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Srimangal-3210, Moulvibazar
An organ of
BANGLADESH TEA BOARD
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C O N T E N T S

Editorial

The 44th volume of Tea Journal of Bangladesh contains five research articles.

First article is the research findings of comparing four biclonal stocks with their parental clones on yield and quality of tea. Generally it is advised to plant clonal tea for getting higher yield and quality than the seedling tea. The planters may get highest yield and quality from biclonal stock BT3 X TV18.

The next article is on necessity of lime for improving the soil and ultimately the growth and yield of tea. Excess application of inorganic fertilizers in tea soil particularly the nitrogenous fertilizer is lowering the pH value (optimum range is 4.5-5.8). Due to low pH of soil, phosphate fixation is occurring and it inhibits the uptake of many essential nutrients.

The research work of third article is on the efficacy of leaf extracts of some indigenous plants in controlling dieback disease of tea. It is a very common and major disease and causes serious damage both in nursery and in mature tea plantation. Generally chemicals are used to control this disease. Leaf extract of Bashok (*Adhata vasica*) can be an effective alternative of chemicals to control dieback disease of tea.

The fourth article is on about the effectiveness of a pre-emergent herbicide-BecAno 50Sc. Authors reported that the herbicide can be used to suppress weed growth in tea but they cautioned not to use the herbicide in nursery as it inhibits seed generation and causes mortality of cuttings

Final article is on the case study of tea production at northern Bangladesh. History of tea production in northern Bangladesh is very recent that is 2000 A.D. During the short period of time, about 1,514 ha of land is under tea plantation and producing about 2.5 million kg in 2015. The success is achieved mainly for adopting "Small holding tea cultivation" concept by the Bangladesh Tea Board.

(**Dr. Mohammad Ali**)
Chief Editor

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STUDY OF THE PERFORMANCE OF FOUR BICLONAL STOCKS AND THEIR THREE PARENTAL CLONES AS CONTROL ON THE YIELD AND QUALITY OF TEA

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Abstract

The present study was conducted to investigate the long term yield and quality performances of four biclones of tea namely BTS1, BTS3, BT3xTV18, TS463 and their parental clones as control (BT1, TV1 & TV19). The results of the experiment revealed that, at immature stage i.e. 1st year to 5th year after plantation, except 2nd and 3rd year, their yield differences were significant in 1st, 4th and 5th year. The biclone BT3xTV18 gave highest yield of 709.8 g/plant and 2267.3 kg/ha made tea compared to parental clones except TV19. Again, at mature stage amongst the four biclones BT3xTV18 gave the highest significant yield of 1160.5 g/plant and 3707 kg/ha made tea compared to parental clones except TV19 which is a famous yield clone of India. The overall cup quality of the test clones and the control was assessed by conventional organoleptic test. The cup quality of biclone BT3xTV18 was found to be above average while cup quality of control TV1 was excellent. Considering yield and quality potentials, the biclone BT3xTV18 appeared quite promising to be released.

Keywords: Tea, Yield performance, Cup quality, Biclones.

Introduction

Tea is one of the most consumed non-alcoholic as well as medicinal beverage in the world. At present, more than 58 countries around the world produce tea, while Bangladesh is now ranked 10th position amongst the tea growing countries. In 2016 our production was 85.05 million kg while our export was only 0.47 million kg (ITC, 2015). Our internal consumption is increasing so rapidly that our production can hardly manage both our consumption and export to different countries. Our present yield per hectare is quite low compared to other tea growing countries of the world. One of the major reason is around 35% of our tea growing area is covered with seedling plants which are over 60 years old and are of lower productivity (PDU, 2015). Developing high yielding varieties and seed stock seems to be our only way to mitigate both demands as Bangladesh is a land hungry country. Improvement through breeding in tea is a slow process because of its highly self-sterile and perennial nature. With the dual objective (i) to produce seed stock for consistent production of seedling progenies of superior standard and (ii) selection of outstanding bushes and releasing them as vegetative clones, Bangladesh Tea Research Institute started its journey from 1957

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(Rashid and Alam, 1990). As an outcome of these works, the institute so far has released twenty vegetative clones in the Bangladesh tea (BT) series (BT1 – BT20) and four biclonal & one polyclonal seed stock to the industry.

Hybridization between clones was initiated at BTRI at the late sixties with a view to develop biclonal seed stocks combining the desirable characters present in different clones. In the way of tea breeding, several generations may be required before a useful progeny can be identified and adequately tested. For establishment of biclonal or polyclonal seedbaries ideal generative clones are to be selected first. For this purpose, constituted generative clones are studied for cross-compatibility. So that, they can produce uniform seedlings of good yield and quality potential. On the basis of breeding results and performance of the seedling progenies first two biclonal seed stocks BTS1 (BT1 X TV1) and BTS2 (B207/39 X TV1) were released for the establishment of biclonal seedbaries in 1985. As a consequences, to meet the demand of tea industries, the present experiment was carried out to study the long term yield and quality performances of four biclonal stocks (BTS1, BTS3, BT3xTV18, TS463) and their parental clones as control (BT1, TV1 & TV19).

Materials and methods

The experiment was carried out to study the comparative performance of four biclonal stocks (BTS1, BTS3, BT3xTV18 and TS463) and their parental clones as control (BT1, TV1 & TV19) in the BTRI experimental farm, during the period from 21st May, 2002 to December, 2016. The experiment was laid out in Randomized Complete Block Design with four replications. Each plot was 5 m x 5 m in size with 120 cm (row-row) x 60 cm (plant-plant) spacing. There were 25 plants per plot. A standard clone BT1, two renowned Indian clones TV1 and TV19 were used as parental lines as well as control for yield and quality comparison. TV19 is the "Yield Clone" of India (Singh, 1979). In general, the yield & quality of seed variety, which is mainly under general seed plant, biclone or polyclone is lower than the clonal varieties of tea (Green, 1971). The experiment was conducted in rain-fed condition. Yield data was collected during the cropping seasons throughout the experimental period. Fertilizer mixture was applied as per BTRI recommendations (BTRI Pamphlet nos. 21 & 22). Young and mature tea pruning were followed as per BTRI recommendations (BTRI Pamphlet nos. 79) for young tea:-Decentre-Prune-Skiff-Prune-Skiff and for mature tea (BTRI Pamphlet nos. 111) Light prune-Deep skiff-Medium skiff-Light skiff. The green leaf was harvested at weekly interval during the plucking season starting from mid-March to mid-December throughout the experimental period. Yield data were recorded and analyzed statistically using MSTAT programme in a microcomputer. The mean values were adjusted by DMRT. The yield was expressed as mean yield of green leaf g plant^{-1} and is presented separately for immature (1st - 5th year) and mature (6th-14th year) stage. The made tea (kg ha^{-1}) was also calculated on the basis of 23% recovery from green leaf. The quality performances of manufactured tea by CTC method in the BTRI mini tea factory. Quality of all the test clones and control were assessed weekly by conventional organoleptic test and scored numerically. General characteristics of four biclonal stocks and their parental clones as control BT1, TV1 & TV19 is given in Table 1.

Table 1. General characteristics of four biclonal stocks and their parental clones as control

Clone/ Biclone	**Bush characters**	**Leaf type**	**Pruning recovery**	**Nursery rooting**	**Cup quality**	**Manu . Pref.**
BTS1	Plants have good branching habit with uniform growth. Plucking table is compact with dense plucking points.	Leaves are medium, erect to semi-erect pose, light green to green in colour with prominent and uniform serration. In general, progenies have close resemblance to TV1 plants.	High	Good	Above average	CTC
BTS3	Semi-orthotropic growth habit with excellent spread. Plants have good branching and satisfactory growth habit with highly compact plucking table.	Leaves are light green, medium to large in size, deeply serrated margin with embossed leaf.	High	Germin ation of seed is excellent .	Above average	CTC
BT3x TV18	Compact ortho-plagiotropic table, thick plucking shoots.	Leaf size medium & broad, semi erect, semi dark green.	High	Excellen t	Above average	CTC
TS463 (TV1x TV19)	Fast growing, non-spreading, compact bush with ortho-plagiotropic bush habit, dense plucking points and thick shoots.	Leaf size medium to large & broad, semi erect, light green.	High	Excellen t	Above average	CTC
BT1	Bush size medium, plagiotropic, thickly branched and compact, fairly dense and evenly distributed plucking points with short internodes.	Leaves semi-dark green, medium sized, horizontal pose. Prominent long apex, leaf margin deeply serrated, leaf blade wavy,	Good	Good	Above average	CTC
TV1	Assam hybrid, orthotropic grower with a very good spread forming dense plucking table.	Medium to large, light green, glossy, erect, serrated margin, prominent leaf apex.	Good	Good	Excelle nt	CTC
TV19	Orthotropic grower with a very good spread forming dense plucking table.	Light leaf, large, semi erect, semi dark green.	Good	Good	Above average	CTC

Note: Pruning recovery & Nursery rooting: Excellent, very good, good, fair/moderate
Cup quality: Excellent, Above average, Average, Below average.

Table 2. The categories of tea clones as yield, standard and quality clones

Category of clones	Yield clone	Standard clone	Quality clone
Yield (made tea/ hector)	>4000 kg^{-ha}	3000-4000 kg^{-ha}	2500-3000 kg^{-ha}
Cup Quality	AA or A*	AA*	E*

* Quality score: E = Excellent (34 to >34 out of 50)
AA = above average (32 to <34 out of 50)
A = average (30-32 out of 50)
BA = Below Average (<30 out of 50).

Results and discussion

The mean yield of green leaf (g per plant) over fourteen experimental years are presented in Table-3 for immature stage (1^{st} -5^{th} year) and in Table-4 for mature stage (6^{th}- 14^{th} year). From Table-3 it reveals that at initial stage of growth, all the biclones showed significant higher yield trend than their parents (BT1, TV1) except TV19 which is a yield clone of India. When the data were analyzed individual year wise their yield differences were significant in 1^{st}, 4^{th} and 5^{th} year. On the other hand, Table 4 shows that, their yield differences are significant in the 6^{th}, 7^{th}, 8^{th}, 9^{th}, 10^{th} and 14^{th} year whereas in the 11^{th}, 12^{th} and 13^{th} year the yield is comparable with parental lines.

Table 3. Mean yield of green leaf (g/plant) of four Biclone clone and three parental clone at immature stage (1^{st} -5^{th} year)

Biclones & their parents	1st Year Up 2003	2nd Year Prune 2004	3rd Year UP 2005	4th Year Pruned 2006	5th Year Skiff 2007	Average
BTS1	202.7ab	336.8b	695.65b	629.2c	1044.6bc	581.8d
BTS3	185.96b	335.92b	748.6ab	776.17b	1235.53b	656.4c
BT3xTV18	216.26a	409.08a	864.97a	817.31ab	1241.48b	709.8b
TS463	189.63ab	329.87b	714.62ab	760.17bc	1113.54bc	621.6cd
BT1	87.59d	170.31d	576.18c	474.25d	887.8c	439.2f
TV1	144.87c	230.38c	605.16b	635.22c	930.34c	509.3e
TV19	208.15ab	402.61a	866.56a	891.18a	1510.03a	775.706a
LSD at 5%	37.41	Insignificant	Insignificant	103.04	134.13	65.9

Within column values followed by different letter (s) are significantly different by DMRT ($p \leq 0.05$)

Table 4. Mean yield of green leaf (g/plant) of four Biclone clone and three parental clone at mature stage (6th - 14th year)

Biclones & their parents	6th Year LP 2008	7th Year DSK 2009	8th Year MSK 2010	9th Year LSK 2011	10th Year LP 2012	11th Year DSK 2013	12th Year MSK 2014	13th Year LSK 2015	14th Year LP 2016	Average
BTS1	899.1bc	1172.9b	1129c	1095.31c	765d	902.2b	989.1c	1562.5bc	810.63ab	1036.2c
BTS3	1030.95b	1203.9b	1301abc	1247.7b	885bc	1011ab	1125.1bc	1602.88b	675.5b	1120.3b
BT3x TV18	1095.01 ab	1345.7ab	1371ab	1260.38b	896bc	927.4ab	1005.45b	1565.72 bc	977.89a	1160.5b
TS463	1019.14b	1394.9ab	1297abc	1295.2b	915b	1079ab	1083.6bc	1555.7bc	769.86ab	1156.6b
BT1	754.8c	1123.1b	1181bc	1133.8bc	827c	966.5ab	1080.6bc	1461.42c	764.42ab	1032.5
TV1	893.16bc	1225.6b	1201bc	1163.7bc	850bc	1049ab	1429.07a	1460c	736.36ab	1112bc
TV19	1257.32a	1572.9a	1466a	1406.9a	995a	1105a	1223.15b	1764.92a	877.23ab	1296.5a
LSD at 5%	160.2	269.23	269.23	123.6	90.23	Insig.	Insig.	Insig.	302.4	136.5

Within column values followed by different letter (s) are significantly different by DMRT ($p \leq 0.05$)

Estimated made tea production (kg^{-ha}) both for immature and mature stage was done and presented in Table-5 and Table 6. Average value of made tea production for immature stage (1st year to 5th year) and mature stage (6th year to 14th year) are presented in Fig-1 & Fig-2. Fig-1 clearly indicates that TV19 is the highest yielder (2477.76 kg^{-ha}) during immature stage followed by BT3xTV18 (2267.3 kg^{-ha}).

Similar trend during mature stage is seen from the Fig-2 where yield of TV19 is 4141 kg^{-ha} which is followed by the BT3xTV18 (3707 kg^{-ha}) and TS463 (3694 kg^{-ha}).

Table 5. Estimated made tea (kg^{-ha}) at immature stage (1st - 5th year)

Biclones & their parents	1st Year Up 2003	2nd Year Prune 2004	3rd Year UP 2005	4th Year Pruned 2006	5th Year Skiff 2007
BTS1	647.5 ab	1075.8 b	2222 b	2009 c	3337 bc
BTS3	594 b	1073 b	2391 ab	2479 b	3947 b
BT3xTV18	690.8 a	1306.7 a	2763 a	2610 ab	3966 b
TS463	605.7 ab	1053.8 b	2283 ab	2428 bc	3557 bc
BT1	279.8 d	544 d	1840 c	1515 d	2836 c
TV1	462.7 c	736 c	1933 b	2029 c	2972 c
TV19	664.9 ab	1286 a	2768 a	2846 a	4823 a
LSD at 5%	119.4	Insig.	Insig.	103.04	183.73

Within column values followed by different letter (s) are significantly different by DMRT ($p \leq 0.05$)

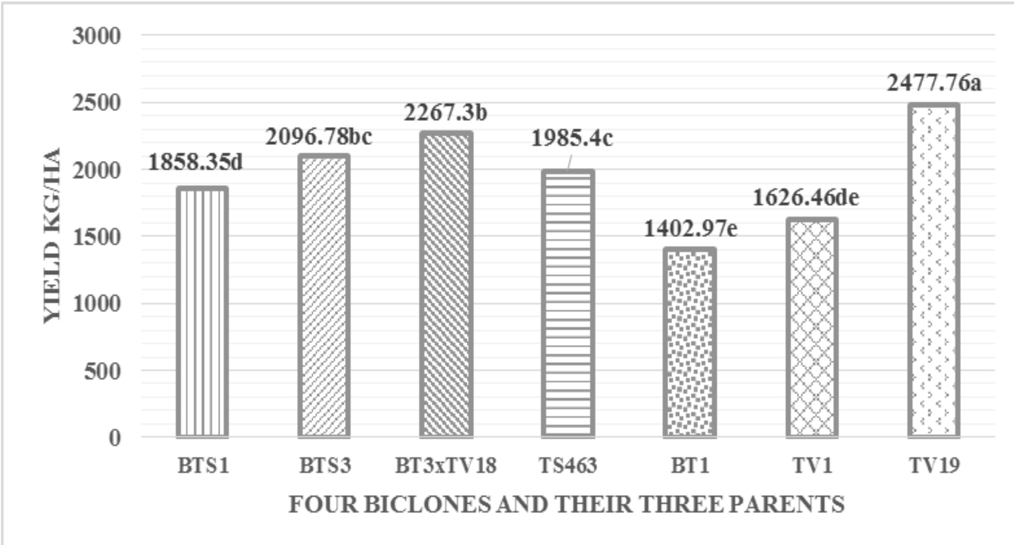

Fig. 1. Average estimated made tea (kg^{-ha}) at immature stage (1st – 5th year)

Table 6. Estimated made tea (kg^{-ha}) at mature stage (6th – 14th year) (2008-2016)

Clone/ Biclone	6th Year LP 2008	7th Year DSK 2009	8th Year MSK 2010	9th Year LSK 2011	10th Year LP 2012	11th Year LSK 2013	12th Year MSK 2014	13th Year LSK 2015	14th Year LP 2016
BTS1	2871.81bc	3746.48b	3606.25c	3498.64c	2443.56d	2881.81b	3159.38c	4991.07bc	2589ab
BTS3	3293.06b	3845.5b	4155.65abc	3985.28b	2826.87bc	3229.34ab	3593.83bc	5119.92b	2157.7b
BT3xTV18	3497.68ab	4298.56ab	4379.25ab	4025.91b	2862bc	2962.3ab	3211.61b	5001.22bc	3123.6a
TS463	3255.34b	4455.72ab	4142.88abc	4137.13b	2922.69b	3446.54ab	3461.24bc	4969.41bc	2459ab
BT1	2410.98c	3587.25b	3772.35bc	3621.52bc	2641.6c	3087.19ab	3451.65bc	4668.07c	2441.7ab
TV1	2852.93bc	3914.84b	3836.23bc	3717.09bc	2715.07bc	3350.72b	4564.74a	4663.53c	2352.1ab
TV19	4016.13a	5024.19a	4682.7a	4493.92a	3178.23a	3529.59a	3906.99b	5637.51a	2802ab
LSD at 0.05	512.1113	860.6475	860.6475	395.1121	288.4382	insig.	insig.	insig.	965.9

Within column values followed by different letter (s) are significantly different by DMRT ($p \leq 0.05$)

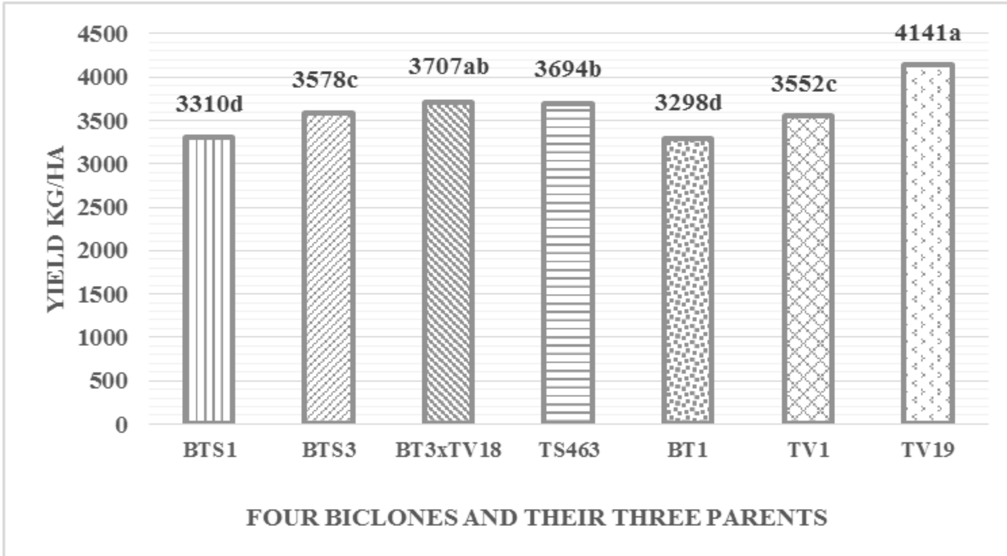

Fig. 2. Estimated made tea (kg-ha) at mature stage (6th – 14th year)

Quality performance

The overall quality performances of the test clones and control assessed by conventional organoleptic test are shown in Table 7. It was observed that the cup characters of the biclones (BTS1, BTS3, BT3xTV18 and TS463) and their parents (BT1 and TV19) were categorized as **"Above Average"** (having 32 to less than 34 quality score out of 50 is considered as above average quality). These biclones have bright infusion, colour liquor with useful strength and briskness. (Table 7)

Table 7. Cup quality of different test clones (Average score of 10 years, from 2001 to 2010)

Test Clone	Infusion (10)	Liquor Colour (10)	Briskness (10)	Strength (10)	Creaming down(10)	Total	Overall Quality
BTS1	7.169 bc	7.518 a	7.303 abc	7.426 ab	3.267 abc	32.68 b	AA
BTS3	7.070 c	7.273 c	7.357 c	7.402 c	2.903 de	32.01 c	AA
BT3xTV18	7.197 bc	7.388 ab	7.251 abc	7.386 abc	2.828 e	32.05 b	AA
TS463	7.322 ab	7.292 bc	7.200 bc	7.263 bc	3.142 cd	32.22 b	AA
BT1	7.261 bc	7.428 ab	7.378 a	7.417 ab	3.188 bc	32.67 b	AA
TV1	7.505 a	7.434 ab	7.332 ab	7.511 a	3.525 a	33.31 a	E
TV19	7.329 ab	7.256 bc	7.301 abc	7.401 abc	3.431 ab	32.72 b	AA
LSD at 0.05	0.22	0.19	0.14	0.19	0.25	0.6	

Within column values followed by different letter (s) are significantly different by DMRT ($p \leq 0.05$)

Considering the yield performances and quality standard throughout the study period compared to the parents (BT1, TV1 and TV19), the biclone BT3xTV18 appeared superior to be released as a new biclonal stock. The biclonal stock TS463 was also found prospective in quality characters and yield and can be used as valuable breeding stock.

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Principal Author's Profile

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Md. Ismail Hossain was born at Chirirbandar in Dinajpur in 1968. He passed SSC examination with 1st division in 1984 from Alokdihi High School. He also passed HSC examination with 1st division in 1986 from Saidpur College, Nilphamari. Then he obtained B.Sc. Ag. (Hons) degree in 1990 (Exam held in 1994) and MS in Crop Botany in 1997 successfully from Bangladesh Agricultural University, Mymensingh. He was awarded with PhD fellowship in 2014 under HEQEP-AIF-UGC program (CP-3021/BAU) and continuing his PhD under the Department of Crop Botany, Bangladesh Agricultural University on germplasm collection and screening of drought tolerant variety of tea. Mr. Ismail joined the Botany Division, Bangladesh Tea Research Institute, Srimangal, Moulvibazar as Scientific Officer in June 1998. He was awarded a Scholarship by Colombo Plan Scheme for "Basic Course in Tea Plantation Management in India" during 1999 -2000. Now he is serving BTRI as Chief Scientific Officer from April, 2017. He has published more than 20 scientific national and international papers. In 2017 Mr. Ismail was awarded a certificate from the honorable Chairman, Bangladesh Tea Board as a successful researcher for release of BT19 as a sweat flavoury and drought hardy clone and BT20 as an excellent cup quality clone. He has developed sustainable vegetative propagation techniques. He has been analyzing tea samples supplied from the factory of the tea estates since 2010. Mr. Ismail is considered to be a professional tea taster and arranging central, valley and group tea tasting session with the participation of professional tea tasters from different broking houses every year. Bearing unique characteristics of health benefitted green tea production and different kind of value added tea production in BTRI facility has been initiated experimentally by Mr. Ismail in June, 2016 by the kind consideration, inspiration and logistic support of honorable chairman Major General Md. Shafeenul Islam, *ndc, psc*. From 2010, Mr. Ismail is conducting a certificate course as a Coordinator and Trainer of "Tea tasting and quality control course for the Army officers of Bangladesh" every year. Mr. Ismail is married and father of 4 Allah gifted lucky sons.

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REQUIREMENT OF LIME IN TEA GROWING AREAS TO IMPROVE GROWTH AND YIELD OF TEA IN BANGLADESH

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Abstract

Yield of tea in Bangladesh is low compared to other tea growing countries of the world. Low pH is one of the main reasons for low yield. To investigate the status of pH level of tea soils, data of different tea estates from 2006 t0 2009 was collected from Bangladesh Tea Research Institute Soil Analytical Reports. Data show that in 2006, optimum pH level (4.5 -5.8) was found in 53% of the samples analyzed whereas in 2009 this level reduced to 26%. It reveals that this optimum range was decreasing gradually per year. On the other hand, percent of soil samples having pH between 4.0 - 4.4 was recorded as 44 in 2006 and it was increased to 59 in 2009.This reveals that pH was decreasing sharply with time. Amount of liming material required to raise pH to certain level depends on initial pH of the soil. This study showed that 2.5, 9.97, 10.14, 14.00 and 17.55 t/ha dolomite were required to raise pH to 5.0 from 4.5, 4.1, 4.0, 3.4 and 3.3, respectively. To find out the impact of lime on the yield in combination with other fertilizers, an experiment consisted of 7 treatments was set up in Sathgao Tea Estate Section 22, Bilashcherra section 8 and section 2. In these experimental areas, calculated amount of dolomite was applied to the treatment along with fertilizers. It was recorded that in Sathgao experimental area the yields of T_6 and T_7 treatments were increased over T_4 and T_5 by 14% and 4.2%, respectively. In Bilashcherra experimental plot 8, yield of T_6 increased over T_4 by 1.6% whereas T_7 increased over T_5 by 6.8%. In case of Bilashcherra section 2, increments of yield were found as 4.4% and 5.8% at the same sequence. Use of fertilizers had also an impact in lowering pH of soil. Effect of liming material was found to vary in two different areas.

Keywords: Dolomitic Lime, Soil pH, Acidity, Efficency of fertilizer, Yield of tea

Introduction

Tea is one of the major cash crops and an export item of Bangladesh. The yield of tea however, is quite low compared to other tea growing countries of the world. Average yield in Bangladesh is 1239 kg/ha, whereas in India, Kenya, Sri Lanka, Argentina and Turkey, it is 1690, 2106, 1684, 2338 & 1921 kg/ha, respectively (ITC, UK, 2015). There are many reasons for such low yields of tea in Bangladesh. One of the main reasons is low soil pH.

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Availability of nutrients to plants depends on optimum pH of the soil. Total content of nutrient in a soil may be high, but it may not be available to plant at optimum level due to the low or high pH of the soil for which plants suffer from toxicity or deficiency of nutrients. In addition to nutrient unavailability, chemical decay of soil occurs when the soil pH goes below 3.9 and produces soluble salicylic acid and hydrated oxides of iron and alumina which also act as cementing materials for the formation of hard pans (Ranganathan and Swaminathan, 1972). This will result in poor aeration, restricted drainage and increased erosion and runoff water. The soil pH can also influence on activities of beneficial microorganisms.

Soil pH ranging from 4.5 - 5.8 is known as favourable for tea cultivation (Hasan *et al*., 1974). Natesen (1999) reported that soil pH of 4.5 – 5.5 is considered to be optimum for the utilization of nutrients especially nitrogen and the growth of tea (Sandanam *et al*., 1978). In Bangladesh, average pH value of different valley circles varies from 3.5 - 5.0. Ahsan (1994) cited referring from BTRI Soil Analytical Report (1984 - 85) that 15% soil had pH less than 4.0, 55% between 4.0 and 4.4, 25 % between 4.5 and 5.0 and 5% above 5.0. This indicates that 70 % soil pH was found below the optimum level for tea growth. This was happened due to high rainfall and extensive use of acid forming fertilizers like ammonium sulphate etc. Karim and Rahman (1980) reported that at low pH, tea growing areas of Bangladesh contain free Al^{3+} ion in soil solution and about 85 percent of the exchange sites are occupied by Al^{3+} ion and its high concentration is noticed to be responsible for interference of the uptake of nutrients, such as Ca, P, Mg, and Fe produces aluminum toxicity resulting in phosphate fixation unless lime is used. Tandon and Kurtz (1968) reported that in high acid soil, many cations like aluminum limit the plant growth and phosphate is likely to be fixed. Chaudhury (1983) also postulated that high concentration of Aluminum is harmful to tea. It inhibits the uptake of P, K and Ca. Besides, low yield and poor quality leaf are also produced from these tea soils.

To increase the yield with perfection of toxicity of soil and to make healthier drink, pH should be increased to optimum level by applying liming materials in soil regularly at required doses. Ahsan (1994) recorded that yield of tea increased up to 22.2% by applying CaO @ 700 kg/ha in mature tea of Madhabpore Tea Estate. Tea accumulates aluminum and fluorine from acidic soil. As a result, aluminum and fluorine in leaf leaches into the tea liquor through infusion; thus posing a serious threat to the health of consumers. So, liming makes good tea as a more hygienic for the consumers of the world. The concentration of these elements in the leaf can be reduced using lime (Fung and Wong, 2004). Moreover, use of lime significantly increases the root length of tea (Chokomi and Gonbad, 2009).

To increasing pH level in your tea garden present practice is to apply 400-600 kg/ha dolomitic lime in the light pruned sections without considering the present pH level of the section. This amount may not be sufficient for increasing pH level to optimum range in order to increase the availability of nutrients. So, it is important to find out amount of liming material required to make the soil a suitable condition for tea growth. With this view, this study was undertaken to know the amount and impact of lime on the pH of soil and yield of tea in Bangladesh.

Materials and Methods

pH data of different tea estates from the 2006-2009 were collected from the advisory reports of Bangladesh Tea Research Institute and categorized into four levels such as below 4.0, 4.0 – 4.4, 4.5 – 5.0 and above 5.0 to see the changing pattern of pH values over the period. For this 3370 pH data were collected. These were converted into percent according to the four categories.

In order to increase the pH to optimum level for maximizing the production, five soil samples were collected from five tea areas located at different topography under two series. Three soils from Bilascherra Experimental Farm(BEF) of BTRI - one from flat area and two from tillah and two from Sathgao Tea Estate- one from flat area and another from tillah to find out actual doses of lime require to increase the pH level to 5.0.

Five soil samples at a depth of 0 - 23 cm were collected from each area. Collected soils were then ground and mixed well to find out the initial nutrient status and to determine the amount of lime required for increasing the pH value to a level of 5.0. For this, an incubation experiment was carried out by applying $Ca(OH)_2$ at doses of 0, 0.02, 0.04, 0.08 g, 0.12, 0.16, 0.2 and 0.24/ 20g soil in moist condition for 25 days. The amount of lime required per hectare was calculated considering treatment of soil by liming materials the depth of 23 cm that is usual in tea cultivation. The calculated amount was then converted into dolomite. Considering the dolomite which would be 90 % purity.

To know the impact of lime on the yield, an experiment consisting of 7 treatments was set up in Sathgao Tea Estate Section 22, Bilashcherra section 8 and Bilashcherra section **2.** The calculated amount of dolomite was then applied to treatment T_6 &T_7 in these three experimental areas. Treatments of the experiment were as follows,

T_1= Control
T_2 = 170kg N/ha + 25 kg P/ha + 125 kg K/ha
T_3 = NPK (Same as T_2) + 50 kg S/ha
T_4 = NPKS (Same as T_3) + 10 kg Zn/ha + 5 kg B/ha
T_5 = NPKS (Same as T_3) + Micronutrients (Same as T_4) + 10 tons Compost
T_6 = Lime (*t/ha) + NPKS (Same as T_3) + Micronutrients (Same as T_4)
T_7 = Lime (*t/ha) +NPKS (Same as T_3) + Micronutrients (Same as T_4) + Compost (Same as T5)

*As liming material, dolomite @ 2.5 , 9.96 and 10.13 t/ha was applied in Sathgao Tea Estate Section 22, Bilashcherra Section 8 and Section 2, respectively, and as fertilizer Urea, TSP, MOP, Gypsum, Zinc sulphate (monohydrate) and Boric acid was applied in all the experimental plots.

Amount of dolomite was applied one month before application of fertilizers. Yield data was recorded for 3 years.

Results and Discussion

Data on pH of soils collected from 2006 to 2009 were computed at 4 categories such as below 4.0, 4.0 – 4.4, 4.5 – 5.0 and above 5.0. The pH range between 4.5 and 5.8 is acceptable as optimum pH for tea in Bangladesh (Hasan et al., 1974). Figure 1 shows that 53 % soils had pH at this level in 2006 whereas in 2009 this was reduced to 26%. This reveals that this optimum pH range was decreasing gradually per year which was an alarming signal. On the other hand, percent of pH between 4.0 - 4.4 was recorded as 44% in 2006 and it was increased to 59% in 2009.This reveals that pH was decreasing sharply. pH less than 4.0 was recorded for 2.54% in 2006 but in 2009 it was found 14.74%. This also indicates that pH was decreasing every year. This decreasing trend of pH was alarming to soil as well as for reduction of yield of tea. Reasons for such decreasing trend pH of the soil were use of nitrogenous fertilizer (SOA & Urea), loss of Ca and Mg from the base through leaching and runoff water by high rainfall and uptake of nutrients by plants through each and every week plucking operation. Another reason was that required amount of liming materials from the analysis report of soil was not applied perfectly to the sections for neutralizing acidity and thus improving the pH level of the soil.

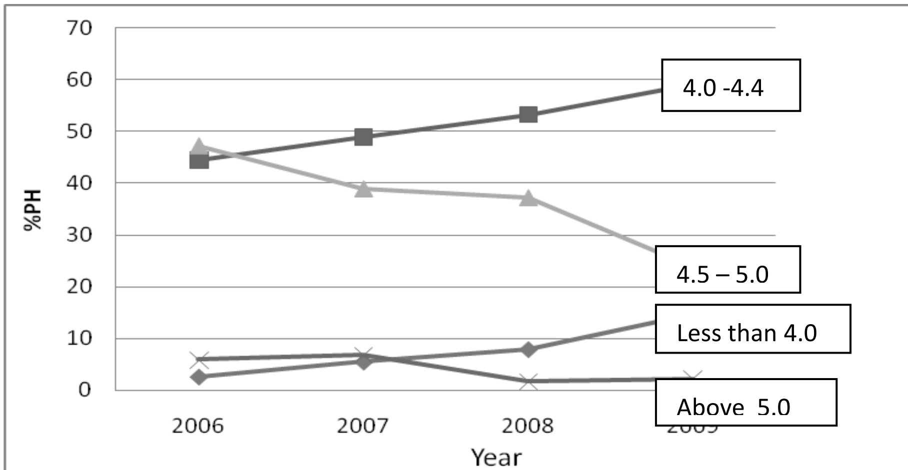

Fig.1 : Changes of different catagoreis of pH level from 2006 to 2009.

A comparative study was also undertaken between the two different periods in order to observe the changes of pH level over the period at 4 categories (Table 1).

Table 1. Changes in the percent pH values with time

pH range	Percent of pH level	
	During 1984-85	During 2006-2009
Less than 4.0	15	7.64
4.0 – 4.4	55	51.5
4.5-5.0	25	36.8
Above 5.0	5	4.1

It is revealed from the Table- 2 that percent of optimum pH range (4.5 to above 5.0) during the period 1984 – 85 was 30% (Ahsan, 1994) where as during the period 2006-2009 it was 40.09 %. This indicated that optimum pH level during 1984-85 was less than that of 2006-2009 by 10.09% and pH level less than 4.0 was about double that of 2006-2009. Reasons for such low pH level during the period 1984 – 85 was use of higher acid forming ammonium sulphate and trace or no use of liming material because ammonium sulphate made more acidity than urea. Later use of urea instead of ammonium sulphate and use of lime helped in improving the situation.

Present practice of tea growing fields of Bangladesh for optimum growth of tea pH might be around 5.0. So, in tea growing areas of Bangladesh to increase the optimum pH values at 5.0 and to find out the increase of yield due to liming material in the experimental areas, amount of dolomite which was calculated from incubation method is presented in the Table 2.

Table 2. Initial pH and amount of lime required for the experimental plots and other areas

	Sampling areas				
	Experimental area			Other areas	
	Sathgao TE (Flat)	Bilashcherra BEF (Flat)	Bilashcherra BEF (Tillah)	Sathgao TE (Tillah)	Bilashcherra BEF (Tillah)
Initial pH (Average)	4.5	4.1	4.0	3.4	3.3
Amount of Dolomite required to raise pH to 5.0 (t/ha).	2.50	9.96	10.13	14.00	17.54
Amount of Dolomite /unit rise of soil pH (t/ha).	5.00	11.07	10.14	8.75	10.33

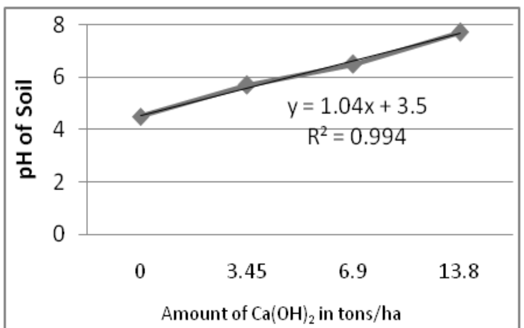

Fig-2: Lime requirement of the experimental area in Sathgao -22

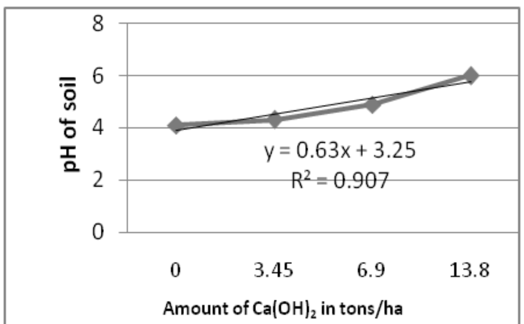

Fig-3: Lime requirement of the experimental area in Bilascherra sec-8

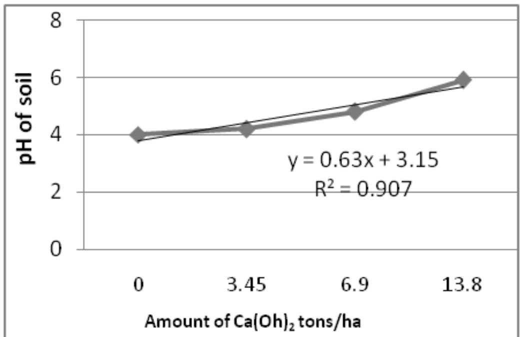

Fig-4: Lime requirement of the experimental area of Bilashcherra Tilla-2

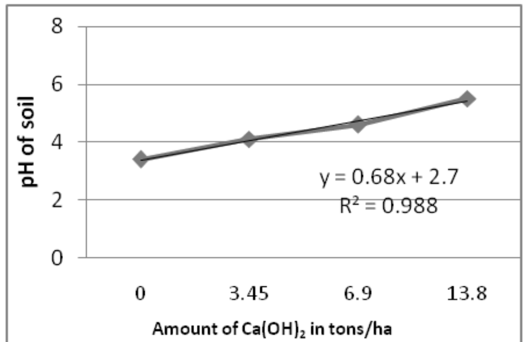

Fig-5: Lime requirement of Sathgao tilla

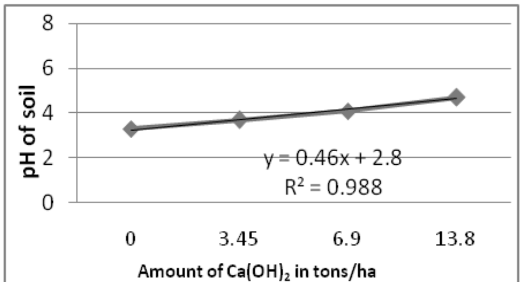

Fig-6: Lime requirement of Bilashcherra (Tilla)

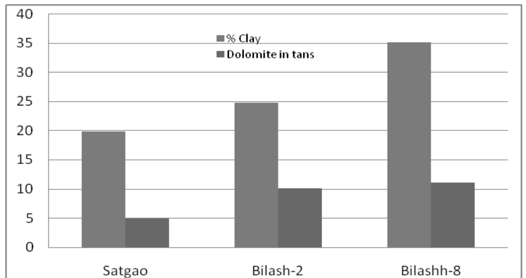

Fig. 7. Relation between percent of clay in soil and amount of dolomite required to raise pH of one onit

It is evident from Table-2 that initial pH level of tillah areas was low (3.3 & 3.4) compared to flat areas (4.1 & 4.5). Wash out of bases in the tillah areas is high which may be the main reasons for low pH. Figure 2 to 6 show that the response of lime in increasing pH are linear irrespective of topography and the slopes of the curves is also similar whereas amount of lime required to increase pH to 5.0 was different due to its initial pH value. Moreover, amount of lime required to increase one unit of pH was not same. A positive correlation was found between percent of clay in soil and amount of lime required (Fig.7). Percent of clay content in soil of Sathgao flat, Bilashcherra tillah and Bilashcherra flat was 19.9, 24.8 and 35.14, respectively, whereas amount of dolomite required to raising one unit pH was 5, 10.14 and 11.07 t/ha, respectively.

In respect of applied fertilizers, the effect of T_4 was similar to T_6 and T_5 was similar toT_7.To find out any impact of lime, dolomite was applied to T_6 and T_7. A positive impact of lime was recorded from all the experimental plots. From the Table 4, it was found that in Sathgao experimental area yield of tea resulted from T_6 & T_7 treatments were increased over T_4 & T_5 by 14% and 4.2%, respectively. In Bilashcherra experimental section 8, yield due to T_6 treatment increased over T_4 by 1.6% whereas T_7 resulted 6.8% increase over T_5 treatment. In case of Bilashcherra section 2, increase of yield were recorded as 4.4 & 5.8% at the same sequence. According to Ahsan (1994) yield of tea increased up to 22.2% by applying CaO in mature tea of Madhabpur Tea Estate. Increase of 3 - 8 % yield was also recorded at different tea growing areas by applying lime over other fertilizers (Kibria, 2001).

Table 3. Three years average yield of the experimental plots

3 years average yield of tea in kg/ha							
Expt. Area	T_1	T_2	T_3	T_4	T_5	T_6	T_7
Sathgao-22	2305	2657	2791	2628	2671	2997	2783
Bilashcherra-8	1782	2022	2031	1973	2018	2004	2155
Bilashcherra-2	1678	1846	1857	1856	1796	1938	1900

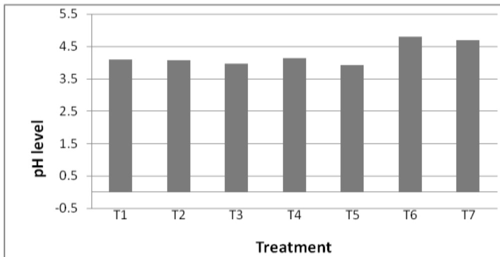

Fig. 8.Three years average pH of Bilashcherra-2

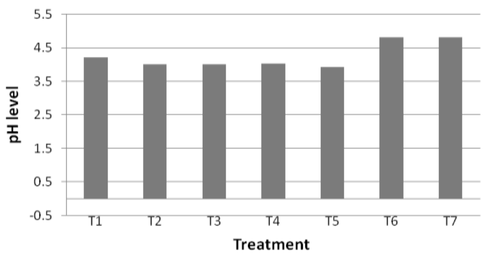

Fig. 9.Three years average pH of Bilashcherra-8

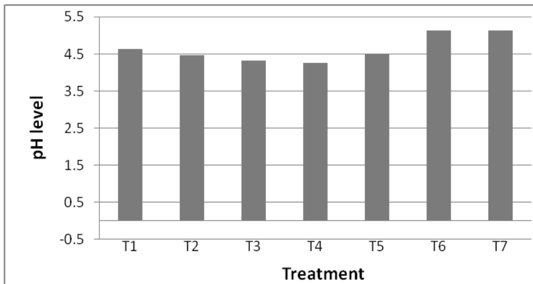

Fig. 10. Three years average pH level of Sathgao-22

It was observed from the figure 8 to 10 that pH of T1 where no fertilizer was applied was found almost constant. But pH value due to treatments T_2, T_3, T_4 and T_5 decreased slightly where fertilizers were applied. Comparatively only NPK had less impact in lowering pH than NPK with S, B and organic matter. This reveals that fertilizers have influence on the change of soil pH.

pH level of soils due to treatment T_6 & T_7 was found slightly above 5.0 in Sathgao experimental area. But in Bilashcherra experimental areas, pH level was found lower than 5.0 though amount of required dolomite applied per unit rise of pH was higher than that of Sathgao experimental area. This reveals that efficiency of liming material was not same for the two different areas. Clay mineral characteristics and amount of clay may be the contributing factors for the efficiency of lime effects.

Conclusion

The pH range of Bangladesh tea soil lies between 4.5 and 5.8. Most of the tea soils in Bangladesh are acidic in reaction having pH values less than 5.0 and this is mainly continuous application of nitrogenous fertilizer (urea) and high rainfall. This would create a nutrient imbalance and subsequently affect the growth and yield of tea plants. It is important to change the pH of the soil at optimum levels by application of lime after assessing the pH value of the soil. Optimum use of lime increases the availability of nutrients and as a consequence improves tea yield.

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EFFICACY OF LEAF EXTRACTS OF SOME INDIGENOUS PLANTS IN CONTROLLING *COLLETOTRICHUM GLOEOSPORIOIDES* (PENZ.)- DIEBACK DISEASE OF TEA

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Abstract

The efficacy of leaf extract of Arjun (*Terminalia arjuna*), Bashok (*Adhatoda vasica*), Neem (*Azadirachta indica*), Bishkatali (*Polygonum barbatum*) and Lemon grass (*Cymbopogon citratus)* against *Colletotrichum gloeosporioides*- a pathogenic fungi of tea were studied. *In-vitro and in-vivo* studies were carried out during 2011 to August 2015 at Bangladesh Tea Research Institute (BTRI). Leaves of tested plants were collected locally and extracts were obtained through water extraction method. The pathogen was isolated on PDA and growth inhibition was tested with these extracts @ 1, 1.5 and 2% by using poisoned food technique. On the basis of *in-vitro* result, the extracts were applied in the field @ 2%. In laboratory condition, less than 50% efficacy was found for 1 and 1.5% of all extracts except *Adhatoda vasica* (>80%) and more than 50% efficacy was found for 2% for the same. In field condition, minimum disease development regarding lesion size both in 7 DAS (3.43%) and 15 DAS (6.91%) were observed in *Adhatoda vasica* treated tea shoots. Maximum disease development (77.77%) was found in untreated control. Lesion size was found to be increased by less than 50% up to 7 DAS for all the treatments, while it was exceeding 50% and reached 66.06% in *Polygonum barbatum* treated tea shoots upto 15 DAS. On the other hand, lowest disease index (19.99) and 86.66% growth inhibition of the pathogen after 15 DAS were also observed in *Adhatoda vasica* treated tea shoots. From the results of the study it was found that the leaf extract of Bashok (*Adhatoda vasica*) @ 2% can be used as a bio fungicide to control *Colletotrichum gloeosporioides* (Penz.) causing dieback disease in tea.

Keywords: Leaf extracts, Dieback disease, Tea.

Introduction

Tea is the most popular and inexpensive non-alcoholic beverage crop. It has been cultivated in more than 50 countries. Tea being a perennial crop is prone to attack by many pests and diseases. The majority of the diseases in tea are of fungal origin. More than 400 pathogens cause various diseases in tea (Chen and Chen, 1990) viz., foliage, stem and root. A fungus *Colletotrichum gloeosporioides* is responsible for causing dieback disease of tea. Die-back of tea is one of the major diseases in Bangladesh both in mature and nursery tea plants. During the late 1960s, it was recorded on the India clone TV9 and reported to be widespread in tea, in

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permanent and temporary shade trees, green crops as well as in rubber plantations in Bangladesh (Ali *et al.*, 1993). Die-back disease of tea was first noticed in the year 1984 in Nucleus Clone Plot (NCP) of Bangladesh Tea Research Institution (BTRI) on the clone BT4. More than 40% of tea bushes were found to be attacked by the disease. In the same year the disease was reported in Tipracherra tea estate where 30% of the seed nursery beds were affected. About 55–60% of the plants died due to this disease. Though the disease was first noticed in the NCP, later the same disease was also found in the nursery as well as mature plantation (Huq, 1997). Chemical control measures are effective in controlling tea diseases so far (Premkumar and Baby, 2005). Continuous use of chemical fungicides in the management of disease also brought new problems with them. More alarming amongst them are pollution of air, water, soil, residual toxicity, development of resistance in pathogen against chemicals and harmful effects on non-target organisms. The fungal growth may cause decrease in germinability, discolouration of grain, loss in weight, biochemical changes and production of toxins (Sinha *et al.,* 1993). Consequently, there has been alarming development of harmful environment for human beings. Contrary to the problems associated with the use of synthetic chemicals, botanical and biocontrol are environmentally non pollutive, renewable, inexhaustible, indigenously available, easily accessible, largely non phytotoxic, systemic ephemeral, thus readily biodegradable, relatively cost effective and hence constitute as suitable plant protection in the strategy of integrated disease management. Hence, screening of plant products for its effective antifungal activity against the pathogen is essentially required to minimize the use of fungicides and to consider as one of the component in the integrated disease management (Khadar, 1999 and Nagesh, 2000). The present study was undertaken to investigate the suitable plant extracts and their concentrations for controlling *Colletotrichum gloeosporioides* and to determine the antifungal activity of crude extracts of *Terminalia arjuna* (Arjun), *Adhatoda vasica* (Bashok), *Azadirachta indica* (Neem), *Polygonum barbatum* (Bishkatali) and *Cymbopogon citratus* (Lemon grass) against *Colletotrichum gloeosporioides* of tea.

Materials and Methods

Both *Invitro* and *invivo* studies were carried out during 2011 to 2015 at Bangladesh Tea Research Institute (BTRI), Srimangal. *Invitro* study was performed at Plant Pathology laboratory and *invivo* study at Nucleus Clone Plots (NCP) and nursery of main field of BTRI.

Isolation of Pathogen

Colletotrichum gloeosporioides (Penz.) was isolated from infected shoots of tea plants by using potato dextrose agar (PDA) medium. The fungus was purified by single spore isolation technique and identified on the basis of morphological and cultural characteristics.

Plant extract preparation

A total of five plants like Arjun (*Terminalia arjuna*), Bashok (*Adhatoda vasica*), Neem (*Azadirachta indica*), Bishkatali (*Polygonum barbatum*) and Lemon grass (*Cymbopogon citratus)* were used in the study. The leaves of these plants were collected locally and cleaned properly. Stock solution of all the plant species were prepared by soaking the crushed plant leaves in sterilized water for 24h at room temperature. The solution was sieved by passing through three layer of muslin cloth. The concentrations of 1, 1.5 and 2% were prepared by adding appropriate quantity of sterile distilled water into the stock solution.

Invitro study

For bioassay, 5ml of extract was mixed with 20ml/ plate sterile PDA medium. The without plant extract medium was served as control. For each treatment five replications were maintained. These plates were inoculated with 5mm disc of freshly grown cultures of *Colletotrichum gloeosporioides and incubated at* room temperature (28±1°C). Observation for antifungal activity was recorded 72 hours after incubation. Fungal growth inhibition was calculated as average of the growth diameter in each treatment relative to its growth in control.

Invivo study

On the basis of the *invitro* study, the *invivo* study was executed only with 2% concentration. The extract solution was applied on the dieback infected tea shoots. Disease progress was recorded by measuring lesion size on the shoots. After application of the extract, inocula of the tea shoots were also plated with PDA media. Observation for antifungal activity was recorded 72 hours after incubation. Fungal growth inhibition was calculated as average of the growth diameter in each treatment relative to its growth in control. For each treatment five replications were maintained.

Data analysis

Finally collected data were analysed statistically by using MSTAT and SPSS programme.

Results and discussion

In laboratory condition, less than 50% efficacy was found for 1 and 1.5% of all extracts except *Adhatoda vasica* (Bashok) (>80%) and more than 50% efficacy was found for 2% for the same. This *ivitro* study also showed that all plant extracts @ 2% concentration inhibit the mycelial growth above 50%. all other concentrations showed less than 50% of that. Among these extracts of Basak showed no mycelial growth of the pathogen. It inhibited 100% growth of the pathogen at all concentrations (Table 1).

Based on these results, the extracts were applied in the field as *invivo* study only at 2% concentration. In field condition, minimum disease development regarding lesion size both in 7 DAS (3.43%) and 15 DAS (6.91%) were observed in *Adhatoda vasica* treated tea shoots. Maximum disease development (77.77%) was found in untreated control. Lesion size was found to be increased by less than 50% up to 7 DAS for all the treatments, while it was exceeding 50% and reached 66.06% in *Polygonum barbatum* treated tea shoots up to 15 DAS. On the other hand, lowest disease index (19.99) and 86.66% growth inhibition of the pathogen after 15 DAS were also observed in *Adhatoda vasica* treated tea shoots. The lowest and identical (10.11%) disease development was recorded with *Adhatoda vasica* (Basak) after 15 days of application. While, it was more than 50% for other treatments. In control plots it was found highest (82.72 %) after same days. On the other hand lowest disease index was found with *Adhatoda vasica* (Basak). Though other extracts control the disease development compared with the blank treatment, but these were negligible (Table 2). Subsequent *Invitro* study showed that *Adhatoda vasica* (Basak) extract @ 2% concentration inhibits the mycelial growth to 86.66% (Table 3). All other extracts showed negligible inhibition with around 60%. In comparison, effectiveness of Tulsi leaf extract against *C. gloeosporioides* is supported by the work of Patel and Joshi (2001) where they reported that tulsi leaf extract was ineffective in inhibiting the mycelial growth of the fungus *Colletrotrichum gloeosporioides*.

Table 1. Effect of five leaf extracts on the growth of *Colletotrichum gloeosporioides* at different concentrations in *invitro* condition

Treatments	Concentration (%)	Mycelial growth of *C. gloeosporioides* (cm)	Growth inhibition (%)
Arjun (*Terminalia arjuna*)	1%	5.00 d	44.44
	1.5%	4.63 f	48.55
	2%	4.06 h	54.88
Bashok (*Adhatoda vasica*)	1%	0.00 i	100.00
	1.5%	0.00 i	100.00
	2%	0.00 i	100.00
Neem (*Azadirachta indica*)	1%	5.00 d	44.44
	1.5%	4.86 e	46.00
	2%	4.50 g	50.00
Bishkatali (*Polygonum barbatum*)	1%	5.50 b	38.88
	1.5%	5.13 c	43.00
	2%	4.50 g	50.00
Lemon grass (*Cymbopogon citratus)*	1%	5.50 b	38.88
	1.5%	4.63 f	48.55
	2%	4.50 g	50.00
Control	-	9.00 a	-

Table 2. Effect of five leaf extracts on the development of Dieback disease (*Colletotrichum gloeosporioides*) at 2% concentration in field condition

Treatments	**Lesion size (cm)**					**PDI**	
	Initial	**7 DAS**	**Increase (%)**	**15 DAS**	**Increase (%)**	**Initial**	**15 DAS**
Arjun	4.25	5.47	28.43 b	6.53	53.53 b	56	64
Bashok	5.24	5.47	4.38 c	5.77	10.11 c	52	56
Neem	5.16	6.77	30.98 ab	8.43	63.23 b	36	48
Bishkatali	5.27	7.43	40.77 ab	9.43	64.57 b	48	64
Lemon grass	6.23	8.13	30.49 ab	9.43	51.35 b	48	64
Control	5.73	8.17	42.47 a	10.47	82.72 a	36	64

DAS: Day After Spray

Table 3. Effect of leaf extracts @ 2.0% of different indigenous plants on the growth of *Colletotrichum gloeosporioides* in laboratory condition

Treatments	**Mycelial growth of *Colletotrichum gloeosporioides* (cm)**	**Growth inhibition (%)**
Arjun (*Terminalia arjuna*)	3.88	56.88
Bashok (*Adhatoda vasica*)	1.20	86.66
Neem (*Azadirachta indica*)	3.00	66.66
Bishkatali (*Polygonum barbatum*)	3.57	60.33
Lemon grass (*Cymbopogon citratus)*	3.75	58.33
Control	9.00	00

Conclusion

From the results of the study it can be concluded that the leaf extract of Bashok (*Adhatoda vasica*) @ 2% can be used as a bio fungicide to control *Colletotrichum gloeosporioides* (Penz.) causing dieback disease in tea.

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BECANO 50 SC- A PROMISING PRE-EMERGENT HERBICIDE IN TEA

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Abstract

Two experiments were carried out at Bangladesh Tea Research Institute (BTRI) and Bilascherra experimental farm, BTRI with a new pre-emergent herbicide BecAno 50 SC to investigate the efficacy and suitability for controlling weeds in tea. It was applied both in nursery and in young tea fields containing sufficient soil moisture. The test herbicide was diluted in 400 L of water per hectare. Degree of weed control was recorded visually at monthly interval on 0%= no control and 100% = complete control basis. BecAno 50 SC @ 150, 200 and 250 ml ha^{-1} shown 100% weed control after 4 months of application and 90 to 100% control was recorded after 6 months of application compared to untreated control. The standard Chinochlor 5G @ 20 kgh^{-1} had shown 80% growth inhibition of weeds. Significant *($P_{0.05}$)* reduction (96%) in dry weight with BecAno 50 SC 150 ml ha^{-1} was assessed after 6 months of application. The results indicated that BecAno 50 SC @ 150, 200 and 250 ml ha^{-1} suppressed weeds more effectively up to 6 months in nursery as well as in young tea. No adverse effect was found on young tea but, mortality of cuttings and inhibition of seed germination were observed in primary beds. The herbicide BecAno 50 SC @ 150 ml ha^{-1} is recommended for tea plantation except nursery containing sufficient soil moisture to check the germination of weed complex.

Keywords: BecAno, Indaziflam, Pre-emergent, Tea complex.

Introduction

Weed management in tea of Bangladesh by chemical means is based on few herbicides viz. Paraquat, Glyphosate, 2, 4-D, Butachlor, Triazine, Glyphosate+2, 4-D mixture etc. (Anon., 2013). Use of post-emergence herbicides like Paraquat and Glyphosate, and pre-emergence herbicides like Butachlor and Triazine required repeated spraying with higher doses. Persistency of these herbicides in plant systems and in aerobic soil environment is very less, that's why the planters spent considerable amount of total budget to control weeds year after year. So, it is therefore, needed to select herbicides in such a way that the planters incur less losses by applying minimum spray with low application rate. BecAno 50 SC, a new pre-emergence herbicide was received from Bayer CropScience during 2013 for evaluation against tea weeds. The herbicide is a derivative of N-[(1R, 2S)-2, 6-Dimethyl-2, 3-dihydro-1H-inden-1-yl]-6-(1-fluoroethyl)-1, 3,5-triazine-2,4-diamine. Its chemical name is Indaziflam ($C_{16}H_{20}F_1N_5$) belongs to the alkylazine class of chemistry, being used as a pre-emergence, non-selective herbicide providing extended residual control of weeds in established

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permanent crops like citrus, grapes, fruits trees, nuts, sugarcane, lawns, turf farms, forest areas etc. throughout the world (Anon., 2012; Henry *et al.* 2012; Mahoney and Unland, 2010). It has the potential to control a broad spectrum of mono- and dicot weeds emerging from seeds, roots, rhizomes, runners and provides a long time growth inhibiting effect at low application rates (Brosnan *et al.* 2010). Functionally, the alkylazines work by inhibiting celluloses biosynthesis and decompositions of celluloses in the meristematic cell wall and finally prevents cell formation, cell division and cell enlargement (Spak and Myers, 2010; Zandstra, 2013). Indaziflam acts as soil herbicides hence, it has to be sprayed on the soil surface. It caused damage to the crop when accidentally sprayed on the parts of the crop foliage. Compared to some others pre-emergent herbicides, Indaziflam is more water soluble, mobile and persistent in aerobic soil environment, so it provides most effective weed control when adequate soil moisture is available and the application is followed by rain or irrigation event (Senseman, 2007; Tompkins, 2010). Indaziflam applied on soil with insufficient soil moisture might allow weeds to emerge. Therefore, the current experiment was designed to test the suitability of BecAno 50 SC for managing weeds in nursery as well as in young tea sections.

Materials and Methods

Experiment 1: The nursery experiment was conducted at Bangladesh Tea Research Institute (BTRI Farm) in the year 2013. The treatments were, T_0 = Control, T_1 = BecAno 50 SC @ 50 ml, T_2= BecAno 50 SC @ 100 ml, T_3= BecAno 50 SC @ 150 ml, T_4= BecAno 50 SC @ 200 ml, T_5= BecAno 50 SC @ 250 ml and T_6= Chinochlor 5G @ 20 Kg ha^{-1} mixed in 400 L of water. The treatments were applied on clean and weed free plots containing sufficient soil moisture. The size of each plot was 10 m^2. Fifty nodal leaf cuttings of tea were planted and fifty tea seeds were sown in each plot after application. Each treatment was replicated three times following Randomized Complete Block Design. Intercultural operations and observations were made during the period of the experiment.

Experiment 2: Field experiment was carried out with same treatments at Bilashcherra Experimental Farm, BTRI during the year 2013. The treatments were applied on weed free young tea (2 years of old) plots containing sufficient soil moisture. The size of each plot was 25 m^2. The herbicide was diluted in 400 L of water per hectare. Each treatment was replicated three times following Randomized Complete Block Design. Further intercultural operations were made during the period of the experiment.

In both the experiments, data was collected in terms of % germination of mixed weeds. The efficacy of the tested herbicide was assessed by visual rating on a 100 point scale with 0 as "no control" and 100 taken as "full control" (Ali and Islam, 2011). Adverse effects of BecAno 50 SC on tea seed germination, mortality rate of tea cuttings and phytotoxic effect (if any) on young teas were also recorded. Data collection was started from one month after spraying of the treatments in ordered to allow sufficient time for weeds to emerge. Observations were continued at monthly intervals. After six months of application, all the germinated weed species from each plot were carefully uprooted and separated first into broad-leaf weeds and grasses. The separated weeds were then identified into component species. The identified weeds were dried in open sunlight for 72 hrs for dry weight estimation. The recorded data were analyzed statistically.

Results and Discussion

The germination of both monocot and dicot weed species in vegetative propagation (VP) nursery were found to be started after 2 and 3 months of application in T_1 and T_2 plots respectively. In untreated control plot (T_0), it was found that the germination of weed species was more than 50% after one month and after 3 months both species reached up to 100%. In treatment T_3, no germination of weed species (both dicot and monocot) was observed (0%) after one month and after 6 months it was only 5-10%. 20% germination was recorded after 6 months in the standard (T_6). No germination (0%) of any weed species was observed during the period of experiment in the treatments of T_4 and T_5 (Fig. 1 and Fig. 2). (As the effect of BecAno 50 SC on weed regeneration in young tea assessed by visual scoring was almost similar to the degree of control achieved in nursery. Only the results obtained from nursery are presented). It is clear that BecAno 50 SC @ 200ml and 250ml /ha shown 100% control at the end of 6 months after application. On the other hand, at the end of 4 months, the BecAno 50 SC @ 150 ml /ha shown 100% control of monocot and dicot weeds, after 6 months it was above 90%. The other two lower doses such as 50ml and 100ml /ha shown below 75% control after 6 months (Fig. 3 and 4). Excellent (100%) result was achieved with BecAno 50 SC @ 200 ml and 250 ml /ha. The degree of weed control achieved with 150ml /ha was (90%) satisfactory and this could be a suitable rate of application to control weed population in tea. Similar results were obtained by Kappro and Hall (2012) in turf and forestry by using Indaziflam and Kathiravetpillai and Punyasiri (1985) and Sandanam *et al.* (1985) by using oxyfluorfen in tea. Sharma (1980) found that the pre-emergence efficacy of herbicides increased linearly with the doses and gave satisfactory control for 12 weeks.

The dry weight of predominant weed species including broad-leaf types like *Ageratum conyzoides, Borreria hispida, Blumea lacera, Leucas aspera, Mimosa pudica,* as well as grasses and the less prevalent weeds were drastically reduced by BecAno 50 SC @ 150ml /ha compared to the effect of Chinochlor 5G when applied in young tea as well as VP nursery (Table 1). The dry weight reduction of weeds was measured as 96% with BecAno 50 SC @ 150ml /ha and 93% was observed with Standard Chinochlor 5G. Sandanam (1983) noted that Oxyflourfen reduced the dry weight of weed species compared to Diuron. From the results, it was observed that the control percentage of broad leaves and grasses was more or less same (90-95%) after 6 months and statistically significant at 5% level. Control of different weeds in the five herbicidal treatments tested varied and rather uniform with respect to *Cyperus rotundus* and *Cynodon dactylon* which appeared to be higher number in plots treated with 50, 100 and 150ml /ha of BecAno 50 SC. In control plots (untreated), about 10 weed species were recorded which are listed in Table 3. In nursery, the adverse effect was found on seed germination as well as on tea cuttings. But no phytotoxic symptoms were observed with soil application of BecAno 50 SC @ 150ml /ha in young tea. Similar result was obtained by Rao and Kotoky (1981) and Shandanam (1983) in case of applying oxyflurofen in tea. Kappro and Hall (2012) were also observed that Indaziflam has no adverse effect on human health and environment.

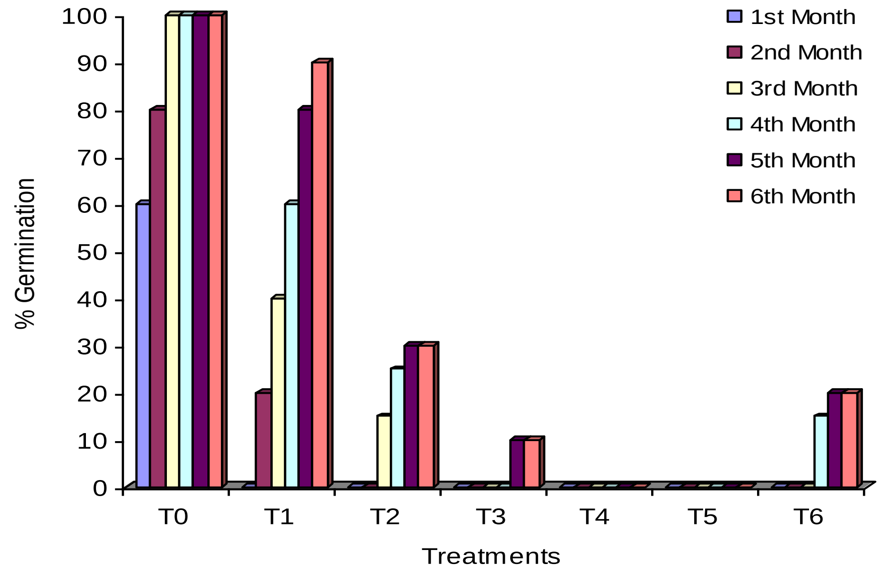

Figure 1. Percent germination of monocot weeds after six months in different treatment of BecAno 50 SC compare to the Chinochlor 5G.

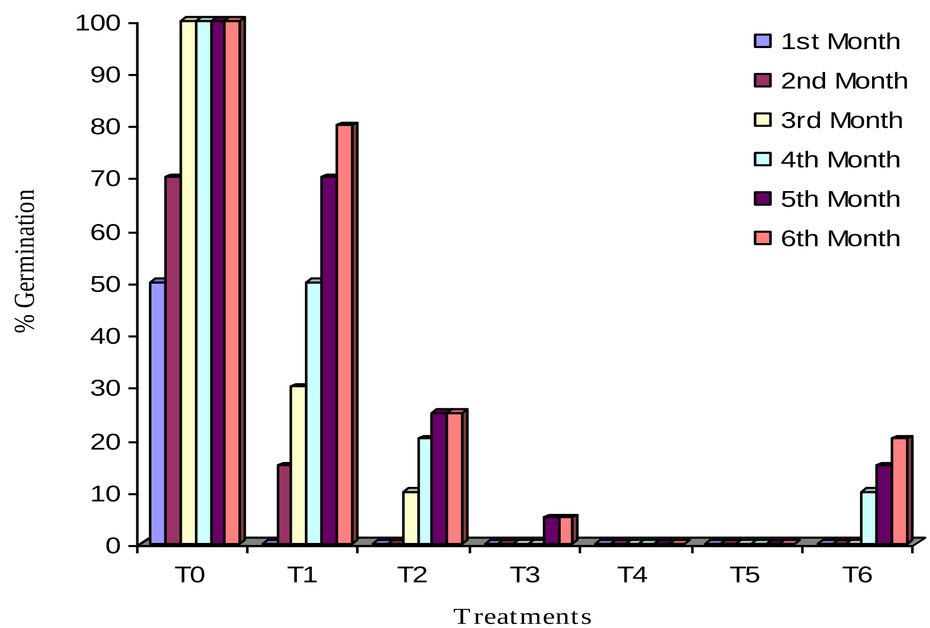

Figure 2. Percent germination of dicot weeds after six months in different treatment of BecAno 50 SC compare to the Chinochlor 5G

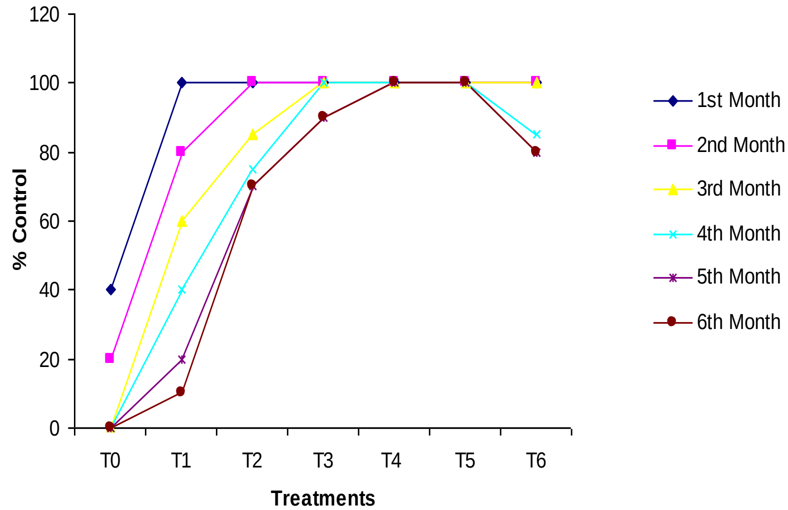

Figure 3. Percent control of monocots after six months in different treatment of BecAno 50 SC compare to the Chinochlor 5G

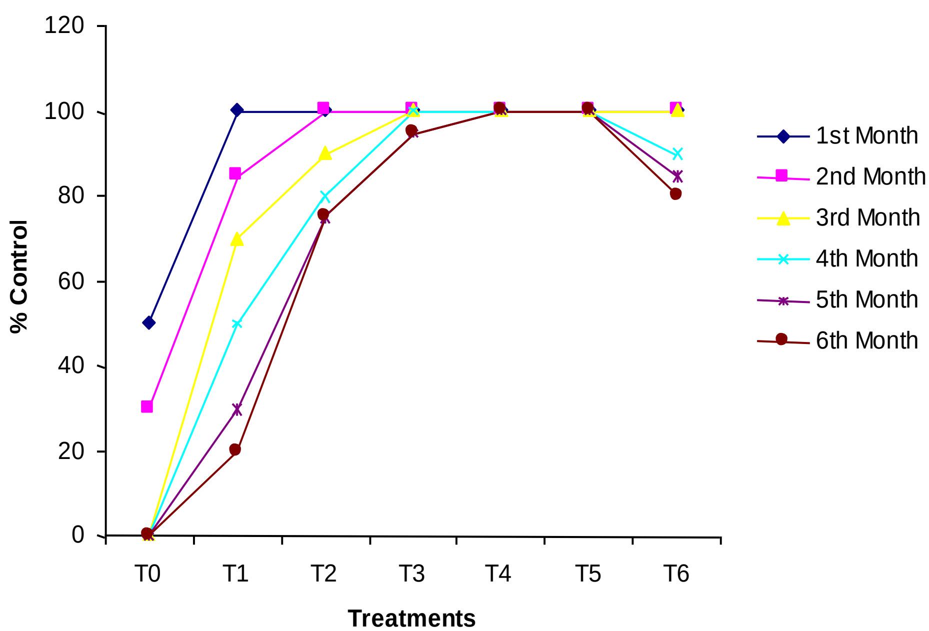

Figure 4. Percent control of dicots after six months in different treatment of BecAno 50 SC compare to the Chinochlor 5G

Table 1. Effect of different treatment on dry weight (g) of weeds after 6 months of application (mean of 3 replications)

Treatments	Weight of dry matter(g) of weeds			% control
	Dicots	Monocots	Total	
T_0	980	840	1820	00
T_1	400	350	750	58
T_2	150	250	400	78
T_3	30	40	70	96
T_4	00	00	00	100
T_5	00	00	00	100
T_6	50	70	120	93
$LSD_{0.05}$	*3.99*	*3.40*		

Table 2. Effect of different treatments on tea cuttings and tea seeds after 6 months of application

Treatment	No. of tea cuttings	Mortality%	No. of tea seeds	Mortality%
T_0	45	00	42	00
T_1	35	22	30	28
T_2	15	66	12	71
T_3	00	100	00	100
T_4	00	100	00	100
T_5	00	100	00	100
T_6	40	11	40	5

Table 3. Major weed species found in control plots

Grasses	**Broad leaves**
Cyperus rotundus	*Borreria hispida*
Cynodon dactylon	*Mimosa pudica*
Elusine indica	*Blumea lacera*
Imperata cylindrica	*Ageratum conyzoides*
Digitaria sanguinalis	*Leucas aspera*

Conclusion

The result of the study indicated that BecAno 50 SC was a promising pre-emergence herbicide for weed control in tea plantations. It was suggested to spray in tea plantation having sufficient soil moisture one time per annum @ 150 ml /ha diluted in 400 L of water. It is not recommended to spray in nursery beds because of high mortality of cuttings and failure of seed germination.

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A CASE STUDY ON TEA PRODUCTION AT NORTHERN BANGLADESH

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Abstract

The history of tea production in Bangladesh is more than 150 years old and it was concentrated mainly in greater Sylhet and Chittagong districts. To meet up the domestic consumption as well as to export this commodity, it was a challenge to increase the total production of tea through cultivating in new areas. And so in 2000 A.D, tea plantation was introduced in northern Bangladesh particularly at Panchagarh. Within a short period of time, about 1,500 ha land is added to the total tea extent and contributing more than 2.5 million kg made tea in the national production.

Key words: Tea, Northern Bangladesh, Small holders

Introduction

As a developing country, we have a few export items and among those tea is a legend one. The tea industry of Bangladesh is not only providing to earn foreign currency but also provides a lot of employment. In fact, due to high population growth and rapid urbanization these days we have a little share of tea to export after meeting up the domestic consumption. It is pertinent to mention here that tea production in Bangladesh is increasing @ 1.1% per year where as domestic consumption of tea is increasing @ 3.5% per year (BTB, 2015). It is predicted by the experts that if substantial increase in production does not take place then Bangladesh will become a net tea importer in next few years. Realizing the above facts, Bangladesh Tea Board and Government of Bangladesh have taken decision to extend the tea plantation in different new suitable places of Bangladesh through introducing small holding tea cultivation system. After implementing that system, more than 2.5 million kg made tea added from the northern districts to the national tea in 2015 and total tea production of the country was about 67.38 million kg (Anonymous, 2015). Moreover, many unemployed people of this area have been involved in tea sector for their earning. Anyone can consider it as a small revolution of socio-economic condition of this backward community which has occurred due to adopt the small holding tea cultivation concept in this area.

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Small holding tea cultivation concepts

Like other countries of Indian sub-continent, plantation of tea initiated in Bangladesh during the British period 1827-1857 and it was concentrated in greater Chittagong and Sylhet districts (Zaman, 1989). Having a large scale of tea plantations in this area (58,096 ha), it is controlled by 160 tea estates. In most of the major tea producing countries e.g. India, Kenya, Sri Lanka, Indonesia etc. are greatly established with small holding tea cultivations co-existing with tea estates. In Sri Lanka, tea smallholdings sector is considered as the most dynamic segment of the tea sector as it represents 59% of its total tea extent and contributes more than 65% to the national tea production (Amarathunga *et al.*, 2008). The idea of establishing small holding tea cultivation in Bangladesh is rather new and first introduced in the Tea Policy of 1984-85 (Ahmed, 2014). Thereafter, a few tea professionals of the country took certain positive steps to promote small holding tea cultivation at Tetulia in Panchagarh district by forming a company, namely Tetulia Tea Company Limited (TTCL) which was a private initiative (TTCL, 2000). Soon a joint venture project of Bangladesh Tea Board and Rajshahi Krishi Unnayan Bank (Agricultural Development Bank) was launched entitled "Development of Small Holding Tea Cultivation in Northern Bangladesh". With a humble beginning of tea cultivation in 2000 A.D, the area and production both are gradually increasing.

Soil and climatic condition

Locally, Panchagarh is considered as the daughter of Himalaya. Being the foot hill of Himalaya, a vast area of this zone is under plain land. The physio-chemical properties of soil are favourable for tea cultivation e.g. soil texture (sandy loam), pH (4.5-5.5), organic matter (1-2%), nitrogen (0.1-0.2%), available phosphorus (10-30 ppm), potassium (40-80 ppm), calcium (100-150 ppm) and potassium (15-30 ppm).

As the area is closer to the Himalaya, during the winter minimum temperature goes down at about 8 ^{0}C and during the summer maximum temperature is as high as 45 ^{0}C. The average annual rainfall is about 1600 mm which is enough for tea cultivation but this rainfall is not uniformly distributed. To minimize the effect of high temperature and drought, growers are providing dense shade in their plantations and applying water through irrigations. Growers who are capable, using sprinkler irrigation system but most of them are applying water through flood irrigation system with shallow pump of 4.0-4.5 HP. In this area, it is the major threat to save the tea bushes from drought. Like the temperature and rainfall, relative humidity of the atmosphere also varies heavily (55-90%).

Planting materials used for tea

Being a newly planted tea area, all most 100 per cent tea of Northern Bangladesh is under clonal tea. Hence the average yield of tea and its quality are better than the traditional tea of Bangladesh. Among the 18 tea clones released from Bangladesh Tea Research Institute (BTRI), growers are mainly cultivating BT2. As this area is lying with the Indian border of West Bengal, many Indian clones are available here particularly the Tocklai varieties e.g. TV23, TV25 and TV26. In 2015, a total of 2521,921 kg tea was manufactured in six tea factories. In 2015, average yield of tea in this area was 2,500 kg/ha which was significantly higher than the national average yield 1,270 kg/ha showed in Figure-1 (Anonymous, 2015).

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Alam (1994) stated that out of the total tea plantation about 90% are seedling tea and it is the main reason for limiting the tea production in Bangladesh.

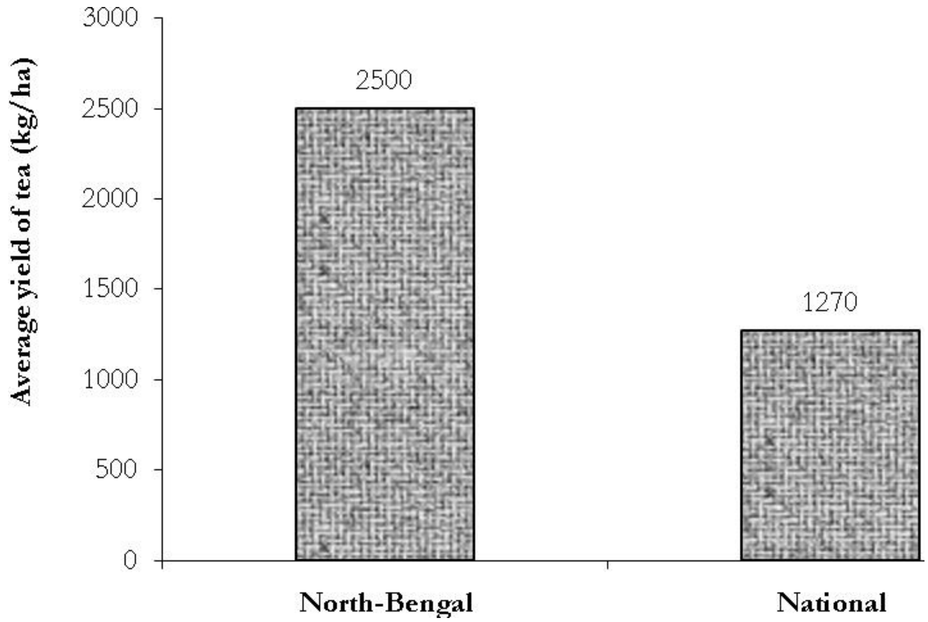

Fig. 1. Difference of yield of tea between North-Bengal and National average in 2015

Types of small holding tea cultivation in Northern Bangladesh

It was planned to plant tea in Panchagarh in 1999 and it was implemented in the main field plantation in 2000. Tea growers in Northern Bangladesh are classified into three categories e.g. Small growers (belonging tea land of <2.0 ha), Small Holders (belonging tea land of 2.0-8.0 ha) and Tea Estates (belonging tea land of >8.0 ha). At the end of 2015, total tea plantation of this area is 1,513.83 ha which is shown in Table 1. All the harvested green leaf are carried to the 'bought leaf factory' for manufacturing where growers are paid fixed and reasonable price. Green leaf price of tea is fixed and monitored by a committee which is regulated by Bangladesh Tea Board and the rate depends mainly on the auction market.

Table 1. Types of tea growers in Panchagarh with their plantation area and production in 2015

Type of Grower	No. of Registered grower	Total area (ha)	Area under plantation (ha)	Harvested green leaf (kg)	Made tea (kg)
Small grower	278	651.53	487.74		
Small holder	15	105.05	96.17		
Tea Estate	9	1,292.84	929.92		
Total	302	2,049.42	1,513.83	118,62,026	25,21,921

Area and production of tea in Panchagarh

Though plantation of tea in Panchagarh started in 2000 A.D, a bought leaf factory was established for growers in 2004 which added a new dimension for growing more tea in this region. From 2005 and onwards, tea growers can sell their harvested green leaf to the bought leaf factory. For increasing the plantation of tea, number of bought leaf factory has also been increased. At present in Panchagarh, six factories are running in full swing during the cropping season and the number will be more during the coming season. Consequently, yield and production also increased. If it is shown the tea plantation area and the production by a figure, it is easily evident that both have upward trends.

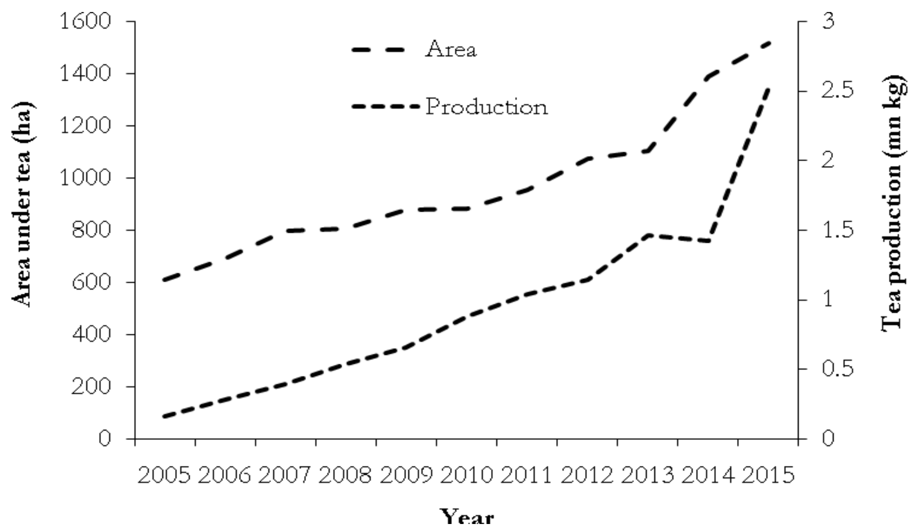

Fig. 2. The area under tea and production of tea at North-Bengal in different years

New suitable areas surveyed for small holding tea in Bangladesh

In 2004, feasibility study was done by Bangladesh Tea Board for growing more tea through small holding sector in Thakurgaon and Lalmonirhat districts which are closer to Panchagarh and in the northern districts of Jamalpur, Sherpur and Mymensingh in the foot hill upland areas of the Garo Hills inside Bangladesh adjoining to the Indian territory border of Assam. It was found that 8,522 ha of land are suitable for tea cultivation in these areas (Ahmed, 2014). Presently these lands remain either as forests or used for highland crops predominantly by Garo tribes. A further survey identified an area of 7,822 ha suitable for tea in the hilly trail of Lohagara along the shoreline in Cox's Bazar district and in Satkania, Bashkhali, Sitakunda and Mirsharai areas in Chittagong district. These lands can also be brought under large holdings as well as small holding tea cultivation. All these lands are potential areas for meeting the fast growing demand of tea in the current millennium.

Vision 2021 of Bangladesh tea production and projection to meet up the target

In 2015, total tea production of northern-Bangladesh was more than 2.5 million kg and it will be more in the near future. If everything goes well, total tea production is projected about 14 million kg from northern-Bangladesh by 2021 A.D. which will be added to the national production. Even a decade earlier, tea was an export oriented crop having a minor share of domestic consumption. Now because of high growth rate of population and rapid urbanization, the internal consumption is increasing faster and by 2020 will far supersede the export share. Hence, a projection has been made to increase the total production of Bangladesh tea by 2021 which will meet up the domestic consumption as well as re-start the export of our tea (Table 2). To make it into reality, all of the feasible areas for tea production should be brought under plantation particularly the northern-Bangladesh and the hilly areas of Chittagong. By this, tea production will be increased through both of techniques *i.e.* horizontally by extending the tea area and vertically by increasing the national average yield.

Table 2. Projection of national tea area, production, consumption and export in addition with the contribution of northern-Bangladesh

Year	National tea production including northern-Bangladesh		Tea production at northern-Bangladesh		Consumption (mn kg)	Export (mn kg)
	Area (ha)	Production (mn kg)	Area (ha)	Production (mn kg)		
2016	59,000	70.0	1,600	4.0	77.57	-
2017	62,000	75.0	1,700	6.0	80.28	-
2018	65,000	80.0	1,800	8.0	83.08	-
2019	70,000	85.0	2,000	10.0	85.98	-
2020	75,000	94.0	2,300	12.0	89.00	5.0
2021	78,000	100.0	2,500	14.0	92.12	7.9

Conclusion

Small holding tea cultivation concept has showed a vista for relieving the unemployment opportunity of northern Bangladesh. More than 15,000 peoples are getting benefit directly or indirectly from this initiation. Feasibility study showed that about 16,000 ha land area is suitable for tea cultivation in Panchagarh. Among this area only about 1,514 ha is under actual tea cultivation. Hence, it has still enough room to extend our tea area and ultimately the production. Bangladesh Tea Board is also playing a major role for increasing tea through providing appropriate technologies by BTRI scientists and supplying tea plants to the growers by different projects.

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