Research Paper

EFFECT OF RAINFALL ON YIELD AND CROP DISTRIBUTION OF TEA

I. Ahmad[1,] A. Hossain[2,] Rowshon Ara[3] M. D. Ziaul Hoque[4], Md. Liton Miah[5] and T. Ahmed[6]

[1]Associate Professor,
Department of Food Engineering & Tea Technology,
Shahjalal University of Science & Technology, Sylhet-3114, Bangladesh,
[2] Chief Scientific Officer,
Agronomy division, Bangladesh Tea Research Institute,
Srimangal-3210, Moulvibazar, Bangladesh,
[3]Assistant Professor, Department of Food Engineering & Tea Technology,
Shahjalal University of Science & Technology, Sylhet-3114, Bangladesh
[4]Department of Food Engineering & Tea Technology ,
Shahjalal University of Science & Technology, Sylhet-3114, Bangladesh,
[5]Department of Food Engineering & Tea Technology ,
Shahjalal University of Science & Technology, Sylhet-3114, Bangladesh.
[6]Senior Scientific officer,
Bangladesh Tea Research Institute, Srimongal, Bangladesh.

Abstract
Tea is a cash crop in Bangladesh. For cultivation, harvesting system and climate vulnerability, it is a unique crop. This type of crops shows wide adaptability and grows in a range of climates. Tea production is greatly dependent on rainfall, temperature and humidity. Among different climatic factors rainfall plays most vital factors. It needs sufficient water but not like in water logging. To determine the infect rainfall on yield and crop distribution of tea as well as finding the correlation the main target of the research. The survey type research work was conducted at 3 tea estate in different location. For data analysis Collected date of monthly rainfall, monthly rainy days and monthly leaf production in last 3 years. Analyzing this type of data by Microsoft Excel and determine significant value by SPSS of IBM. After analyzing this data we find that tea leaf production is slightly increasingly in different tea estate of Sylhet district due to increased rainfall. Most critical factor for tea production both rainfall and rainy days. Rainy days are crucial factor for tea production. There affects negative for maximum rainfall with minimum rainy days. There affects positively on production in the situation of maximum rainfall with maximum rainy days. For maximum production, needs maximum rainfall with maximum rainy days.
Key words: Rainfall, Rainy days, Production.

INTRODUCTION
Tea, *Camellia sinensis* (L.) O. Kuntze is the world's second most popular beverage, after water. More people in the world are drinking tea than ever before, joining a booming worldwide trend.

art of tea cultivation in Bangladesh began over a century and half ago in the 1840s near the Chittagong Club and first tea garden for commercial purpose was established at Mulnicherra in Sylhet in 1854 [1]. Its commercial production began shortly thereafter in 1857 [2]. This sector contribute about 0.815 of the national GDP of Bangladesh. There are 163 tea estates [3] having covering almost 50896 hectares. The total environment of tea is a complex integration of physical and biological elements. The physical elements are related to climate and soil and include radiation, precipitation, and the movement and composition of air; as well as the texture of the soil and its structure, depth, moisture capacity, drainage, nutrient content, and topographic position. Rainfall is one of the most important ingredients for plant growth as well as tea plant. Tea is an auto trophy or obtains all the nutrients it need from the environment around them. It is highly susceptible to drought and will not thrive well when moisture is limiting. The seasonal monsoons, of course, also greatly affects the quality of tea [4]. Efficiency is water productivity, which is the crop yield divided by the amount of water applied (i.e., crop-per-drop). If the crop is highly water-efficient, there would be a positive relationship between water (rainfall, for the rain fed systems) and water productivity [5]. It is a unique crop relative to any others typical crop due to its cultivation, harvesting system and climate vulnerability. This type of crops shows wide adaptability and grows in a range of climates and soils in various parts of the world [6]. The climate of Bangladesh tea area can be classified regime-wise under four important parameters rainfall, temperature, humidity-evaporation and sunshine which are responsible for successful tea culture. Since both rainfall and sunshine are needed for photosynthesis an empirical expression is proposed which relates vegetative growth to the product of rainfall and bright sunshine hours over a specified period. Tea is a crop in which the yield is entirely vegetative and harvested throughout the year. Being a rain fed plantation crop in sylhet, tea depends greatly on weather for optimal growth. Therefore, change in weather conditions would undoubtedly affect tea production [7]. Environment stress such as drought affects the size of growing shoots, thus reduction the total weight at harvested crop [8] found a relationship between shoot weight at harvest and rainfall during the period of period of about two months before plucking. The daily independent newspapers reported that tea production as scanty rainfall likely to heat tea production. The author mentions that tea production in Bangladesh could miss the production target by about 25% this year (2012) for drought like situation. Emdadul Haque, manager of a tea garden at Lakkatura near Sylhet city, said poor rainfall and unusual fluctuation in temperature are the main reason for the fall in production. This season has experienced at least 50%less rainfall over the corresponding period of the last season. The Climate of Bangladesh tea area can be classified regime-wise under four important parameters: rainfall, temperature, humidity-evaporation and sunshine are responsible for successful tea culture [9]. Of these, perhaps rainfall play the most important role in the development and growth of plants and ultimately yield per unit area. The objective of the study is to assess the yield of tea in respect of rainfall and rainy days, impact of rainfall on crop distribution and to identify the relation between rainfall and rainy days in respect of production.

MATERALS AND METHODS
Study Area:
Sylhet and Moulvibazar is the major tea producing area in Bangladesh. Sylhet lies in the delta of the Shurmariver and Moulvibazar lies in the delta of the Mono River. Sylhet district is situated in 24°53'11.17'' latitude and 91°52'50.60'' longitude and Moulvibazar is situated in 24°17'43.13'' latitude and 91°44'50.14'' longitude. Habibnagar and M. Ahmed tea estate is in north –western part in Sylhet and BTRI is in Srimongol at Moulvibazar are selected for study area.
Based on production of tea (as reported by the tea garden authority) and location in different agro climatic zones, 3 tea garden from North East Bangladesh have been selected for the study. Details of each tea garden are given in table 1

Table1: Information of selected garden

No	Garden name	Location	Agro climatic Zone	Latitude	Longitude	Area (He)
1.	BTRI	Moulvibazar	Shurma valley	24°17'43.13"	91°44'50.14"	8
2.	Habibnagar	Sylhet	Shurma valley	24°53'11.17"	91°52'50.60"	257
3.	M. Ahmed	Sylhet	Shurma valley	24°53'11.17"	91°52'50.60"	502

Monthly rainfall and monthly rainy days and monthly production from last 3 years 2011 – 2013 used in the study was obtained for all the above mentioned tea garden. These data gaps were filled up using:

1: Data sets made from map data of Auto Navy, Google Imagery Terra matrices in 2015.

2: Total monthly rainfall and total rainy days from tea garden authorities, keeping by using Rain gauge meter.

3: Monthly yield of green leaf from tea garden factory.

This study was carried out a period of three month ranging from July 2014 to September 2014. The date was analyzed graphically by using MS Excel and statically by using SPSS software.

Total Monthly Rainfall:

Total Monthly rainfall is the rainfall over one month. It is expressed by millimeters (mm).It is found from rainfall data recording book. Monthly rainfall is maximum on May, June, July and August.

Total Rainy Days:

Total Rainy Days is the numbers of days of rainfall.

RESULT AND DISCUSSION

Table-2: Total Monthly Rainfall and Rainy days on the experimental garden of BTRI

Year	2011		2012		2013		Avg. Rainfall mm	Avg. Rainy days
Month	Rainfall (mm)	Rainy days	Rainfall (mm)	Rainy days	Rainfall (mm)	Rainy days		
Jan	6	1	1	1	0	0	2.33	.67
Feb	7	1	0	0	9	1	5.33	.67
Mar	56	4	17	4	31	2	34.67	3.33
Apr	96	8	90	19	104	11	96.67	12.67
May	585	22	268	16	785	22	546.00	20.00
Jun	401	23	387	28	301	16	363.00	22.33
Jul	418	24	127	23	493	27	346.00	24.67
Aug	304	25	360	21	447	22	370.33	22.67
Sep	109	21	138	18	241	15	162.67	18.00
Oct	73	4	193	12	159	10	145.00	8.67
Nov	0	0	21	4	0	0	7.00	1.33
Dec	0	0	0	0	5	1	1.67	.33
Total	2055	133	1602	146	2575	127	2080.67	135.34

Table-3: Total Monthly Production of green leaf of the experimental garden of BTRI

Year / Mon	2011(kg)	2012(kg)	2013(kg)	Avg. production (kg)
Jan	287	181	202	223.33
Feb	64	48	31	47.67
Mar	676	519	334	509.67
Apr	3206	2490	2428	2708.00
May	4482	5706	4927	5038.67
Jun	6571	6752	6793	6705.33
Jul	8159	8494	10212	8955.00

Aug	8194	9322	9448	8988.00
Sep	8740	8915	9193	8949.33
Oct	8597	8163	9114	8608.00
Nov	6072	7071	7253	6798.67
Dec	4082	4862	4543	4495.67
Total	59130	62524	64472	62027.01

Maximum yearly Rainfall is occurred in 2012(1602 mm) and number of days are maximum (146). Minimum yearly rainfall is occurred in 2011(2055 mm) but minimum yearly number of days in 2013(127). In last 3 years maximum rainfall on May, June, July, August, and the number of days of rain is also maximum. On November, December, January, February there occurred less rain. Average rainfall of the last 3 years is 2080.6 mm and average rainy days are 135.34. Maximum green leaf production is 8988 kg and minimum is 47.67kg. Maximum production occurred in 2013(64472kg) and minimum in 2011(59130kg). The production is maximum with the respect of rainfall on July, August, September and October. Average Production in last 3 years is 62027.01 kg. Production is collapsed on January and February in maximum tea garden for maintenance period. But in BTRI the production is less by irrigation.

In **2011** the rainfall and rainy days are increasing in on March to May and the production is increased. The rainfall was decreasing on May to August along July but the rainy days are uniform and above 20. On this situation the production is increasing. The rainfall is high on May (585 mm) but number of days of rain are not high (22). Rainy days is high on August (25). The production is above 1000 kg/ha on July to October. The production was mostly high (1093 kg/ha) on September but the rainfall is 109 mm and rainy days was 21.The Production is minimum on February (8 kg/ha). After October production is decreased for pruning season and some production by irrigation. In **2012** the rainfall is increasing on March to June and the rainy days also increasing along May. For the reason the production was increasing. On June to October the rainfall and the rainy days is not uniform. Rainfall and number of days rain is high on June (387mm and 28). The production is above 1000 kg/ha on July to October. The production is mostly high (1165 kg/ ha) on August but the rainfall is 360 mm and rainy days is 21. The production is greater than the years of 2011. In **2013** the production was increased with respect with increasing rainfall. In may rainfall is high (785 mm) but the production is not high. Finding the reason is on May rainy days are not high. The number of days of rain is maximum(27) on July. For the reason the production of green leaf is mostly high(1277 kg/ ha). In August to October the rainfall and rainy days are decreased so that the prodution was decreased. In november and december the production was 907 kg/ha and 568 kg/ha for irrigation.
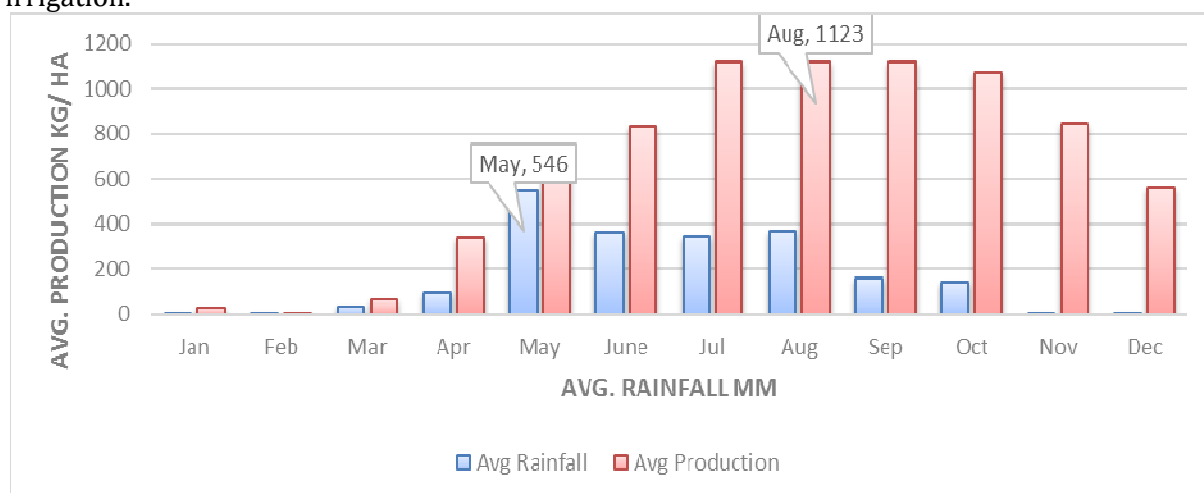

Fig- 1: Average Production of tea in respect of Rainfall of experimental field of BTRI
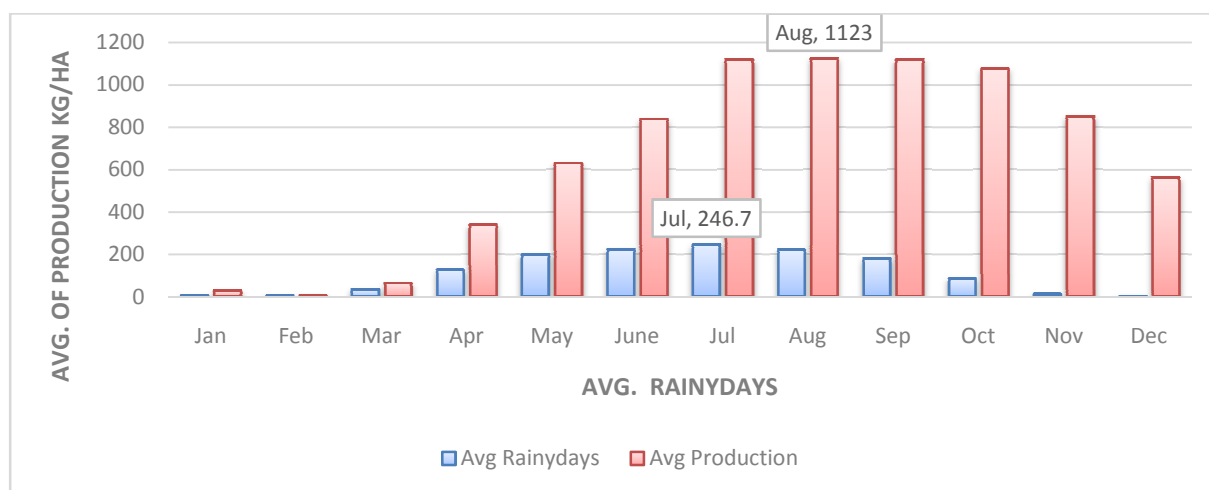
Fig- 2: Average Production of tea in respect of Rainy days of experimental field of BTRI

In fig- 1: and fig- 2: shows that the average production is above 1000 kg/ha on July to October. The average production curve line of graph is significant with average rainy days against rainfall. For maximum production needs uniform rainfall with maximum rainy days.

Table-4: and table-5: were tested analysis of variance between different values. The significant value of regression indicates that hypothesis is either rejected or not rejected.

Table-4:Analysis of variance of Avg. tea product for rainfall

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	39528002.693	1	39528002.693	3.975	.074
Residual	99448275.492	10	9944827.549		
Total	138976278.185	11			

Table-5: Analysis of variance of Avg. tea product for rainy days

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	62338369.924	1	62338369.924	8.134	.017
Residual	76637908.261	10	7663790.826		
Total	138976278.185	11			

By *P- value* findind what is the most significant between regrationnal analysis between rainfall and rainy days with Production. Here dependent variable prodction and independent variable is rainfall and rainy dys.

In table-4: *the P- value* of the regation between rainfall and production is 0.074. This value is between 0.05 and 0.10, the results are regarded as only tending towards statistical significant.

On the other hand table-5: *the P- value* of the regation between rainy days and production is 0.017. This is between 0.01 and 0.05, the results are regarded as statistically significant.

Table-6: Total Monthly Rainfall and Rainy days of M. Ahmed Tea Estate.

Year	2011		2012		2013			
Month	Rainfall mm	Rainy days	Rainfall mm	Rainy days	Rainfall mm	Rainy days	Avg. rainfall mm	Avg. rainy days
Jan	o	0	24	5			8.00	1.67
Feb	6	2	6	1	9	2	7.00	1.67
Mar	220	10	91	7	51	4	120.67	7.00
APR	175	8	838	25	158	10	390.33	14.33
May	472	20	473	18	1141	27	695.33	21.67
Jun	703	23	1361	26	627	18	897.00	22.33
Jul	730	21	765	28	562	27	685.67	25.33
Aug	881	25	726	27	762	23	789.67	25.00
Sep	373	16	358	21	306	17	345.67	18.00
Oct	100	16	480	10	488	9	356.00	11.67
Nov	0	0	50	4	0	0	16.67	1.33
Dec	0	0	0	0	0	0	0	0
Total	3660	141	5172	172	4104	137	4312.68	150

Table-7: Total Monthly Production of green leaf of M. Ahmed Tea Estate

Year / Mon	2011 (kg)	2012(kg)	2013(kg)	Avg. Production kg
Jan	0	0	0	0
Feb	0	0	0	0
Mar	31451	19675	24017	25047.67
Apr	131404	131898	86074	116458.67
May	204487	167026	123182	164898.33
Jun	322151	271583	276415	290049.67
Jul	326629	310091	354288	330336.00
Aug	311585	370625	308362	330190.67
Sep	291680	324464	266779	294307.67
Oct	321532	283328	322188	309016.00
Nov	159065	234356	166861	186760.67
Dec	50672	62387	103811	72283.33
Total	2099984	2175433	2031977	2119348.68

Rainfall is Maximum in 2012 (5172 mm) and number of days are maximum (172). Minimum yearly rainfall is occurred in 2011(3660 mm) but minimum yearly number of days in 2013(137). Average rainfall of the last 3 years is 4312.68 mm and average rainy days is 150. Maximum green leaf production is 330336 kg and minimum is 25047.67kg. Average production is 4221.81 kg/ha. Maximum production occurred in 2012(2175433kg) and minimum in 2013(2031977kg). The production is above 25000 on June, July, August, September and October with the respect of rainfall. Average Production in last 3 years is 2119348.68 kg. Production is collapsed on January and February in for the maintenance period.

In **2011** the rainfall is increasing in on March to August along Aril. But the production is increased on March to July. The rainfall is not uniform but the rainy day are uniformly increasing and May to August the number of days of rain is above 20. The production is maximum on June to October. The rainfall is high on August (881 mm) and number of days of rain are also high (25) .The production is 600 kg/ha up on June, July August and October. The production is mostly high (650 kg/ ha) on July with the aspect of the rainfall is 730 mm and rainy days is 21.The Production is minimum on March (63 kg/ha). After October production is

decreased for pruning season and some production by irrigation. In **2012** the production is more than 2011. The rainfall is fluctuated month by month. For the reason the production is also fluctuated. Rainfall is high on June (1361mm) and number of days are high on August (28). The production is above 500 kg/ha on June to October. The production is mostly high (738 kg/ha) on August but the rainfall is 726 mm and rainy days are 27. In **2013** the production is increased along May with respect with increasing rainfall. In may rainfall is high (1141 mm) but the production is so much poor (246 kg/ha) with the aspect of high rainfall also finding rainy days is also high . Reasons for the variation are excess water and poor drainage system. The number of days of rain are also maximum(27) on July on this month the production of green leaf is mostly high(704 kg/ ha). The production is flacktuated very much from May to October for may be ununiform rainfall.
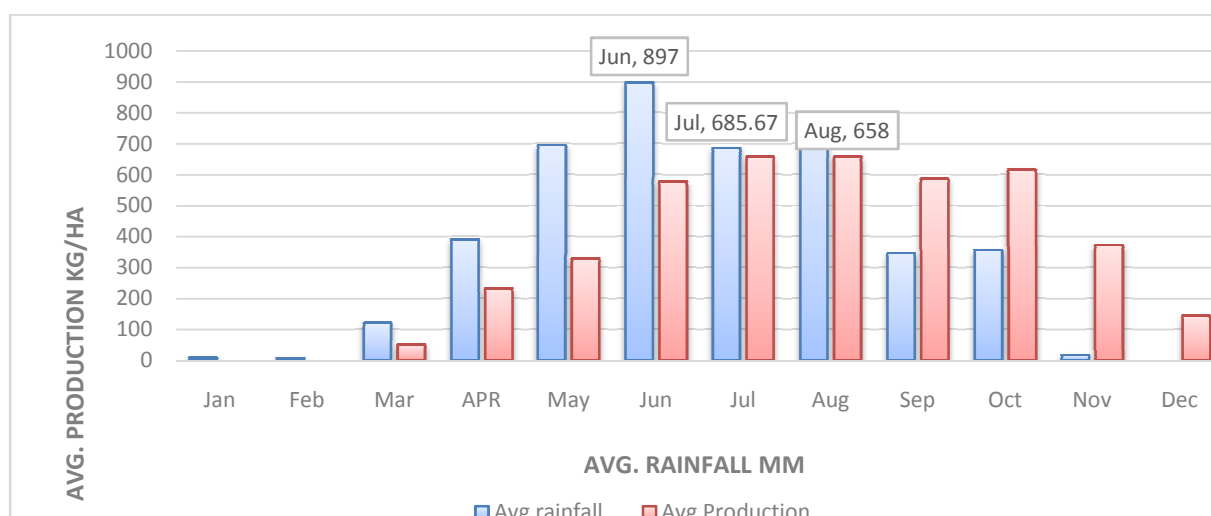

Fig -3: Average Production of tea in respect of Rainfall of M. Ahmed Tea Estate
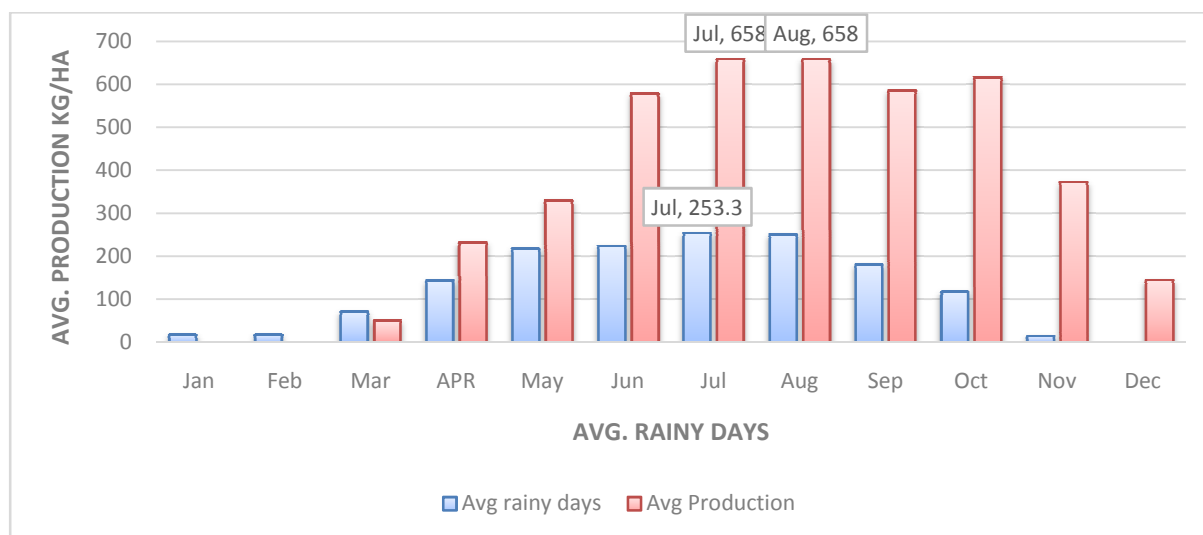

Fig -3: Average Production of tea in respect of Rainfall of M. Ahmed Tea Estate

In fig-3 and fig-4 the production is above 658 kg/ha on July August. The average production curve line of graph is significant with aspect of Ave rainy days than rainfall. For maximum production needs uniform rainfall with maximum rainy days.

Table-8: Analysis of variance of Avg. tea product for rainfall

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	106262334855.526	1	106262334855.526	12.457	.005
Residual	85304777408.881	10	8530477740.888		
Total	191567112264.407	11			

Table-9: Analysis of variance of Ave tea product for rainy days

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	115496652369.275	1	115496652369.275	15.183	.003
Residual	76070459895.133	10	7607045989.513		
Total	191567112264.407	11			

In table-8 and table-9, *the P- value* of the regation between rainfall and production is 0.005 and *the P- value* of the regation between rainy days and production is 0.003 . Two value is less than 0.01. So these two analysis are highly significance. But the *P-Value* of ANOVA for production with aspect of rainy days is most significance than rainfall.

Table-10: Total Monthly Rainfall and Rainy days of Habibnaga Tea Estate

Year	2011		2012		2013		Avg. Rainfall mm	Avg. Rainy days
Month	Rainfall mm	Rainy days	Rainfall mm	Rainy days	Rainfall mm	Rainy days		
Jan	0	0	22	4	0	0	7.33	1.33
Feb	5	2	8	1	9	1	7.33	1.33
Mar	218	8.	85	7	50	4	117.67	6.33
April	195	9	857	25	185	10	412.33	14.67
May	510	23	413	16	1158	28	727.00	22.33
June	670	22	1289	24	644	19	867.67	21.67
July	741	24	703	27	525	24	656.33	25.00
Aug	841	20	673	26	795	23	769.67	23.00
Sep	388	17	286	16	338	18	337.33	17.00
Oct	88	14	522	12	488	9	366.00	11.67
Nov	0	0	52	3	0	0	17.33	1.00
Dec	0	0	0	0	0	0	0	0
Total	3656	139	4910	161	4192	136	4285.99	145.33

Table-11:Total Monthly Production of green leaf of Habibnagar Tea Estate

Year / Mon	2011	2012	2013	Avg. production
Jan	0	0	0	0
Feb	0	0	0	0
Mar	28,598	35053	29063	30901.33
Apr	105009	102497	73091	93532.33
May	144996	166491	169255	160247.33
Jun	225127	216807	216383	219435.67
Jul	258577	279056	406960	314877.67
Aug	291411	299028	237254	275897.67
Sep	275405	312237	253657	280433.00
Oct	275836	273855	284958	278549.67
Nov	161275	228805	168861	186313.67
Dec	51917	57144	68657	59239.33
Total	1766234	1970973	1908139	1899427.67

Rainfall is Maximum in 2012 (4910 mm) and number of days is maximum (161). Minimum monthly rainfall is occurred in 2011(3656 mm) but minimum monthly number of days in 2013(137). Maximum green leaf production is 314877 kg and minimum is 30901.33kg. Average production is 7391.77 kg/ha. Maximum production occurred in 2012(1970973kg) and minimum in 2011(1766234kg). Average Production in last 3 years is 1899427.67kg/ha. Average rainfall of the last 3 years is 4285.99 mm and average rainy days is 145.33.

 In **2011** the rainfall is uniformly increasing in on March to August along Aril. The production is also uniformly increased on March to August. It is good correlation. The rainfall is not uniformly fluctuation but the rainy day are uniformly fluctuation and May to August the number of days of rain was above 20. The production is maximum on July to October and up to 1000 kg/ha. The rainfall is high on August (841 mm) but number of days of rain is high on July (24). The production is mostly high (1134 kg/ ha) on August with the aspect of the rainfall is 841 mm and rainy days are 20.The Production is minimum on March (111 kg/ha). After October production is decreased for pruning season and some production by irrigation. In **2012** the rainfall is fluctuated month by month. But the production is uniformly fluctuated. Rainfall is high on June (1298mm) and number of days are high on July (27). The production is above 500 kg/ha on June to October. The production is mostly high (1215 kg/ ha) on September but the rainfall is 286 mm and rainy days are 16. The production is greater than 2011. In **2013** the production is unnaturally increased on July with respect with 525mm rainfall and 24 rainy days . Rainfall is high on May (1158 mm)and rainy days are maximum but the production is 659 kg/ha. Reasons for the variation are excess water and poor drainage system.
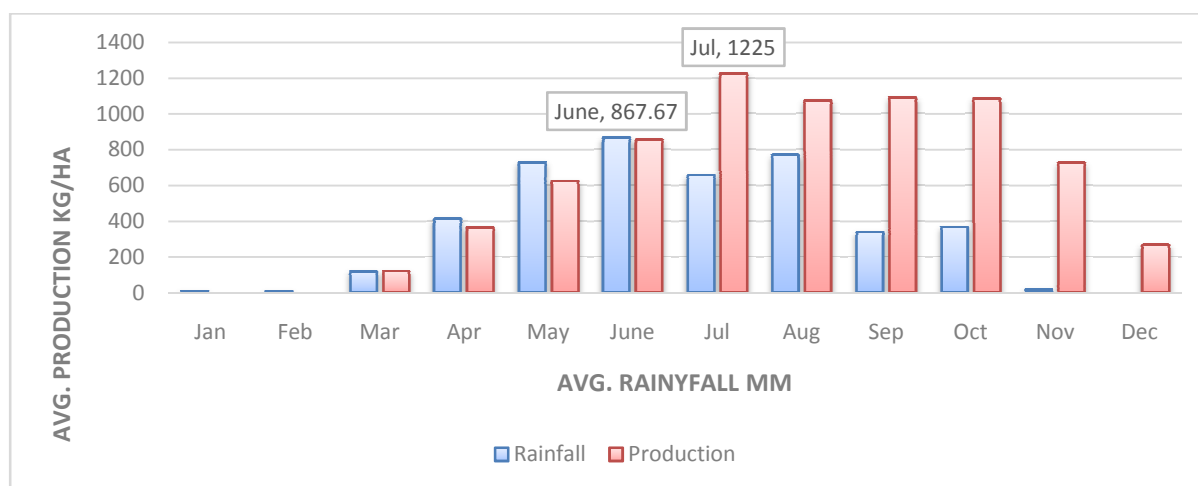
Fig -5: Average Production of tea in respect of Rainfall of Habibnagar Tea Estate
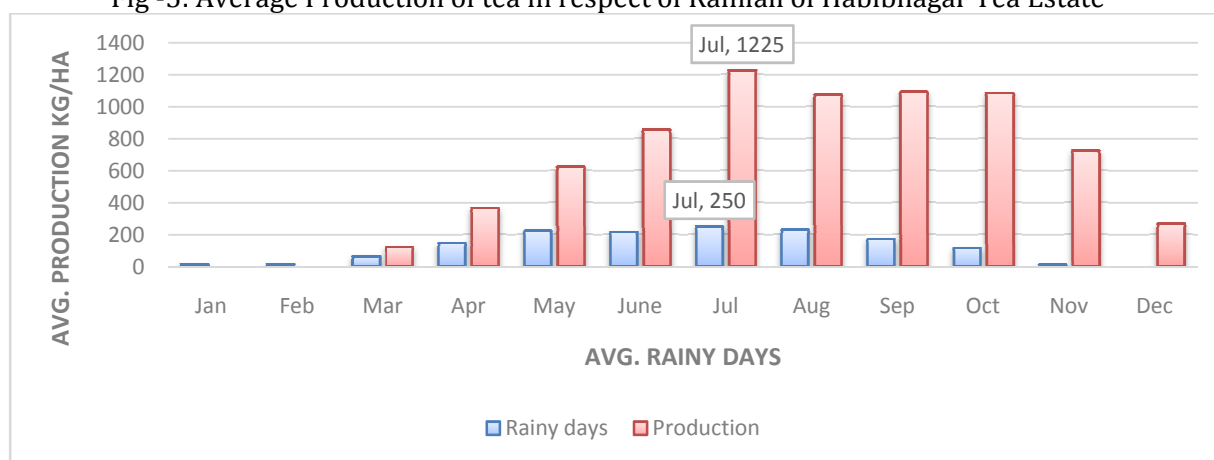

Fig -6: Average Production of tea in respect of Rainy days of Habibnagar Tea Estate

In fig-5 and fig-6 the production is above 658 kg/ha on July August. The average production curve line of graph is significant with aspect of uniform average rainy days than rainfall. For maximum production needs uniform rainfall with maximum rainy days.

Table-12: Analysis of variance of Ave tea product for rainfall

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	69499329356.146	1	69499329356.146	8.363	.016
Residual	83105091055.956	10	8310509105.596		
Total	152604420412.102	11			

Table-13: Analysis of variance of Ave tea product for rainy days

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	82924088110.514	1	82924088110.514	11.901	.006
Residual	69680332301.588	10	6968033230.159		
Total	152604420412.102	11			

In table-12: *the P- value* of the regation between rainfall and production is 0.016. This value is between 0.01 and 0.05, the results are regarded as statistically significant.
On the other hand table-13: *the P- value* of the regation between rainy days and production is 0.006. It is less than 0.01, So the results are regarded as highly significant.

CONCLUSION

Heavy or scanty or delayed rainfall adversely affects the growth and yield of tea but it has been found that tea leaf production is slightly increasing with increase in annual rainfall. Study also provides that for good production of tea leaf, the number of day of rain is critical factor. By analysis data of different tea garden, provides that if the number of days of rain is up to 20 with maximum rainfall, production of leaf is good. Tea needs maximum water but it cannot support water logging. Tea needs optimum rainfall with well drainage system. There have correlation between rainfall and production. Tea uptakes that amount of water which need it physiological activity. It cannot uptake excess water. Most critical factor for tea production is not only rainfall but also rainy days. Rainy days is a key factor for tea production. There affects negative for maximum rainfall with minimum rainy days. If rainfall is maximum in maximum number of day duration, there affects positive on production. For maximum production, needs maximum rainfall with maximum rainy days.

REFERENCES

1. Redowan, M. and Kanan, A. H. 2013. A study on Maximization of Land Use with Associated Crops Other Than Tea and management. *Int*. J. of Ecol. And Devt., 25(2):57-70.
2. Nasir, T. and Shamsuddhoa, M. 2011. Tea production, Consumption and Export: Bangladesh perspective. International Journal of Education Research and Technology 2(1):68-73.
3. BTD (Bangladesh Tea Board), 2012. http://www.Teaboard.gov.bd/accessed 25 June 2012.
4. Anon, 1996. Tea from Sri Lanka Tea Board, Colombo, Sri Lanka.
5. St. Paul (2010). Harvest Choice, 2010. "Rainfall Variability and Crop Yield Potential." International Food Policy Research Institute, Washington, DC., and University of Minnesota.
6. Hamid, F. S. 2006. Yield and Quality of Tea under Varying Condition of Soil and NitrogenAvailability. Pakistan Research Repostry, Higher Education Commission Pakistan. http://eprints.hec.gov.pk/2348/1/2203. Htm accessed 10 July 2012.
7. Carr, M. K. V. and Stephens, W. 1992. Climate weather and the yield of tea, in: Tea: *Cultivation to Consumption*, Willson K.C and Clifford M.N. (eds), Chapmann and Hall, London, pp.87-135.
8. Portsmouth. G. B (1957). Factor affecting shoot production in tea (*Camellia sinensis*) when grown as a plantation crop. II. The influence of climatic conditions and age from prunin on flash shoot production, Tea Q..28.8-19
9. Sana, D.L. (1998). Tea Science, Ashrafia Boi Ghar, Bangla Bazar, Dhaka, Bangladesh, pp 1-89.