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EFFECT OF SOIL pH IN ROOTING AND GROWTH OF TEA CUTTINGS *(CAMELLIA SINENSIS* L.*)* AT NURSERY LEVEL

F.S. HAMID, TAHIRA AHMAD, *B.M. KHAN, A. WAHEED AND NASEER AHMED

National Tea Research Institute, PARC, Shinkiari Mansehra, Pakistan.

Abstract

Single nodal tea cuttings were obtained from the healthy bushes and raised in different soil media during the year 1999, 2000 and 2001 in the nursery at National Tea Research Institute, Shinkiari, Mansehra. The soil was treated with different levels of farm yard manure (F.YM), aluminium sulphate ($Al_2(SO_4)_3$), and sulphur (S) and filled in polythene sleeves. The experiment was repeated for consecutive three years. Aluminium sulphate @ 600 g m^{-3} gave the maximum shoot length, number of leaves and number of roots followed by the elemental sulphur @ 300 g^{-3}. Significant reduction was observed in soil pH in the nursery during the experimental years with different amendments. Aluminium sulphate was found to have more acidifying effect as compared to the other treatments.

Introduction

Tea plants improvement by seed had been the standard practice in most of the tea growing countries, but the great variation found in seedling population made the breeder aware of advantages of clonal propagation for establishing large and uniform populations. Banerjee (1993) reported that vegetatively propagated plants produced a higher yielding uniform stand of tea, which was both economical and time saving. The technique of propagation by cutting has received close attention from the various tea Research Institutes of the world. It is, however, evident that their recommendation are in part influenced by the local circumstances which may not apply elsewhere. Vegetative propagation from selected tea bushes greatly improved the possibilities of rapid multiplication of tea plants with high attributes for yield and quality.

The success of vegetative propagation as a means of producing material for commercial planting depends on soil, mother bushes and techniques of propagation but the pH of the soil is the most critical for raising the nursery plants.

The most successful method of vegetative propagation in tea is the use of single node cuttings from the selected bushes in the field (Sharma, 1984). The success of vegetative propagation depends on the selection of outstanding mother bushes with desirable characteristics, which would lend itself to a rapid and easy means of propagation. In order to produce a uniform crop with predetermined characters, vegetative propagation through single node leaf cutting is a reliable and economic method (Hajra, 2001). The cuttings should be planted soon after the excision in the propagation beds having a good soil with adequate water holding capacity and a low pH as the high pH induces over callusing and may delay rooting in the nursery plants. Hamid *et al*., (1991) recommended the period around September /October as the most suitable time for raising tea cuttings under plastic tents in the tea growing areas of Pakistan.

*Department of Biological Sciences, Quaid- i-Azam University, Islamabad, Pakistan.

Soil texture is of great relevance to the performance of tea cuttings. The relative proportion of sand, silt and clay determines the texture of the soil. The preferable pH range of soil for raising of tea cuttings is 4.5 to 5.5. A high pH can be corrected by mixing sulphur @ 151 to 454 gm per 0.76 cubic meters of heaped soil or treatment of aluminum sulphate solution @ 224 gms per 0.91 meter of soil (Kathiravetpillai *et al*., 1986). The rooting of cuttings critically depends on the soil in which the cuttings is placed (Green, 1973). Occasionally, the tea roots will not grow into untreated soil having the pH more than 7.0 and as a result growth is slowed down and plants may die when they have been in the ground for a year. For nursery use the soil must be acidified treated with sulphur ranging from 115-450 m^{-2} or aluminum sulphate @ 450 gm^{-2} depending on the soil pH (Othieno, 1992). Tea Research Foundation of Kenya suggested the mixing of 170 gm^{-2} of sulphur or 300 gm^{-2} of aluminum sulphate for the nursery soil having the pH around 6.1. Elemental sulphur is decomposed in the soil by microorganisms, releasing sulphuric acid. This is a very slow process and roots can be damaged if they come into contact with high concentration of decomposing sulphur. Aluminum sulphate contains 14% sulphur and may be of incidental value as a nutrient. The sulphur content is water-soluble and aluminum sulphate even in high concentration does not damage the tea roots (Tolhurst *et al*., 1973). Sivapalan (1988) stated that the addition of organic matter to the soil produces acid directly on decomposition and produces humus that enhances C.E.C. and consequently reduces the percentage of base saturation. Tesseng *et al*., (1992) recorded the higher rates of survival of the rooted cuttings in the beds containing 3.5 kg. F.Y.M + soil and best growth of two cultivars in the beds contained 3.5 kg F.Y.M + soil m^{-2} placed at 15 cm depth. For increasing the organic matter contents by 1% to the depth of 30 cm, an addition of about 45 tons of dry material^{-1} is required.

In Pakistan the tea plantation has been initiated in Hazara and Swat using tea seeds as parent material imported from China. Based on early growth, vigor and yield, tea bushes of twelve years old were selected to develop the healthy clones under local edaphic conditions. The objective of the present study was to determine the suitable chemicals and soil media for raising healthy tea clones in the nursery for further propagation.

Materials and Methods

A pot experiment was conducted in the nursery at National Tea Research Institute, Shinkiari, Mansehra to determine the suitable chemical for the amendment of high soil pH to raise the healthy clones. The study was conducted on the sandy loam top soil having pH 7.1. The other properties of nursery soil were observed as HCO_3 1.6, m.eg.l^{-1} P 2.52, available K 32, NO_3-N 3.49, Fe 4.44, Cu 2.26 and Zn 0.80 mg kg^{-1}. Polythene sleeves were filled with the soil after having been ameliorated with different doses of farmyard manure, aluminium sulphate and sulpher. The treatments are as follows:

Treatment no.	Treatments given	Dose m^{-3}
T_1	Check/Control	0
T_2	Soil + F.Y.M	3.5 kg
T_3	Soil + F.Y.M	5.0 kg
T_4	Soil + F.Y.M	7.0 kg
T_5	Soil + $Al_2(SO_4)_3$	200 g
T_6	Soil + $Al_2(SO_4)_3$	300 g
T_7	Soil + $Al_2(SO_4)_3$	600 g
T_8	Soil + Sulphur	100 g
T_9	Soil + Sulphur	200 g
T_{10}	Soil + Sulphur	300 g

Single nodal tea cuttings were obtained from 12 years old tea bushes of Chinese "Qi-Men" variety and planted during the month of September. The soil supplemented with sulphur was filled in polythene sleeves two months before inserting the tea cuttings, whereas, the soil with aluminium sulphate and farmyard manure was filled in polythene sleeves one month before planting the cuttings. There were 24 tea cuttings in each treatment planted in the sleeves. The sleeves were tunneled with plastic sheet in nursery underneath a 10 ft high nylon shade to protect them against cold injury during winter season and direct sunlight during hot weather. All the agronomic practices and application of fungicide (Dithane) @ 2% were continued during the period of study. The experiment was laid out according to Randomized Complete Block Design (RCBD) with four replications and repeated for consecutive there years (1999-2001). Three plants from each treatment were sampled to record data on number of roots, their length, number of leaves and shoot length after 6 and 12 months. The pH value of the soil was also recorded after 6 and 12 months. The data collected were analyzed statistically, using Duncan's Multiple Rang test.

Results and Discussion

Shoot length: The data presented in Table 1 show that various amendments have an effect on shoot length of nursery tea plants during the year 1999. Maximum length of 13.61 and 13.48 cm were obtained with $Al_2(SO_4)_3$ @ 600 g m^{-3} and sulphur @ 300 g m^{-3} respectively. It is evident that 73% and 72% increase over that of control were obtained with $Al_2(SO_4)_3$ and sulphur treatments at the rates stated above. However the increase in the shoot length due to various amendments was statistically non-significant (Table 1).

During the year 2000 maximum shoot length of 19.0 cm (555% increase over control) was obtained by the treatment of $Al_2(SO_4)_3$ @ 600 g m^{-3} followed by 17.38 cm (499% increase over control) obtained from the application of sulphur @ 300 g m^{-3} (Table 1). Among various amendments, however there was no significant difference in the shoot lengths obtained by the application of different levels of these amendments (Table 1). In the year 2001, the maximum shoot length of 24.25 cm (148 % increase over control) was obtained by the application of $Al_2(SO_4)_3$ @ 600 g m^{-3} followed 20.38cm (109 % increase over control) by sulphur @ 300 g m^{-3} Table 1). During 2001, shoot length of tea nursery plants was greater as compared to that obtained in the preceding years (Table 1).

Number of leaves: The number of leaves of nursery tea plants as affected by the application of various amendments for three years. The data show that during the year 1999, there was no significant difference among various treatments on the number of leaves (Table 1). However, there existed a trend of slight increase in the number of leaves obtained due to the various amendment applications. Maximum number of leaves (7.912) were obtained with the application of $Al_2(SO_4)_3$ @ 600g m^{-3} followed by the sulphur @300 g m^{-3} (7.74.5 cm), the increase being 34% and 31% over that of control treatment respectively (Table 1).

During the years 2000, there was a significant increase in the number of leaves due to amendment applications (Table 1). Greater increase in the number of leaves was observed from the treatment $Al_2(SO_4)_3$ @ 600g m^{-3} (14.625) followed by that of elemental sulphur @300 g m^{-3} (10.37), which represented 828% and 555% increase over that of control, respectively. The number of leaves increased progressively with corresponding increases in the levels of both the amendments. Aluminium sulphate was found more effective as compared to sulphur in increasing the number of leaves.

Table 1. Effect of different amendments on the growth of tea plants in the nursery during the study period.

Treatments	S.L (cm)	% IC	N.L	% IC	N.R	% IC	R.L	% IC
	Year 1999							
T_1	7.855 b	-	5.915	-	14.50 c	-	7.863 b	-
T_2	10.71 ab	36	6.580	11	22.50 bc	55	8.865 b	13
T_3	11.19 ab	42	6.148	4	32.08 ab	121	8.890 b	13
T_4	10.86 ab	38	6.580	11	22.75 bc	57	9.472 b	20
T_5	10.18 ab	30	6.665	13	32.33 ab	123	10.15 ab	29
T_6	11.56 ab	47	6.916	17	45.16 a	211	10.86 ab	38
T_7	13.61 a	73	7.912	34	21.75 bc	50	12.36 ab	57
T_8	12.86 a	64	6.665	13	21.75 bc	50	8.913 b	13
T_9	11.85 ab	51	7.077	20	26.00 ab	79	8.422 b	7
T_{10}	13.48 a	72	7.745	31	31.75 ab	118	14.60 a	86
	Year 2000							
T_1	2.900 d	-	1.575 d	-	10.575	-	3.40 c	-
T_2	3.775 cd	30	2.000 d	27	10.9	3	5.050 c	49
T_3	11.02 abc	280	9.625 bc	511	17.375	64	7.125 c	109
T_4	8.400 bcd	190	4.375 cd	177	15.625	48	7.500 abc	120
T_5	12.65 ab	336	8.625 bc	448	20.5	94	8.375 abc	146
T_6	12.63 ab	335	9.375 bc	495	26.825	154	13.00 ab	282
T_7	19.00 a	555	14.625 a	828	28.575	170	14.0 a	311
T_8	9.000 bcd	210	5.500 bcd	249	15.125	43	5.750 c	69
T_9	11.38 abc	292	9.375 bc	495	18.875	78	8.875 abc	161
T_{10}	17.38 a	499	10.375 ab	558	13.625	29	9.950 abc	193
	Year 2001							
T_1	9.750 d	-	5.000 b	-	5.500 e	-	2.250 e	-
T_2	13.00 bcd	33	5.375 b	7.5	7.735 de	41	3.500 de	56
T_3	14.00 bcd	44	7.375 ab	47.5	11.88 cde	116	4.875 cde	117
T_4	11.13 cd	14	8.075 ab	61.5	11.00 cde	100	9.500 ab	322
T_5	13.25 bcd	36	5.250 b	5.0	15.50 bc	182	8.000 abc	256
T_6	18.63 abc	91	8.125 ab	62.5	21.00 ab	282	10.38 a	361
T_7	24.25 a	148	10.375 a	107.5	26.00 a	373	8.900 ab	296
T_8	17.13 abcd	76	5.500 b	10.0	11.63 cde	111	4.750 cde	111
T_9	18.13 abc	86	7.300 ab	46.0	14.50 bcd	164	6.125 bcd	172
T_{10}	20.38 ab	109	7.400 ab	48.0	24.25 a	340	7.250 abc	222

Mean followed by the same letter (s) do not differ significantly at 5% probability levels.
S.L: Shoot length.
%IC: % Increase over Control.
NL: No of Leaves.
NR: No of Roots.
RL: Root length.

During 2001, maximum number of leaves was obtained by the application of $Al_2(SO_4)_3$ @ 600 g m^{-3} (10.37) followed by that of FYM @ 7 kg m^{-3} (8.75) and showed 107.5% and 61.5 % increase over control, respectively. The maximum dose of elemental sulphur @ 300 g m^{-3} gave 7.4 numbers of leaves represented 48% increase over that of control. It was observed that number of leaves increased progressively with corresponding increases in the levels of all the amendments.

Number of roots: The data regarding the effect of various amendments on the number of roots for the three consecutive years showed a significant increase in the number of roots of nursery tea plants by the application of various amendments (Table 1). During the year 1999, comparing the various amendments maximum number of roots per plant (45.16) was obtained by the application of $Al_2(SO_4)_3$ @ 300g m^{-3} followed by the application of $Al_2(SO_4)_3$ @ 200 g m^{-3} (32.33) and FYM @ 7 kg m^{-3} (22.75), the increase being 123, 118 and 57% over that of control (Table 1).

During the year 2000, there existed a trend of increase in the number of roots over that of control treatment. Although this increase was statistically non significant (Table 1) yet the difference in the number of roots of $Al_2(SO_4)_3$ treated plots was obvious and in ascending order of treatments i.e. higher the dose of treatment of 200, 300 and 600 g m^{-3} of amending material produced higher number of roots as 20.5, 26.82 and 28.57 per plant respectively. In contrast, the higher number of 17.37 and 18.87 roots per plant were obtained in the plots treated with the medium dose of 5 kg $m^{-3}$of F.Y.M and 200 g $m^{-3}$of sulphur. This showed that amongst the amending materials, $Al_2(SO_4)_3$ played the best role in boosting of the growth of cuttings in the nursery (Table 1).

In the year 2001, it was observed that maximum number of 26 roots per plant were obtained from the application of $Al_2(SO_4)_3$ @ 600 g m^{-3} which represents an increase of 373% over that of control. Next higher number was 24.25 roots per plant which represent an increase of 341% over control and this increase was obtained form the application of elemental sulphur @ 300g m^{-3} (Table 1).

Root length: The data showed that during 1999 the maximum root length was observed in the treatment supplemented with sulphur @ 300 g m^{-3} (14.60 cm) followed by aluminium sulphate @ 600 g m^{-3} (12.36 cm). The values of the root length represent 86% and 57% increase over that of control respectively (Table 1).

During the year 2000, maximum root length of 14.0 cm was obtained from the application of aluminium sulphate @ 600 g m^{-3} (311% increase over that of control) followed by the application of aluminium sulphate @ 300g m^{-3} (282% increase over control). The minimum length of the roots were observed by the application of F.Y.M @ 3.5 kg m^{-3} (49% increase over control) followed by the application of aluminium sulphate @ 200 g m^{-3} (69% increase over control).

In the year 2001, it was observed that maximum root length of 10.38 cm were produced by aluminium sulphate @ 300 g m^{-3} followed by the application of aluminium sulphate @ 600 g m^{-3} , which gave 8.9 cm of root length. These values represent 361% and 296% increase over that of control respectively. There existed a trend of increase in the root length over that of control treatment but this increase was statistically non significant.

It is evident form the present study that aluminium sulphate @ 600 g m^{-3} gave the maximum shoot length, number of leaves, number of roots per plant and root length followed by the application of sulphur @ 300 g m^{-3}. On the basis of three years average during the study period it was noted that the aluminium sulphate @ 600 g m^{-3} gave the maximum of 18.95 cm shoot length, 11.75 cm of root length and the number of roots 25.44 per plant. The average number of leaves was 10.97 during the three years. In contrast, the sulphur @ 300 g m^{-3} gave the average shoot length of 17.26 cm, root length

10.6 cm and 23.2 numbers of roots per plant during the three years of experiment. Generally, plant growth was more favoured by the application of aluminium sulphate @ 600 g m^{-3} followed by the sulphur @ 300 g m^{-3} as compared to the other amendments. Tea is aluminium accumulator. Aluminium is freely available in acidic soil and absorbed in large quantities by tea. It stimulates the absorption of phosphorous, nitrogen and potassium (Willson & Clifford, 1992).Good performance of the growth of tea cuttings in low pH may be due to its ability in formation of vigorous root system which could absorb more nutrients from the soil and thus produced healthy clones.The findings of the present study support the views of Willson & Clifford (1992).

Effect of amendments on soil pH in the nursery: The data regarding the effect of various amendments on the soil pH in the nursery have been presented in the Table 2. The data shows that during 1999 the aluminium sulphate @ 600 g m^{-3} and sulphur @ 300 g m^{-3} lowers the soil pH significantly (6.4) as compared to control treatment. Similarly, during 2000, aluminium sulphate @ 600 g m^{-3} and sulphur @ 300 g m^{-3} reduced the soil pH (6.5) significantly as compared to control treatment. During the year 2001, the aluminium sulphate @ 600 g m^{-3} and sulphur @ 300 g m^{-3} lowered the pH significantly up to 6.4 and 6.5, respectively. On the basis of average data of three years it was found that the maximum dose of FYM @ 7 kg m^{-3} lowered the soil pH by 3.8%, aluminium sulphate @ 600 g m^{-3} 8.7% and sulphur @ 300 g m^{-3} 9.1% over that of control.

Significant reduction in soil pH was observed by the application of farmyard manure, aluminium sulphate and sulphur but the effect was more pronounced in case of aluminium sulphate on the soil. Sulphur is not soluble in water but it acidifies soil relatively quickly. It improves the rate of growth of tea plants considerably. Aluminium sulphate is very soluble in water and acidifies soil without adverse effect on tea. It is quicker and cheaper to use aluminium sulphate to lower the soil pH as also reported by Othieno (1992), and Banerjee (1993).

Table 2. Effect of different amendments on soil pH in the tea nursery during the experimental period.

Treatments	Year 1999	Year 2000	Year 2001	Average
T_1	7.125 a	7.200 a	7.125 a	7.15
T_2	6.950 b	6.975 c	6.925 b	6.95
T_3	6.850 b	6.975 b	6.825 bc	6.88
T_4	6.850 b	6.875 b	6.825 bc	6.85
T_5	6.857 b	6.900 b	6.650 cde	6.80
T_6	6.475 c	6.700 c	6.650 cde	6.61
T_7	6.425 c	6.575 c	6.475 e	6.53
T_8	6.875 b	6.875 b	6.925 b	6.89
T_9	6.875 b	6.675 c	6.700 cd	6.75
T_{10}	6.400 c	6.575 c	6.525 de	6.50

Mean followed by the same letter (s) do not differ significantly at 5% probability levels.

Table 3. Monthly temperature, relative humidity, precipitation at NTRI.

Months	Temperature ºC		Relative	Rainfall
	Minimum	Maximum	Humidity %	mm
		Year 1999		
January	4.06	14.6	69.0	105.3
February	6.1	16.17	63.0	56.5
March	7.3	20.0	56.0	131.2
April	12.0	29.9	46.0	16.8
May	15.1	34.2	36.2	11.5
June	18.6	37.2	42.5	11.8
July	22	34.3	68.4	253.1
August	20.8	30.3	77.3	152.5
September	20.0	32.0	84.0	83.9
October	9.8	29.3	60.9	2.4
November	7.1	21.8	76.3	85.5
December	2.5	22.8	89.6	0
Mean	**12.11**	**26.88**	**64.1**	**910.6**
		Year 2000		
January	1.8	15.5	88	74.7
February	2.1	15.7	87.5	34.7
March	5.3	22.3	78.8	39.7
April	12.0	31.0	70.0	6.9
May	17.3	35.7	66.8	57.2
June	13.6	36.0	64.1	137.2
July	20.3	31.8	78.0	298.2
August	20.0	31.3	74.0	118.5
September	16.2	31.5	70.9	151.6
October	11.0	30.7	53.6	30.0
November	7.0	24.4	55.0	0
December	3.6	20.3	53.0	40.3
Mean	**10.8**	**27.18**	**69.9**	**989**
		Year 2001		
January	1.7	19.5	51	0
February	4.0	20.2	54	15.0
March	6.3	24.3	48	69.5
April	11.6	27.2	61	87.5
May	16.3	35.7	45	64.5
June	20.3	33.3	67	149.6
July	22.4	32.0	78	229.4
August	21.4	32.4	74	101.3
September	15.2	32.4	63	132.1
October	10.5	31.3	79	3.8
November	6.2	25.1	80	43.6
December	4.2	19.7	58	3.5
Mean	**11.7**	**27.8**	**63.17**	**899.8**

References

Banerjee, B 1993. History of tea, *Tea production and processing.* Oxford and IBH Publishing CO .Pvt Ltd. New Delhi, 1-8.

Bonheure, D and K.C. Willson. 1992. Mineral nutrition and fertilizers. *Tea cultivation to consumption.* Chapman and Hall London.P.269-329.

Chenery, E.M. 1955. A preliminary study of aluminium and the tea bush. *Plant and Soil*, 6(2): 174-200.

Chakravartee, J., M. Hazarika and D. Gogoi. 1986. Effect of soil pH in Callusing and root growth in nurseries. *Two and a bud* 33(1/2): 29.

Green, M.J. 1973. A summary of some TRI rooting media experiments. *Tea in East Africa*, 2: 21-28.

Green, M.J. 1964. Tea Research Institute of Africa, *Pamphlet* No. 20.

Hajra, N.G. 2001. Mineral nutrition of fertilizer management. *Tea Cultivation Comprehensive Treatise*. 338-354.

Hamid, F.S., N. Ahmad, A. Waheed and A. Rauf. 1991. Adventitious root formation in tea cuttings planted on different dates. *Srilankan.J.Tea.Science*, 60(2): 70-75.

Harler, C.R. 1966. The propagation of the tea plant. *Tea growing.* Oxford, Univ. Press, London, 99-113.

Kathiravetpilla, A. and Kulasegaram. 1986. Nursery and nursery practices, *Handbook on tea,* Tea Res. Institute Sri Lanka 20-35.

Othieno, C.O. 1992. Soils. *Tea cultivation to consumption.* Chapman and Hall London. pp137-170.

Sivapalan, P. 1988. Liming of tea fields. A critical need. *Tea Bull*., 8(1): 3-22.

Sivasubramanium, S. and O. Talibuddin. 1971. Effect of Aluminium on the growth of tea (*Camellia sinensis*) and its uptake of potassium and phosphorus. *J. Sci. Fd. Agric*., 22: 325-32.

Sharma, V.S. 1984. Vegatative propagation in tea a review. *Proceedings of the fifth annual symposium on plantation crop*, 1-15.

Teseng, F.M. and J.S. Chen. 1992. Studies on the effect of soil fumigation and organic manure on the growth of tea cuttings. *Taiwan Tea Res. Bull*., 11: 57-62.

Tolhurst, J.A.H. and M.J. Green. 1973. Fertilizers for East African tea. Tea Res. Institute of East Africa. *Pamphlet 22/73* pp.12.

Willson, K.C. and M.N. Clifford. 1992. Effect of individual nutrient. Tea *cultivation to consumption*: Chapman and Hall London, 288-9.

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