Urea	6.4	2.0	12.8*	10.0	64.0	2.0@	12.8	18.0	115.2
K	MOP	12.3	2.0	24.6*	10.0	123.0	2.0@	24.6	18.0	221.4
P	DAP	20.0	4.4	88.0*	22.0	440.0	4.4*	88.0	22.0	440.0
Zn	$ZnSO_4$	45.0	2.0	90.0**	12.0	540.0	2.0@	90.00	18.0	810.0
Mn	$MnSO_4$	100.0	0.31	31.0**	1.86	186.0	1.0@	100.0	9.0	900.0
Mg	$MgSO_4$	12.0	2.0	24.0**	12.0	144.0	2.0@	24.0	18.0	216.0
B	Boric Acid	120.0	0.11	13.2**	0.66	79.2	1.0@	120.0	9.0	1080.0
NAA	Planofix	330.0	0.045	14.85**	0.27	89.1	0.045@	14.85	0.405	133.65

KNO_3	**Potassium nitrate**	91.0	4.0	364.0**	24.0	2184.0	2.0@	182.0	18.0	1638.0
GA_3	**Ryzup**	36500	--	--	--	--	0.01@	365.0	0.09	3285.0
AA	**Kadostim**	450	--	--	--	--	0.3@	135.0	2.7	1215.0
Total	--	--	--	662.45	--	3849.3	--	1156.25	--	10054.25

*:five rounds/year; **:six rounds/year and @:nine rounds/year (for seedling tea 8 rounds/year at a cost of Rs.8986/ha/year)

Acknowledgements:

We sincerely thank the National Tea Research Foundation (NTRF), Kolkata for the financial assistance. We also thank the management & staff of Srikundra estate & Korangumudi estate of M/s. Woodbriar Group for all the support and help extended to us in conducting these experiments. The authors thank Dr.R.Raj Kumar, Senior Plant Physiologist, UPASI TRI for his valuable suggestions.

References:

Basavarajeshwari, Patil, C., Hosamani, R.M., Ajjappalavara, P.S., Naik, B.H., Smitha, R.P., and Ukkund, K.C. 2008. Effect of Foliar Application of Micronutrients on Growth and Yield components of Tomato *(Lycopersicon esculentum* Mill.*). Karnataka Journal of Agricultural Sciences.* **21** (3): 428-430

Chandel, A.S., Tiwari, S.K. and Saxena, S.C.1989. Effect of micronutrient application on soybean *(Glycine* max.*)* growth in Uttar Pradesh foothills. *Indian Journal of Agricultural Sciences.* **59**: 62-63

Dongre, S.M., Mahorkar, V.K., Joshi, P.S. and Deo, D.D.2000. Effect of micronutrients spray on yield and quality of chilli *(Capsicum annum* L.*)* cv. Jayanti. *Agricultural Science Digest.* **20**: 106-107

Govinda, M.V.R. and Basavaiah. 2006. Effect of growth regulators on leaf lobation and sex expression of kajli and Mysore local varieties of mulberry. National conference on new strategies in research and development of sericulture. Pp.27.

Hasina Gul, Ahmad Said, Beena Saeed, Fida Mohammad and Ijaz Ahmad. 2011. Effect of foliar application of nitrogen, potassium and Zinc on wheat growth. *ARPN Journal of Agricultural and Biological Science.* 6(4): 56-58

Kuruppaiah, P.2005, Foliar application of micronutrients on growth, flowering and yield characters of brinjal cv.Annamalai. *Plant Archives.* **5**(2): 605-608

Mohamed M.El-Foulyl, Zeinab M. Mobarak1 and Zeinab A. Salama. 2001. Micronutrients

(Fe, Mn, Zn) foliar spray for increasing salinity tolerance in wheat *Triticum aestivum* L. *African Journal of Plant Science.* **5**(5): 314-322

Mohan Kumar, P., Victor J Ilango, R., Saravanan, M., Radhakrishnan, B., Siby Mathew., Sankaranarayanan, P. and Ajayakumar, K. 2008. A survey on mechanization of harvesting in tea in south India. *Planters' Chronicle.* **104** (12): 6-11.

Paikray, R.K., Mishra, P.J., Mohapatra, A.K., Haldar, J. and Panda, S.2001. Response of niger (*Guizotia abyssinica*) to secondary and micronutrients in acid red soil. *Annals of Agricultural Research.* **22**:140-142.

Sargent, J.A. and Blackman, G.E. 1962. Studies on foliar penetration. Factors controlling the entry of 2,4-dichlorophenoxy acetic acid. Journal of Experimental Biology. **13**:348-368.

Sasthri, G., Thiagarajan, C.P., Srimathi, P., Malarkodi, K. and Venkatasalam, E.P. 2000. Foliar application of nutrient on the seed yield and quality characters of non aged and aged seeds of cotton Cv. MCU5. *Madras Agricultural Journal.* **87**: 202-208.

Singh, S.S. and Verma, S.K.1991. Influence of potassium, zinc and boron on growth and yield of tomato *(Lycopersicon esculentum* Mill.*). Vegetable Sciences.* **18**:122-129.

Sivasankaran, M.T., Srinivasan, T.R., Rangaswamy, A. and Arunachalan, N. 1995. Effect of foliar application of diammonium phosphate and naphthalene acetic acid on seed cotton yield and fibre properties of *Gossypium hirsutum* L. cotton. *Journal of Indian Society for Cotton Improvement.* **15**: 154-147.

Suryanarayana reddy, P., Reddy, R.M.G., Veeraghavaiah, R., Subramanyam, K. and reddy, S.D. 1985, Response of tomato micronutrients. *South Indian Horticulture.* **33**: 23-35.

Stoyanow, D. and Gikov, G.L. 1990. Foliar application of trace elements to cotton. *Pochvozhanie.* **25**: 45-46.

Turner, N.C. and Begg, J.E. 1973. Stomatal behaviour and water status of maize, sorghum and tobacco under field conditions. Plant Physiology. **51**: 31-36.

Victor J Ilango, R., Ajayakumar, K., Muraleedharan, N., Rajkumar, R., Marimuthu, S. and Senthilkumar, R.S. 2001. Field evaluation of motorized harvesters in tea. Bulletin of UPASI Tea Research Foundation. **54**: 1-13.

Vijaya, D., Yeledhalli, N.A., Ravi, M.V., Nagangoud, A. and Nagalikar, V.P. 2009. Effect of fertilizer levels and foliar nutrition on M-5 mulberry leaf nutrient content, quality and cocoon production. *Karnataka Journal of Agricultural Sciences.* **22** (5): 1006-1012.