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INTERRELATIONSHIP BETWEEN PRODUCTIVITY AND ABIOTIC FACTORS-AN INVESTIGATION IN REPRESENTATIVE DOOARS REGION TEA GARDENS OF WEST BENGAL

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AUTHOR'S CONTRIBUTION

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Dooars region comprises the northern part of West Bengal bounded by the Teesta river in west, Sankosh river and Assam in the east, the Kingdom of Bhutan in the north and Bangladesh in the south. Roughly the area is 130 km by 40 km and includes the districts of Jalpaiguri, Alipurduar and Coochbehar. Large areas of forest cover is interrupted with plenty of tea gardens which not only add boost in economy but also add socio cultural hotspot because of the fact that good number of tribal peoples inhabited in and around the tea garden who are the workers of the forest and tea garden. But now a day's tea industry in this area is facing a major break due to less productivity in spite of taking all available precautions. Loppers are the chief culprit in this scenario. Moreover pest surveillance also depends on climatic condition more specifically different environmental abiotic factors. This paper addresses this vital issue. Here attempts are undertaken to understand effect of rainfall and temperature on productivity of tea. In this study Madhu Tea Estate is taken as control site as because since last 10 years it was lockout and proper maintenance such as pruning, irrigation and pesticide spraying is not at all being done. On the other hand Borodighi Tea garden and Chowafulli tea garden are selected as experimental sites where proper maintenance is being done. The Borodighi Tea garden and Chowafulli tea garden are situated in Jalpaiguri District. More specifically two experimental sites are in close proximity. Through MINITAB software version 18 analysis it has been found that both rainfall and temperature having positive correlation with productivity.

Keywords: Lopper; pesticide; sampling; leaf area index; red spider; caterpillar.

1. INTRODUCTION

West Bengal is a major tea producing state and contributes about 1/4th of the total production of tea in India. Darjeeling, Terai and Dooars are the traditional tea growing areas in the state [1]. There are 309 tea estates in the organized sector covering 103431 hectares under tea cultivation [2]. Besides 8078 small growers are growing tea in an area of 11094 hectors [3]. The industry is passing through a crisis due to lack of investment to maintain health of tea garden, raising cost of inputs, lower yield rate, fall in price etc. [4,5,6,7]. The present crisis in the industry is mainly the outcome of negligence, of the garden owners to maintain the health of the industry out of the profits earned by the garden owners has not been ploughed back for investment in the industry [8]. Dooars area occupies most of the tea garden and

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forests. Now it is occupied in the territory of Jalpaiguri and Alipurduar district [9,10]. Tea industry solely depends on healthy tea leaf. Naturally there are some predators or pest which completely devours tea leaf directly or indirectly [11]. Therefore, enter stagey of the gardener is to kill the pest by application of pesticide or cultivation of indigenous pest resistance variety by tissue culture [12]. But pests are so powerful that now they have develop insecticide resistance gene in their genome [13,14]. Since loppers are the main culprits affecting tea leaf in all the season. Initiative is taken in to see the area of the damage leaf in term of their quantity of tea production [15]. If leaf is pierced much more than more leaf is needed to produce same quantity of tea in same factory by same machinery [16]. Moreover pests like loppers life cycle is related with different abiotic factors like rainfall, therefore correlation between rainfall and pest infestation in terms of productivity of tea is calculated statistically using Minitab Software.

1.1 Experimental Study Area- at a Glance

Borodighi Tea Estate is managed by Rydak Syndicate Ltd. Jalpaiguri having total area 560 hectares. It is located in N26°47.115', E088°45.791 and having elevation of 121 mts. On the other hand Chowafulli Tea Estate is managed by Dutta Agro Industry Ltd. Jalpaiguri. It is situated in N26°47.175, E088°45.848 and having elevation of 110 mtrs. Chief pest of tea leaf of these garden are *Helopeltis* larva, Red spider, Looper, Caterpillar etc (Figs. 1 and 2). It is reported that about 19% tea production is affected each year by pest attack.

2. METERIALS AND METHODS

2.1 Survey Work

In this pilot study Madhu Tea Garden (MTG) is taken as control site. We know this tea garden was a profitable tea garden 10 years back. But due to some deteriotion of the relationship between management and tea workers it is not working since last 10 years. Tea plants are not pruned and manure regularly. There is no record of application of pesticide since it is locking out. Naturally all the tea plant under jurisdiction of Madhu Tea Garden is affected with pests. Nearby Gorumara National Park Baradighi Tea Estate (A unit of Rydak Tea Syndicates) and Chowafulli Tea Estate (Managed by Dutta Tea Industry Limited) was considered as Experimental site. Logic behind this is both the tea garden is well managed and there is no history of lockout cases. Since both the garden is nearby and management practice is somewhat same (spray of the pesticide, its dose and application strategy is also same).

Quadrates of 2 mtr X 2 mtrs size are being made. Then affected tea leaf is first collect by opening eyes (Biased sampling). Then same quadrate size is taken in different place of the same tea garden. Repetition of same protocol is being done. But plucking of the tea leaf was done by closing eyes (Unbiased sampling). After recording temperature, humidity and last 5 years from recorded data we do sampling and whatever survey work was done it is recorded by GPS mapping. Leaf area Index (LAI) was calculated in both the biased and unbiased sampling in the entire site. Since from factory inspection and brief interview given by Superintendent Manager it was known that 1 k.g raw leaf is needed for getting 200 gms of Tea. Therefore, it is theoretically possible to make a correlation of the raw weight of the leaf along with number of leaf more specifically with leaf areas in both biased and unbiased sampling.

2.2 GPS Mapping

GPS is carried by a moving vehicle or person, that uses the global positioning system to determine and track its precise location and hence that of its carrier at intervals.GPS monitoring is efficient to measure the pin point location of own working place. With the help of GPS monitoring, we can measure the latitude, longitude and elevation of a particular place.

2.3 Data Collection about the Productivity vs Abiotic Factors Like Temperature & Rainfall of Last 5 Years

These are secondary data are obtained from factory Manager.

2.4 Biased and Unbiased Sampling of the Tea Leaves

a. Biased sampling: Intentionally collection of affected tea leaves.
b. Unbiased sampling: Natural, accurate, well balanced randomly collection of tea leaves. Through random (unbiased) sampling, the sample should represent the target population.

Biased vs unbiased sampling is needed because in biased sampling, it is impossible to know how well we are representing the population and also cannot calculate the confidence intervals and margins of error. For this problem unbiased sampling is needed.

Fig. 1. Brown blight at Borodighi tea garden

Fig. 2. Looper in tea leaf at Chawafelli tea garden

2.5 Analysis of the Productivity vs Different Abiotic Factors Namely Temperature and Rainfall by Minitab Software

Using Minitab Software correlation, t test and ANOVA is being carried out.

3. RESULTS

The exact location of Borodighi Tea Estate from where collection of the pest is being done is N26°47.175, E088°45.848. Elevation from sea level is 110 mt. All together 70 leaves are collected from Biased sampling and 70 leaves from unbiased sampling. Their dry weight of biased sampling is 34.5 gms and unbiased sampling is 37 gm. . Therefore, weight varies about 3.5 gm. The loss of the weight in two different sampling procedures is due to the loss of tea leaf area due to Pest infestation.

In unbiased sampling random collection of tea leaves (samples) including both affected & unaffected tea leaves. The total leaf area and affected area is being calculated by Leaf area index meter. The obtained data of 70 leaves are tabulated in Table 1. Because of unbiased sampling the no of affected leaves is less than biased sampling.

In Biased sampling collection of predominantly pest affected tea leaves is being done. Similar to Unbiased Sampling total 70 leaves are collected. Total area and affected area data are tabulated in Table 2.

Because of biased sampling the total affected area is more than unbiased sampling. Year wise rainfall and production in Baradighi Tea Estate having directly proportional relationship (Fig. 3). Similarly total area and affected area of both biased sampling and unbiased sampling having some positive co relationship (Fig. 4).

Multiple correlation studies among year, rainfall and productivity clearly illustrated some positive correlation (Fig. 5) which indicate for tea production natural rainfall in optimum level is one of the primary requisite.

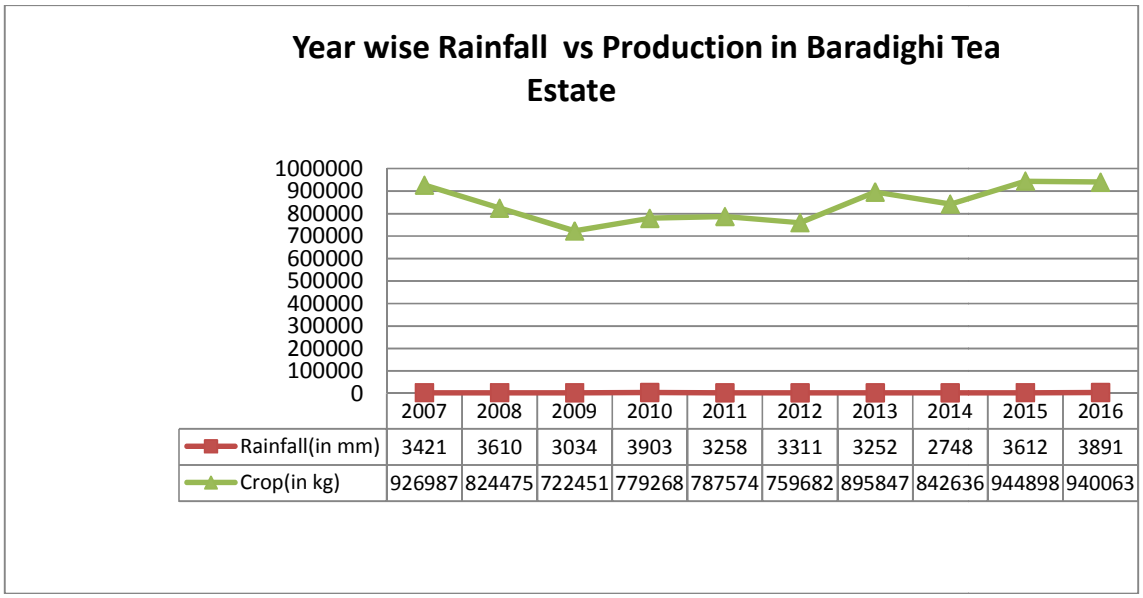
Table 1. Summed up data of unbiased sampling

Sl. No. of leaf	Total leaf area in cm^2	Affected area in cm^2	Sl. no. of leaf	Total leaf area in cm^2	Affected area in cm^2
1	25	0.5	36	16.25	0.65
2	18	0.37	37	21.75	1.5
3	32	2.5	38	21.25	0.9
4	24	0.85	39	34.5	1.9
5	25	1.85	40	28	0.8
6	22	0.65	41	14.5	1.5
7	17	1.25	42	15.75	0.7
8	20.75	1	43	9.75	0.8
9	28	0.25	44	9	0.5
10	14	0.25	45	12.5	0.25
11	21	0.75	46	38.5	0.5
12	14	0.75	47	9.5	0.5

Sl. No. of leaf	Total leaf area in cm^2	Affected area in cm^2	Sl. no. of leaf	Total leaf area in cm^2	Affected area in cm^2
13	20	0.65	48	10.75	0.2
14	19	2.65	49	28.5	1.25
15	11.75	0.75	50	22.75	1.5
16	10.75	1	51	17.25	0.17
17	28	1.5	52	18.25	0.13
18	20	1	53	19.5	0.9
19	21	2.5	54	23	0.55
20	28	0.75	55	25	0.56
21	13	0.55	56	21	0.39
22	31.35	9.25	57	8	0.14
23	30	1.6	58	13	0.28
24	17	1.5	59	21	1
25	11.75	1	60	27.25	0.92
26	19	0.85	61	39.11	1.31
27	38.5	1.95	62	27.5	1.75
28	29	0.25	63	31.5	0.54
29	22	0.15	64	29	0.55
30	18.22	0.65	65	45	1.54
31	17.5	3.4	66	20.2	0.42
32	16.75	1.85	67	28	0.7
33	27	1.75	68	25.25	2.2
34	21	0.75	69	24	0.71
35	26	2.5	70	15.25	0.78

Table 2. Summed up data of biased sampling

Sl. No of leaf	Total leaf area in cm^2	Affected area in cm^2	Sl. No. of leaf	Total leaf area in cm^2	Affected area in cm^2	Sl. No of leaf	Total leaf area in cm^2	Affected area in cm^2
1	18	0	24	8	0.5	47	4	0
2	16	0	25	17	0	48	12	0
3	17	1.5	26	16	0	49	8	0
4	12	0	27	12	0	50	20	0
5	16	2	28	8	0	51	7	0
6	4	0	29	18	0	52	18	0
7	11	0.5	30	16	0	53	18	0
8	5	0	31	31	0	54	25.5	0
9	14	0	32	18	0	55	8	0
10	7	0	33	19	0	56	19	0
11	29	1	34	21	0	57	11	0
12	25	1	35	43	8	58	27	0
1	6	2.5	36	10	0	59	12	0
14	14	0	37	4	0	60	6	0
15	13	0	38	7.75	0	61	11	0
16	12	1	39	29	2	62	25	0
17	11	0	40	12	0	63	33	0
18	17	0	41	13	1	64	19	0
19	19	0	42	23	1	65	17	0
20	12	7	43	19	0.5	66	47	0.5
21	36	0	44	15	0	67	31	0
22	12	0	45	12	0	68	16	0
23	13	3	46	9	0	69	31	0
						70	44	2.5



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Rainfall(in mm)	3421	3610	3034	3903	3258	3311	3252	2748	3612	3891
Crop(in kg)	926987	824475	722451	779268	787574	759682	895847	842636	944898	940063

Fig. 3. Yearwise rainfall (in X axis) vs production (in Y axis) at Baradighi tea estate (from 2007-16)

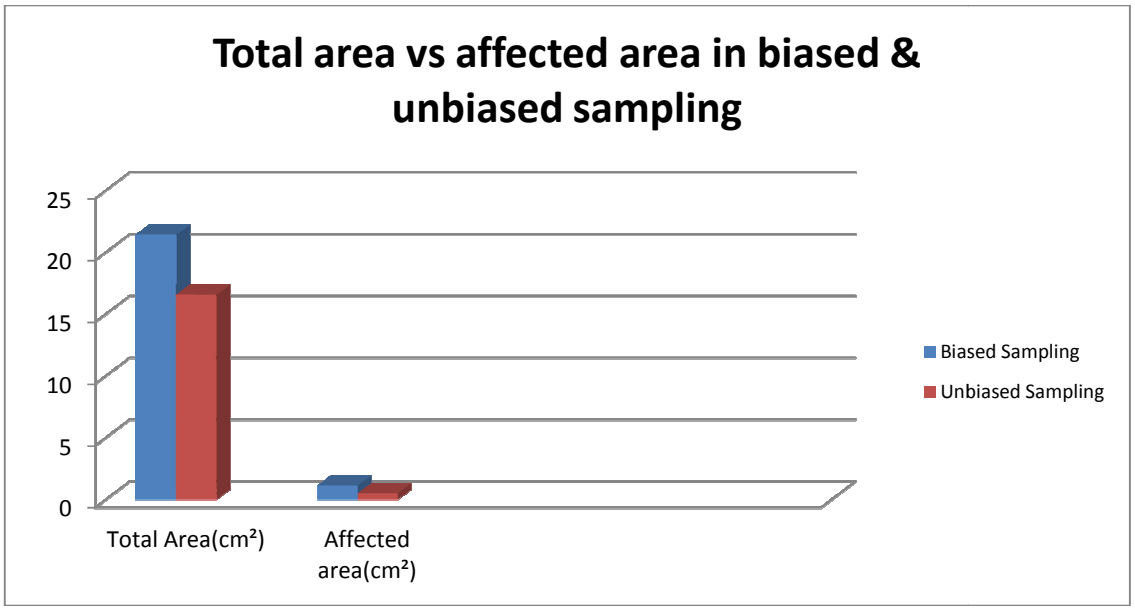


Fig. 4. Comparative histogram analysis between Biased vs. unbiased sampling based on Leaf area index. (Note-leaf area index is calculated manually using mm range graph paper)

4. DISSCUSSION

Tea board of India data clearly revel the fact that total production of tea in India since 2008 to 2016 is not continuously increasing [17,18,19,20].Therefore, production of the tea largely depends on natural rainfall of the country which indirectly signifies the necessity of study the correlation between abiotic factors and tea productivity.

Since pest infestation is directly related with productivity of tea i.e., if pest devour much more tea leaf than much more quantity of leaf is needed for production of same quantity of tea, it is obvious that total area of unaffected leaf versus affected part studies clearly states that whether pests are homogenously distributed in sampled Tea garden. Therefore, two different sample techniques have been adapted based on

concept of statistical error. We know statistical error is automatically came. It may be biased or nonbiased. In our sampling strategy when affected Tea leaf is plucked by seeing it in open eyes it is biased sampling.

Therefore from the above it can be concluded that in Baradighi Tea Estate and Chowafulli Tea garden pests are homogenously distributed. Therefore strong correlation exist between pest infestation and tea Leaf affected area which is also tally with our naked eye observation.

Basic concept of correlation is to determine strength of association between two variables. In this study rainfall data of Barodighi Tea garden (with effect from 2007 to 2015) tally with the total productivity of tea (as per factory report) keeping total cultivated area constant and maintaining strategy constant. In such cases it's found that total productivity of tea is positively correlated with rainfall in level of significance 5% that mean observed result are considered significant at or below 5 % level of significance. Finally it can be concluded although irrigation facility is available, tea productivity is always depends on natural rainfall.

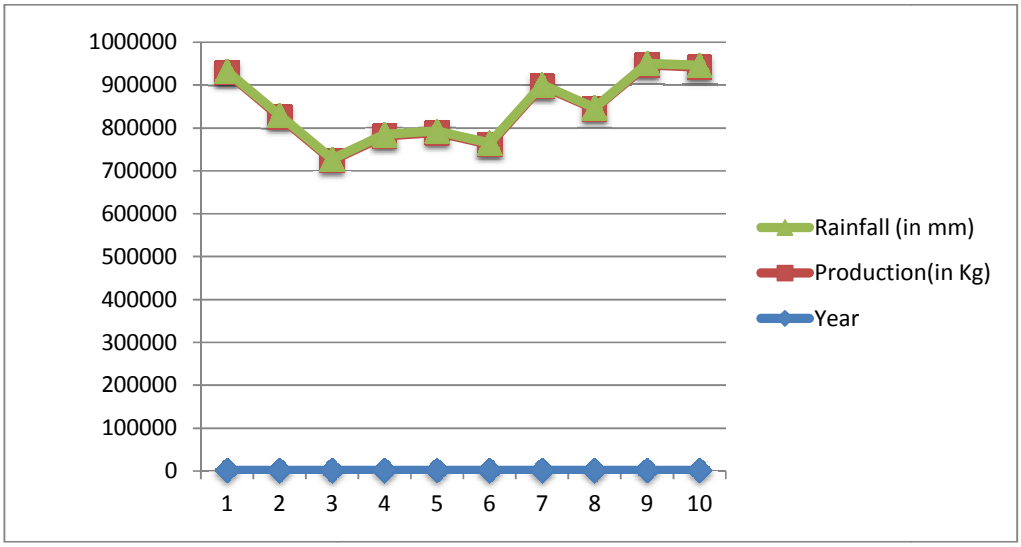


Fig. 5. Multiple Correlation studies among rainfall, production versus year using software Minitab (X axis represent year and Y axis represent production quantity)

Table 3. Pearson corelation between temerature and productivity at Barodighi tea estate

Year	Variable studied	Pearson correlation	Comment
2013	Month, mean temp (in^{0}C), rainfall (in mm), productivity (in kg)	Temp vs Productivity= 0.781 P-value = 0.003	This indicates Fairly high degree of positive co-relation between the two variables. As the value is positive, it can be deduced that if Mean temperature increases, productivity also increases & vice- versa.
2014	Month, mean temp (in^{0}C), rainfall (in mm), productivity (in kg)	Temp vs Productivity= 0.617 P-value = 0.032	Moderate degree of positive co-relation between the two variables. As the value is positive, it can be deduced that if Mean temperature increases, productivity also increases & vice-versa.
2015	Month, mean temp (in^{0}C), rainfall (in mm), productivity (in kg)	Temp vs Productivity= 0.671 P-value = 0.017	Moderate degree of positive co-relation between the two variables. As the value is positive, it can be deduced that if Mean temperature increases, productivity also increases & vice-versa.
2016	Month, mean temp (in^{0}C), rainfall (in mm), productivity (in kg)	Temp vs Productivity= 0.774 P-value = 0.003	Fairly high degree of positive co-relation between the two variables. As the value is positive, it can be deduced that if Mean temperature increases, productivity also increases & vice-versa.

5. CONCLUSION

Pearson correlation studies between temperature and productivity from 2013 to 2016 data specifically reveals either moderate or fairly high degree of positive correlation (Table 3). This interim deduce that if mean temperature increases productivity also increases and vice versa.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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