5

RESULT AND DISCUSSION

CONTENTS

5.1 DATA ACCESS ABOUT GUI AND WEBSITE

Tools for applying control logic in real life will be discussed here.

Lastly the PC based GUI and website will be discussed with their advantages and applications the human and data interaction will provide the necessary control required for efficient water monitoring system. The purpose of human is to regulate water demands as per current seasons in tea estate. Hence the operator will read data and plan for the operation of soil moisture monitoring system. The more convenient path to access data the more efficient will be our soil moisture monitoring system. Therefore integrating World Wide Web/ Internet with soil moisture monitoring system will be a promising pillar of efficient soil moisture monitoring system.

The operator needs a GUI to check the status of the sensor, to monitor the moisture level and status of the water sprinkler etc. this graphical user interface (GUI) developed using visual studio software and for database we are using MySql.

LOGIN WINDOW

Through the login window user can enter to the sensor application program authentically.

Figure 5.1: Login window of the sensor application

SENSOR DATA MONITORING WINDOW

From this window user can view the date, time Sensor id and receiver value from the sensor. Against this sensor value we can also view the date, time and sprinkler's ON/OFF status. Using this window user can set the sprinkler start and stop value as per the moisture requirement of the plant. We can also select the no of working sensors as per the requirements of the area plot.

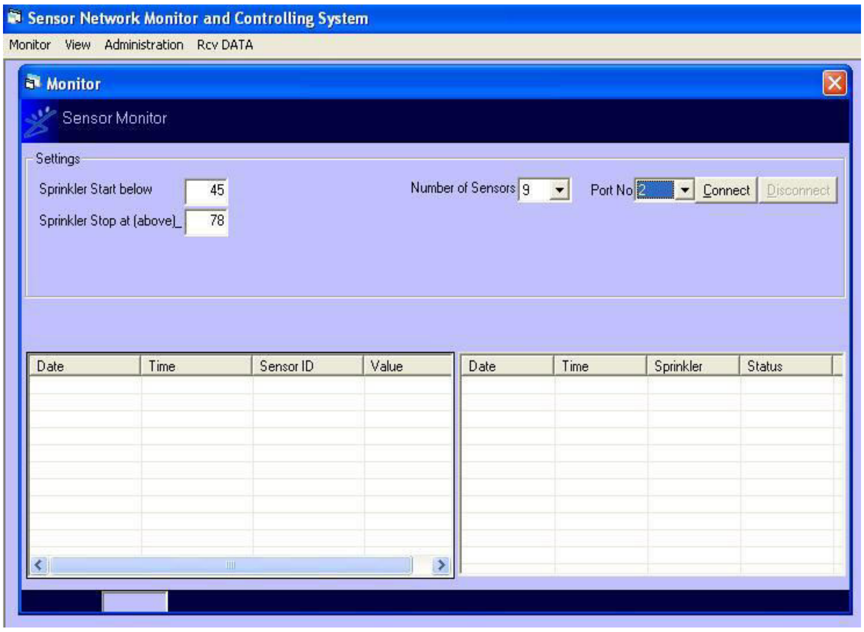


Figure 5.2: Sensor Data Monitoring Window

SENSOR DATA LOG

Using this window we can view sensors previously recorded data by sorting Sensor ID or serial ID.

From prevailing tools available we have opted for solenoid valve operating water sprinkler for irrigation. For ease in sensor data evaluation and easy access we have host a website **www.wsndatalogger.in**. From this website we can easily monitor the acquire data from the field at anywhere in the world.

Figure 5.3: Website for online monitoring the system.

After acquiring month wise data we store the data into database as date wise. For comparing purpose we also collect the moisture data of the soil manually (Lab Tested). In laboratory we using dry oven method to collect the data. At same date and same time we simultaneously collect the data from sensor as well as manual sample for lab.

Table - 5.1: Date wise sensor and manually collected soil moisture data

Days	Sensor Data Soil Moisture (%)	Manually Collected Data (Soil Moisture) (%)
03/01/2016	11.00	10.07
10/01/2016	12.02	11.00
17/01/2016	10.78	10.90
24/01/2016	10.24	11.00
07/02/2016	12.34	14.00
14/02/2016	10.21	9.21
21/02/2016	11.19	11.19

28/02/2016	9.23	10.04
06/03/2016	10.44	11.33
13/03/2016	8.16	9.44
20/03/2016	10.00	11.00
27/03/2016	13.00	12.04
03/04/2016	15.00	15.08
10/04/2016	11.45	10.00
17/04/2016	12.23	12.69
24/04/2016	16.01	14.12
01/05/2016	18.33	18.50
08/05/2016	20.21	18.44
15/05/2016	22.33	23.33
22/05/2016	19.00	21.78
29/05/2016	25.00	26.54
05/06/2016	30.70	33.12
12/06/2016	32.23	30.49
19/06/2016	31.60	33.23
26/06/2016	35.00	33.89
03/07/2016	38.00	37.69
10/07/2016	35.34	34.03
17/07/2016	34.34	35.23
24/07/2016	33.55	32.90
31/07/2016	35.76	34.78
07/08/2016	38.84	39.67
14/08/2016	36.22	36.89
21/08/2016	37.44	38.66
28/08/2016	38.33	37.02

Continuous acquiring of the data by the moisture sensor it was stored in database. A graph was prepared for monthly basis data was collected, four times in month both manually and traditionally. Here is the graph to comparing how accurate sensor collected data to the traditionally collected data.

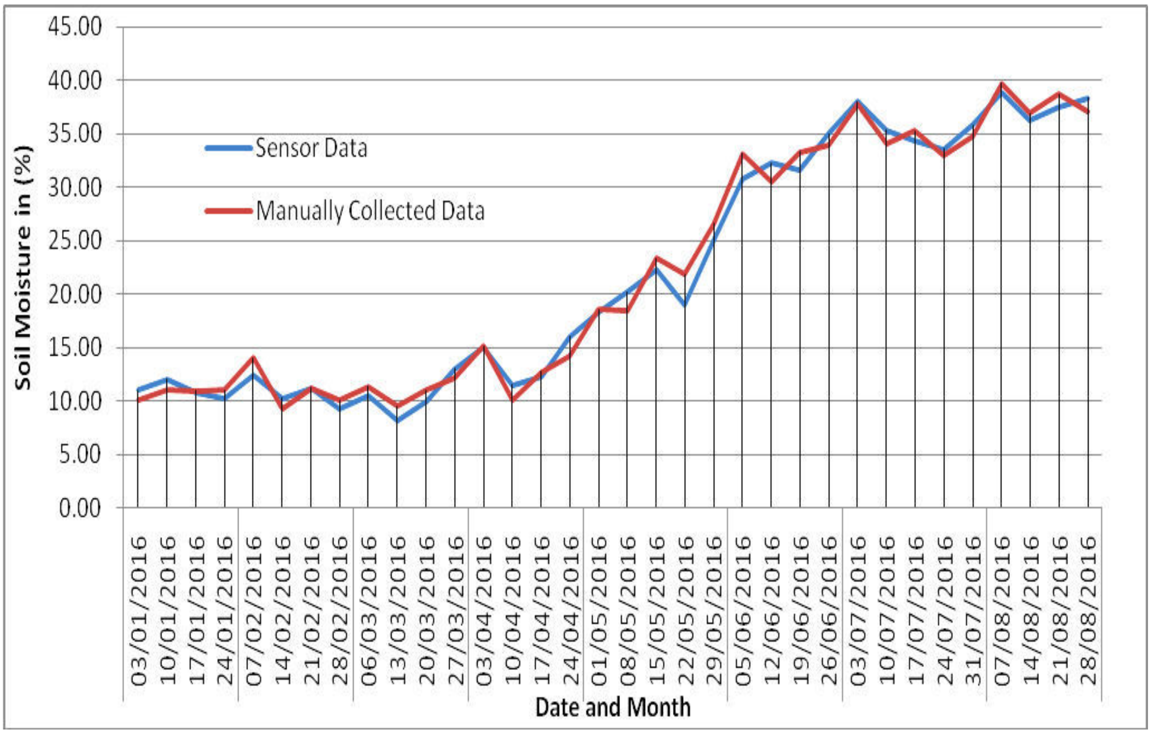


Figure 5.4: Graph to comparing accurate sensor collected data to the traditionally collected data.

From the above graph we revealed that the sensors acquire data and manually collected data (Laboratory analyzed data) has a closed match. It is tedious job to collect data manually in frequent time duration. But it can be done by the wireless sensor network to get the moisture level of the soil in frequent time duration for proper and better irrigation in the garden.

5.2. FACTORS AFFECTED ON TEA PRODUCTIVITY

We have collected the four main factors which will affect the productivity of the tea leaves. These factors are rainfall, temperature, moisture of soil and pH value of the soil. Firstly we have selected three different small gardens for experiment and the experimented area of each garden is 14,400 sq ft.

Each garden is equally dived into two parts, both are equipped with Data Acquisition system but only one half is equipped with facilities to maintain soil moisture using irrigation. Other half soil moisture is governed by natural condition and no changes to soil moisture have been delivered from our end.

The list of the collected data are given below

After setting up the Data acquisition system to different gardens the following data are:

Table - 5.2: Table for productivity and different parameters are affected in Tea productivity in the year of 2015 (Garden –A)

Month	Rainfall (MM)	Temperature (c)	Soil Moisture		pH		Productivity	
			Before use of data acquisition System	After use of Data Acquisition System	Before use of Data Acquisition System	After use of Data Acquisition System	Before use of Data Acquisition System	After use of Data Acquisition System
January	0	20.96	9.45	37.23	4.5	4.7	0	0
February	53.8	22	13.63	38.13	4.3	4.4	0	0
March	21.4	27.41	12.33	34.55	5	5.4	55	94
April	27.2	33.17	12.78	40.19	4.5	4.5	70	104
May	509.4	31.48	40.35	40.35	4.7	4.8	135	149
June	826.8	32.27	58.9	58.9	4.5	4.3	150	160
July	446	33.62	44.63	44.63	5.5	5.5	152	163
August	879	31.36	63.41	63.41	5.9	5.7	164	170
September	572	31.55	40.82	40.82	4.5	5.1	170	159
October	12.2	30.7	16.32	36.13	5.8	5.5	100	145
November	0	27.1	9.13	33.51	4	4.4	65	140
December	0.8	22.24	8.1	34.17	4.8	4.7	0	0

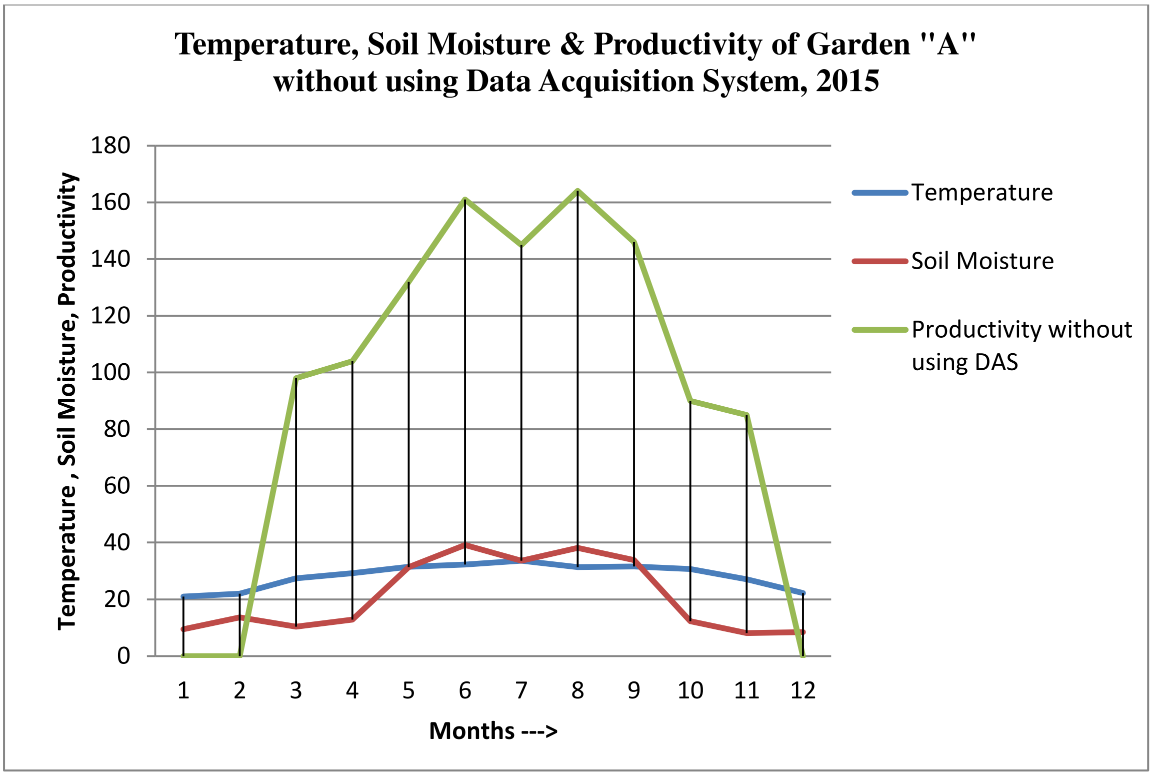


Figure 5.5: Graph for Temperature, Soil Moisture & Productivity of Garden "A" without using Data Acquisition System, 2015

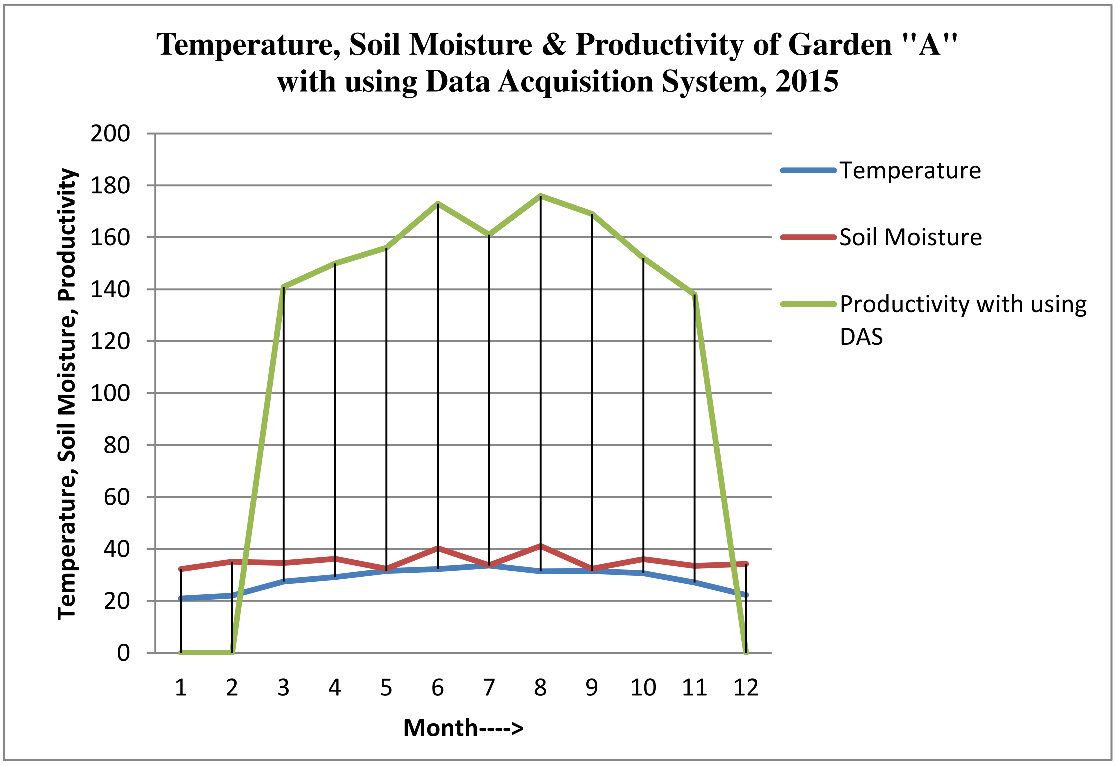


Figure 5.6: Graph for Temperature, Soil Moisture & Productivity of Garden "A" with using Data Acquisition System, 2015

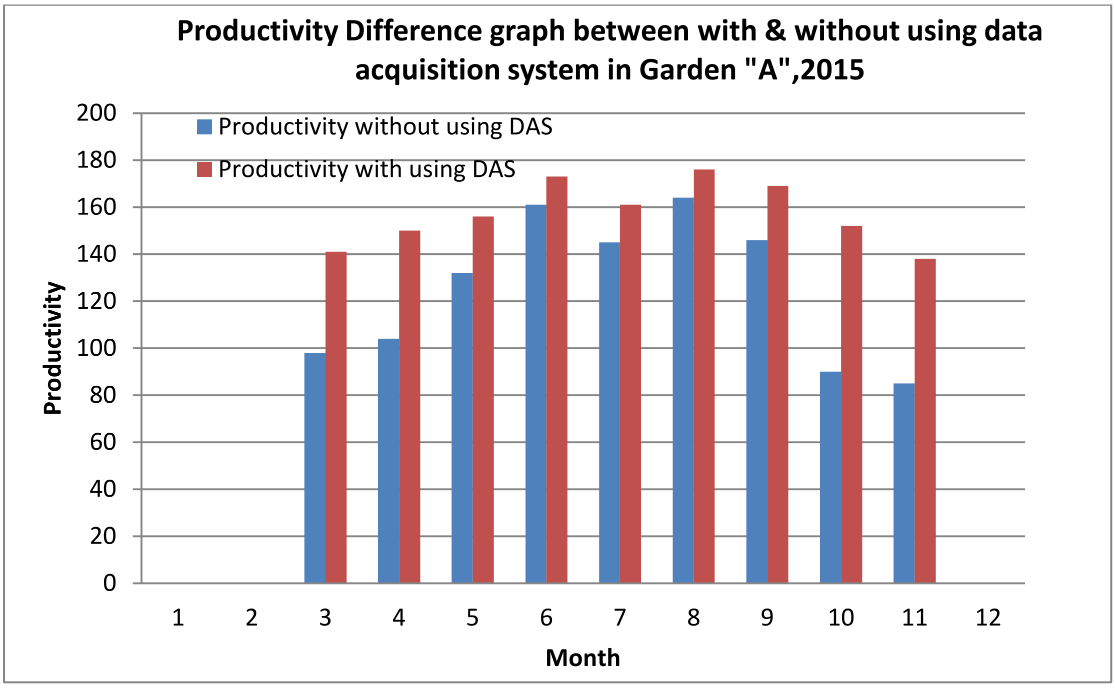


Figure 5.7: Graph for Productivity Difference graph between with & without using data acquisition system in Garden "A", 2015

Table 5.3: Table for productivity and different parameters are affected in Tea productivity in the year of 2016 (Garden –B)

Month	Rainfall (MM)	Temperature (c)	Soil Moisture		pH		Productivity	
			Before use of data acquisition System	After use of Data Acquisition System	Before use of data acquisition System	After use of Data Acquisition System	Before use of Data Acquisition System	After use of Data Acquisition System
January	9.8	21.37	9.08	38.08	4.6	4.3	0	0
February	1.2	23.75	8.23	33.23	4.8	4.9	0	0
March	43	28.94	11.56	33.11	4.2	4.4	61	140
April	188.8	29.62	20.79	35.15	4.5	4.5	82	153
May	576.6	31.51	31.77	34.77	5.5	5.3	150	152
June	1146.2	30.56	45.36	45.36	4.5	4.3	165	175
July	532.8	33.34	38.65	38.65	5	4.9	163	173
August	1155.2	32.06	46.37	46.37	4.9	4.6	166	176
September	310	31.81	29.49	36.49	5.2	5.4	143	162
October	2.4	31.63	12.86	34.54	5	5.6	82	159
November	7.4	26.36	9.84	33.13	5.5	5.5	70	138
December	16.8	21.81	10.22	34.22	5.6	5.3	0	0

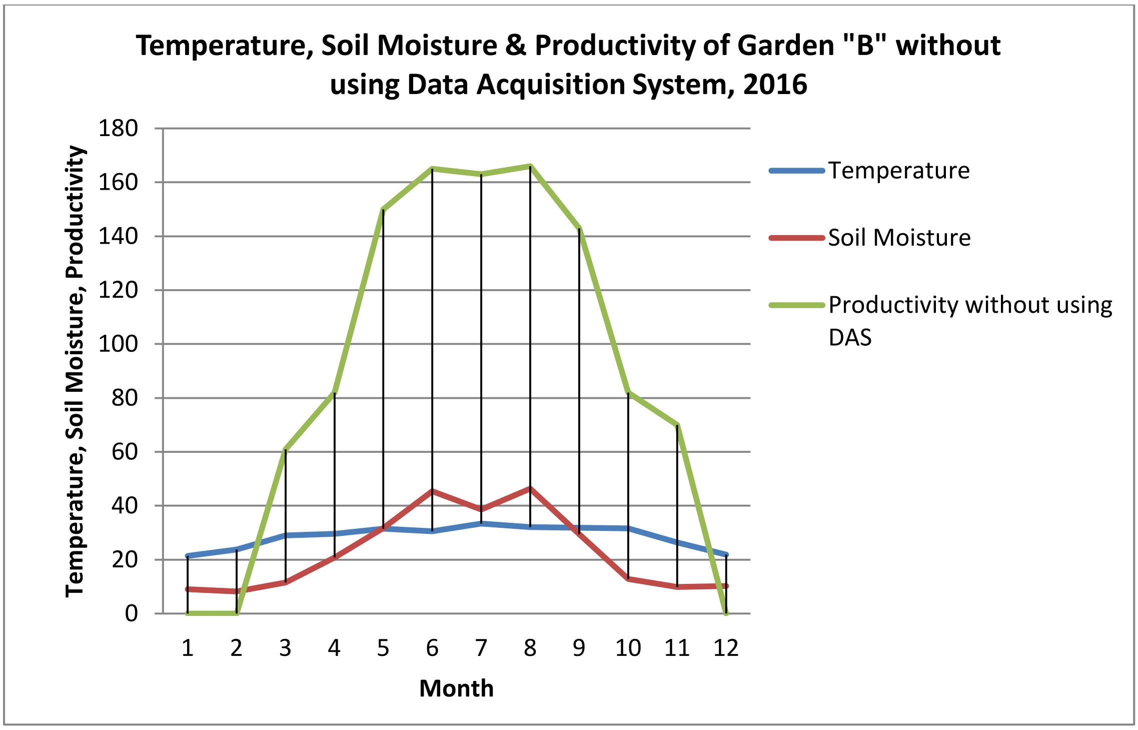
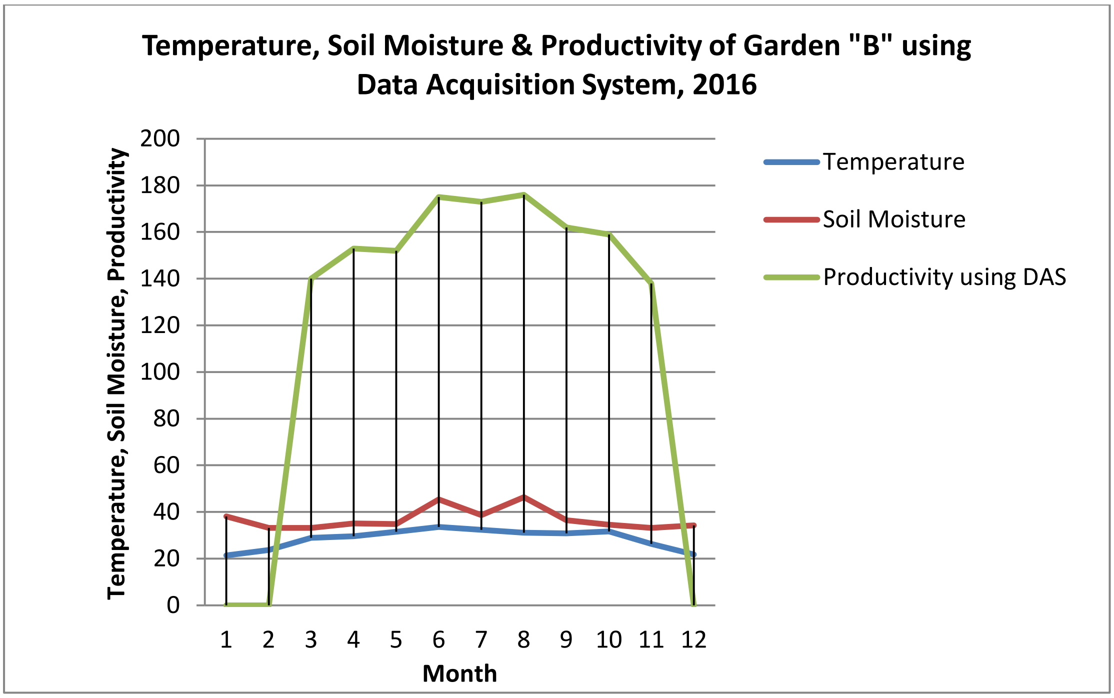


Figure 5.8: Graph for Temperature, Soil Moisture & Productivity of Garden "B" without using Data Acquisition System, 2016



Graph 5.9: Graph for Temperature, Soil Moisture & Productivity of Garden "B" using Data Acquisition System, 2016

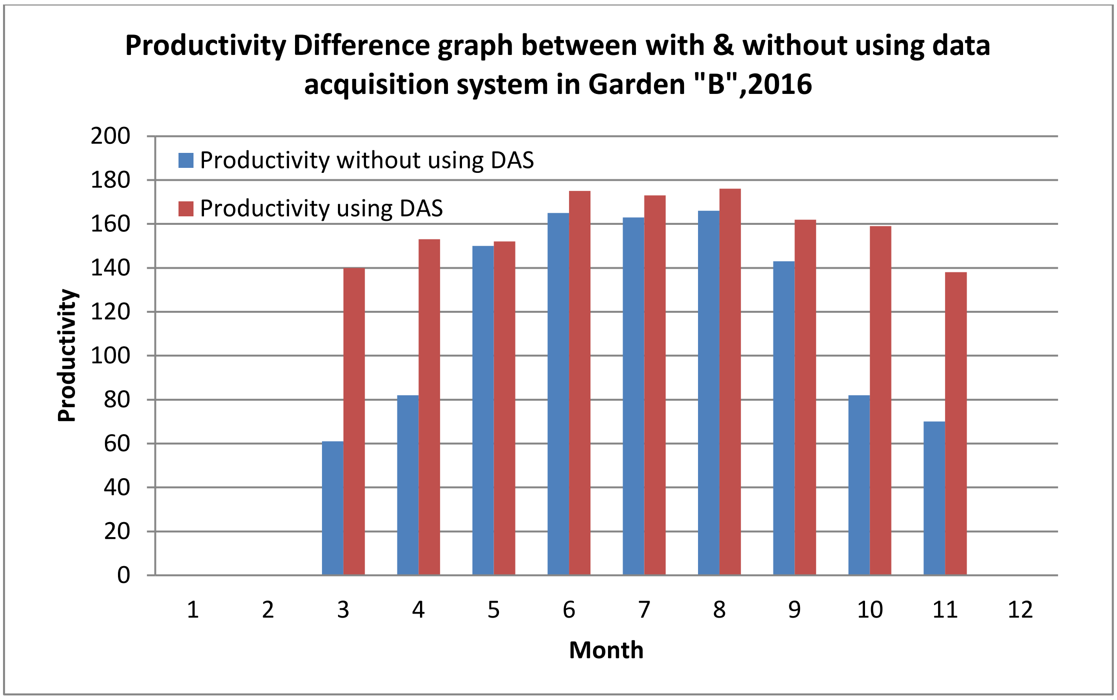


Figure 5.10: Graph for Productivity difference graph between with & without using data acquisition system in Garden "B", 2016

Table 5.4: Table for productivity and different parameters are affected in Tea productivity in the year of 2017 (Garden –C)

Month	Rainfall (MM)	Temperature (c)	Soil Moisture		pH		Productivity	
			Before use of data acquisition System	After use of Data Acquisition System	Before use of data acquisition System	After use of Data Acquisition System	Before use of Data Acquisition System	After use of Data Acquisition System
January	4.6	20.29	21.37	38	4.3	4.3	0	0
February	0	24.81	23.75	34.12	4	4	0	0
March	132.6	29.74	28.94	33.7	5.3	5.3	73	98
April	348.6	30.79	29.62	40.14	4.5	4.5	90	120
May	447.8	30.55	31.51	42.66	4.8	4.8	143	155
June	658	32.58	30.56	48.19	4.9	4.9	160	165
July	583.4	31.27	33.34	47.11	4.8	4.8	163	169
August	114.6	34.79	32.06	38.25	5.9	5.9	140	168
September	318.4	31.48	31.81	35.46	5.6	5.6	145	165
October	191.4	30.51	31.63	39.37	5	5.2	120	168
November	0	27.39	26.36	35.14	5.4	5.2	86	105
December	0	23.41	21.81	38.11	4.6	4.8	0	0

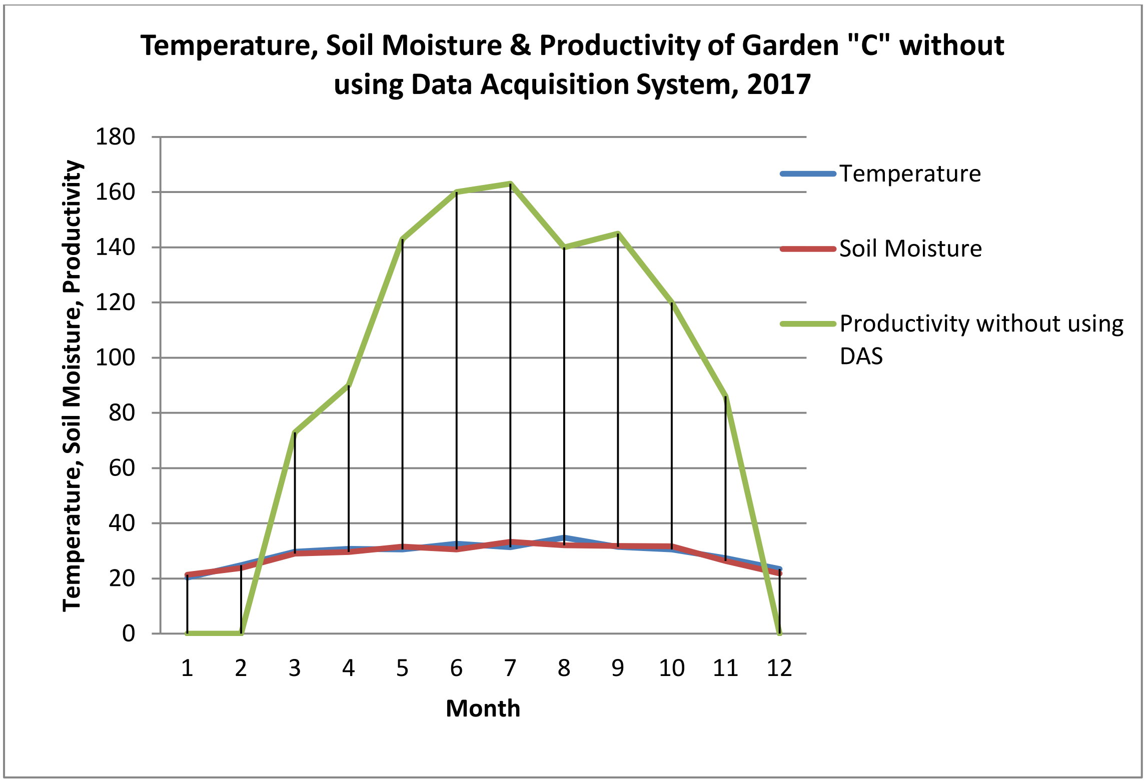


Figure 5.11: Graph for Temperature, Soil Moisture & Productivity of Garden 'C' without using Data acquisition System, 2017

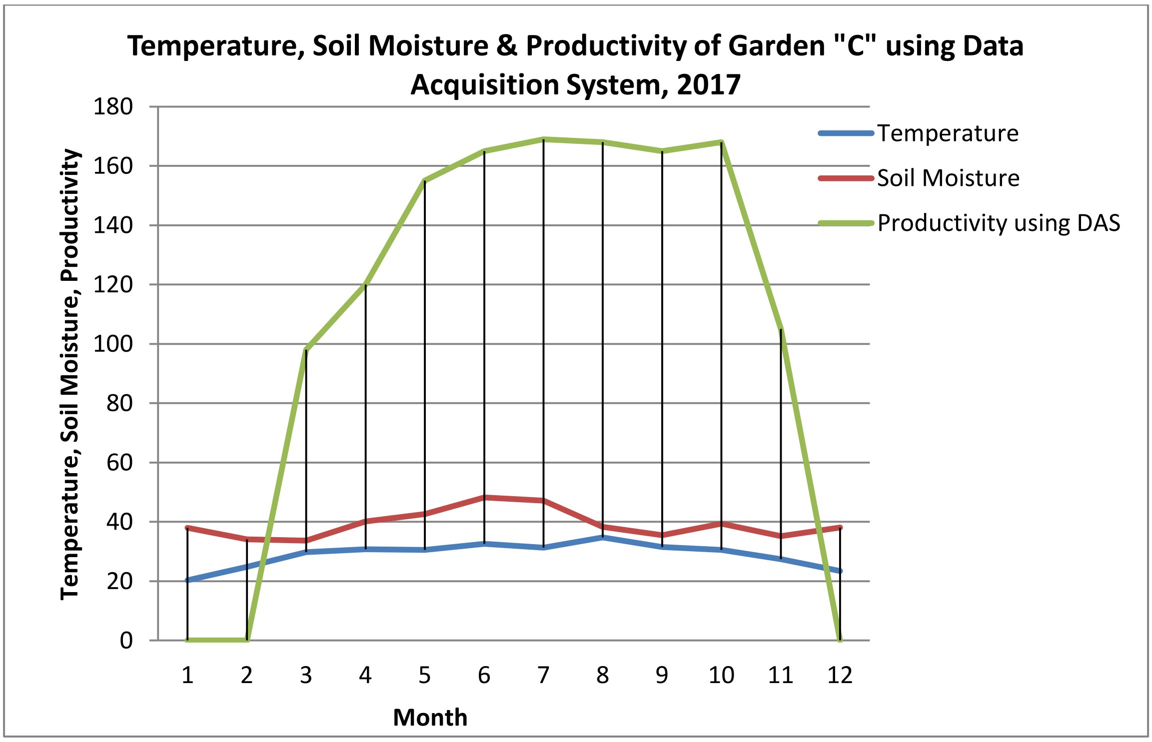
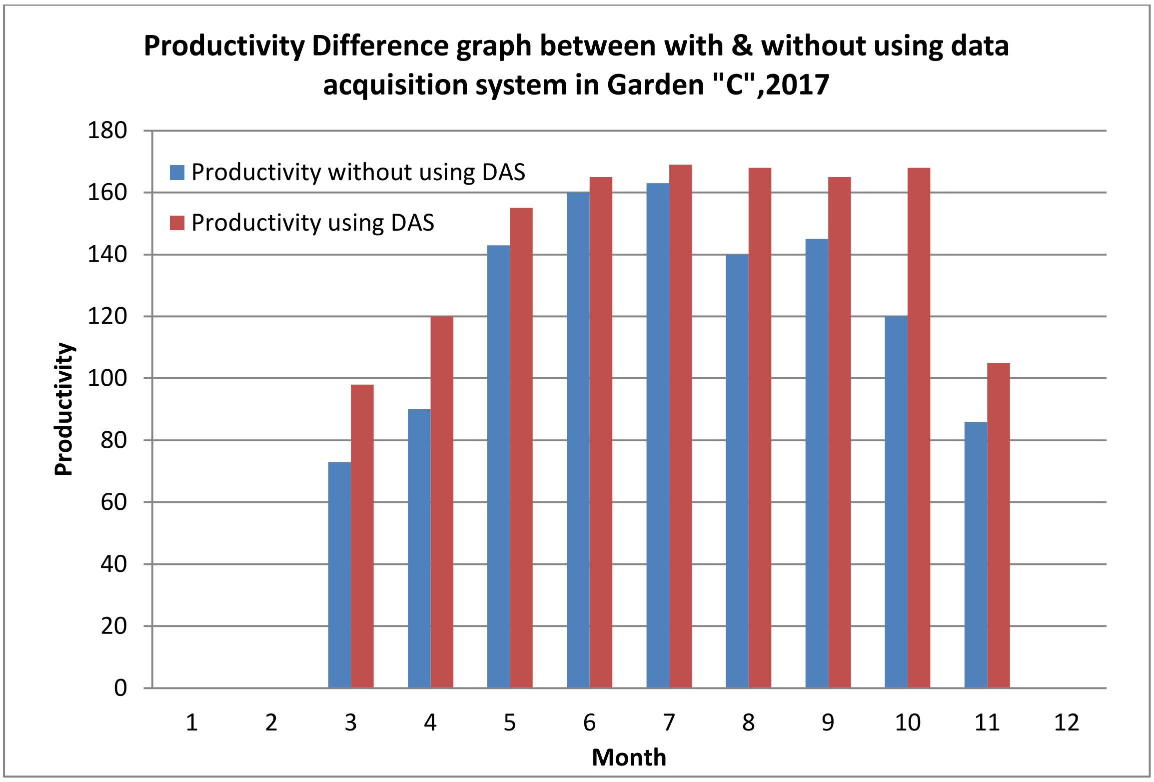


Figure 5.12: Graph for Temperature, Soil Moisture & Productivity of Garden 'C' using Data Acquisition System, 2017.



Graph 5.13: Productivity difference graph between with & without using data acquisition system in Garden 'C', 2017

5.3. ANALYSIS OF WITHOUT USING DATA ACQUISITION SYSTEM IN TEA GARDEN

In absence of adequate rainfall, moisture level drops and optimum productivity cannot be achieved due to lack of sufficient level of soil moisture. The solution would be a data acquisition system which help to sense soil moisture from soil and perform operations to raise level of moisture in soil sufficient for nourishment of plant. Without any data acquisition system real time monitoring and control operation of soil moisture cannot be achieved.

January February is considered non productive period proved to be true as there was no noticeable productivity. With start of March productivity starts to increase From March to April both moisture and surrounding temperature increases so increase in productivity is observed. April to May temp increases but drop in moisture is observed which resulted in production increase of 4-6% of last month. May to June temp and moisture both increases which result in maximum productivity of the year. June to July temperature increases but moisture falls, production drops although it's highest temperature of year highlighting that only temperature increase does not guarantee productivity. July to August moisture is at highest with second highest temperature gives highest productivity of year. August to Sept temperature is almost same but drop in moisture reduced productivity. Sept to October temperature drops moisture increased but productivity dropped suggesting only moisture without temperature cannot provide maximum productivity. October to November temperature moisture both dropped to lowest productivity of the month. November to December moisture increased but temperature further decreased resulting in un-noticeable productivity.

5.4 ANALYSIS OF USING DATA ACQUISITION SYSTEM IN TEA GARDEN

Jan Feb considered non productive period proved to be true as there was no noticeable productivity. Feb has more rainfall than Mar but due to nourishment from Feb rainfall productivity starts to increase. From March to April more rainfall increased moisture level thereby increasing productivity. April to May temp increases but tremendous rainfall increases moisture which resulted in production increase. May to June temp and moisture both increases which resulted in maximum productivity of the year. June to July temperature increases but moisture falls, production drops. July to August in fact highest rainfall of the month moisture is at highest with second highest temperature gives highest productivity of the year. August to Sept temperature is almost same but drop in moisture reduced productivity. Sept to October temperature drops moisture drastically dropped so productivity also dropped. October to November temperature moisture both dropped to lowest productivity of the month. November to December moisture and temperature further decreased resulting in un-noticeable productivity.

5.5 SUMMARY OF USING AND WITHOUT USING DATA ACQUISITION SYSTEM IN TEA GARDENS

The productivity has started to increase after the month of February. In the month of June, July and August the rate of production increase per month is in the range of 7-12% which is less compared to months of Feb March. Also these three months have highest productivity for the entire year. It highlights the optimum level of production has been achieved and hence expected productivity similar to February-March and September-November could not achieved, still 7-12% increase in productivity was observed every month because plant has optimum level of production.

This extra increase in productivity was observed in plot where Data acquisition system was maintaining water moisture in soil since January. We concluded some points using data acquisition system and without using data acquisition system during this study which is given below:

- With three years data captured on monthly basis, prepared by capturing average value every month for soil moisture, surrounding temperature, productivity and rainfall is applied to understand its effects on tea productivity. The careful observation helps to understand how productivity changes when plants surrounding change. With our main focus on change in soil moisture and surrounding temperature.
- When smart watering system is facilitated to plants even during non productive season, annual production found to be improved 25-30%.
- The practice of focusing on yearly productivity plan was found effective compare to monthly productivity plan.

- The monthly productivity after use of Data Acquisition was higher than monthly productivity before use of Data Acquisition system.
- The productivity data for three years show January February December months as non profitable productivity.
- The relation between soil moisture and productivity is directly proportional in the range of 25-40% because it was found that, at same temperature, month with high productivity has more soil moisture level compared to month with low productivity with low moisture level.
- Also beyond 40% of soil moisture productivity starts to saturate and no further increase of productivity is observed. However during this saturation phase productivity increase was directly proportional to surrounding temperature but magnitude of change is very small.
- In case of rainfall during a month, soil moisture naturally rises from its last level. In addition if in succeeding month there happens to be rainfall soil moisture further increases but if there is no rainfall in succeeding month soil moisture level drops from its last level. Also if for consecutive months same level of rainfall occurs then moisture level of two months in consideration remains almost same.
- It is also found that higher rainfall in previous month increases the soil moisture for next month.

From the statistical study on factors affecting production, the following points have to be discussed

- With usage of Data acquisition system the overall productivity of tea garden has achieved 20-25% increase in productivity
- In the month of December January February considered as off season is proved to be true as there was no noticeable productivity but this period is used for maintaining moisture level between 25-40% for the soil by the system for better productivity.

- Although maintain soil moisture between 25-40% is continued for Jan Feb March but there was no profitable productivity but with approach of March we observed rise in temperature which gave 25% increase in productivity
- Productivity is observed above temperature of 27 degrees
- April had higher temperature and moisture content so productivity jump of 14.2% is observed

5.6 SIGNIFICANCE OF DATA USING REGRESSION METHOD

To show statically the significance between soil moisture and productivity we are using tools of regression in MS-Excel. We test the data before use of Data acquisition system in garden and after use of data acquisition system in garden .

Table 5.5: Regressing Table for Soil Moisture in the year of 2015

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.908141101
R Square	0.82472026
Adjusted R Square	0.799680297
Standard Error	20.1333674
Observations	9

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	13350.75484	13350.75484	32.93616152	0.000706357
Residual	7	2837.467379	405.3524827		
Total	8	16188.22222			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	53.67974231	13.12975917	4.08840266	0.004640287	22.63279537
X Variable 1	1.919459674	0.334458702	5.73900353	0.000706357	1.128590515

Table 5.6: Regressing Table for Soil Moisture in the year of 2016

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.88519951
R Square	0.783578173
Adjusted R Square	0.752660769
Standard Error	21.78884838
Observations	9

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	12032.28	12032.28	25.34424	0.001506
Residual	7	3323.277	474.7539		
Total	8	15355.56			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	64.31676879	13.86557	4.638596	0.002374	31.52991
X Variable 1	1.658297174	0.329399	5.034307	0.001506	0.879392

Table 5.7: Regressing Table for Soil Moisture in the year of 2017

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.794971409
R Square	0.631979541
Adjusted R Square	0.57940519
Standard Error	21.86121077
Observations	9

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	5744.834	5744.834	12.02068	0.010447
Residual	7	3345.388	477.9125		
Total	8	9090.222			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-270.0854333	114.026	-2.36863	0.049706	-539.714	-0.45671
X Variable 1	12.87303375	3.712927	3.467085	0.010447	4.093358	21.65271

In the above regression summary table we observed that the value of $P<=0.95$ which indicates the significance between soil moisture and productivity.

HYPOTHESIS -1

Working Hypothesis: Data Acquisition System (Soil moisture) has influences the tea productivity in tea garden.

H_N: Data Acquisition System (Soil moisture) doesn't have any significance in Tea productivity in tea Garden.

H_A: Data Acquisition System (Soil moisture) has significance in Tea productivity in tea Garden.

After using the regression we got the value of $P>=0.95$ which indicates the significance between soil moisture and productivity. Therefore, there is overwhelming evidence at the confidence label 0.95. So the Null hypothesis (H_N is rejected and Alternate Hypothesis (H_A) is accepted. Hence Hypothesis1 is statically proved.