Temporal Oscillations in Flowering in *Passiflora Incarnata*

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A dissertation submitted in partial fulfilment of the requirements

for the MS degree in Chemical Sciences

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Certificate of Examination

This is to certify that the dissertation titled "**Temporal Oscillations in Flowering in *Passiflora Incarnata***" submitted by **Mr. Surender Goyal** (Reg. No. Mp13004) in partial fulfilment of the requirements for the MS degree of the Institute, has been examined by the thesis committee duly appointed by the Institute. The committee finds the work done by the candidate satisfactory and recommends that the report be accepted.

Dr.Abhishek chaudhari Prof. K.S.Viswanathan Professor N. Sathyamurthy (Supervisor)

Dated: April , 2016

Declaration

The work presented in this dissertation has been carried out by me under the guidance of Professor N. Sathyamurthy at the Indian Institute of Science Education and Research Mohali.

This work has not been submitted in part or in full for a degree, a diploma, or a fellowship to any other university or institute. Whenever contributions of others are involved, every effort has been made to indicate this clearly, with due acknowledgement of collaborative research and discussions. This thesis is a bonafide record of original work done by me and all sources listed within have been detailed in the bibliography.

Surender Goyal

(Candidate)

Dated: April 22, 2016

In my capacity as the supervisor of the candidate's project work, I certify that the above statements by the candidate are true to the best of my knowledge.

Professor N. Sathyamurthy

(Supervisor)

Acknowledgement

My first and foremost thanks is to my thesis supervisor Professor N. Sathyamurthy. It was a great experience to work in his guidance on a nice challenging problem. I very much appreciate his unique way of handling a students doubt by providing him/her the correct line of thought and then allowing one to figure out by oneself, as it helped me learning many new things during the process. Along with his inputs, he also provided me enough freedom to approach the problem differently by encouraging my ideas. Moreover,he is a very nice and down-to-earth person.

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Abstract

Temporal Oscillations in flowering of *Passiflora Incarnata* have been studied over a period of two years. Fourier transform of the temporal behaviour reveals a period of approximately thirty days. Effects to correlate the number of flowers with change in temperature and humidity are described.

Chapter 1

Introduction

This study is focused on analysing the **temporal oscillations in flowereing Passiflora Incarnata**. There are different types of oscillations that occur in nature. Oscillations in the population of bacteria[1], neural oscillations[2] are some of the oscillating systems that have been investigated one of the best known oscillatory reactions is perhaps the **Belousov-Zhabotinskii reaction**[3], a reaction catalysed by cerium sustained periodic oscillations are observed in the concentration of cerium ions. If one uses the catalyst and phenanthroline indicator the periodic oscillations are visualised as colour changes between reddish-orange and blue. Till 1950, a lot of periodic phenomiena were observed in chemical and biological systems. The first kinetic model for an oscillatory reaction was analysed by Lotka and Voltera[4] to account for the oscillations in prey-predator system in ecology. Hodgkin and Huxley gave a biological oscillatory model[5] based on the experimental and theortical studies which account for the sustained oscillations in the membrane potential in living cells. This classic study of Hodgkin and Huxley came in the same year as Turing[16] published his pioneering paper on the spatial patterns in chemical systems. Prigogine and Balescu[17]showed that sustained oscillations could occur far from thermodynamic equilibrium in open chemical systems governed by appropriate, nonlinear kinetic laws.The most ubiquitous biological rhythms are those that occur with a period close to 24 h in all eukaryotes and in some prokaryotes such as cyanobacteria. These circadian rhythms allow or-

ganisms to adapt to the natural periodicity of the terrestrial environment, which is characterized by the alternation of day and night due to rotation of the earth on its own axis. Circadian clocks provide cells with an endogenous mechanism, allowing them to anticipate the time of day. Experimental advances during the last decade have clarified the molecular bases of circadian rhythms, first in Drosophila and Neurospora, and more recently in cyanobacteria, plants ,and mammals.[6]. In one study at Lowland Tropical Rain Forest Trees at La Selva, Costa Rica a long-term (12 yr) survey of flowering in 254 lowland tropical rain forest trees of 173 species were studied.[7]. Analysis of this survey data relied primarily on graphical analysis. After that fast fourier transforms were performed and the patterns were analysed. The four basic classes- continual, annular, sub-annular and supra annular were observed.

Chapter 2

Passiflora Incarnata

The plant of *Passiflora incarnata*, known as the passion flower is a perrenial vine. The "Passion" in "passion flower" refers to the passion of Jesus in Christian theology. In the 15th and 16th centuries, Spanish Christian missionaries adopted the unique physical structure of this plant, particularly the numbers of its various flower parts, as symbols of the last days of Jesus and especially his crucifixion. It is a common wildflower in the southern United States. The best soils for P. incarnata are well-drained, as this provide for good growth. The main chemical substance in *Passiflora Incarnata* is flavanoids. More concentration of flavonoids has been reported in leaves. Chrysin is thought to be the main substance responsible for the sedative effect of *PI*.

2.0.1 Structure

Passiflora Incarnata grows well on loamy soil. It does not bear fruit. It is widely grown in frost-free areas around the world. Studies were carried out for measuring the opening and closing of floweres of *Passiflora Incarnata* in mornings and evenings, respectively. Time taken for opening and closing by a flower is 13-20 minutes and 60-90 minutes, respectively. Shape and size of the pollens and ovules were measured by binocular stereomicroscope. Passion flower is typically 5.7 cm. in diameter,petals light purple of length 2.7cm , white sepals of length 2.7cm Each stigma is 1.3cm long. White-green ovary is of length 0.7 cm. The angle between each stigma is

apprioximately 120 ° . Anthers of 0.8cm length contain yellow pollens. Flowers abscise within 3-4 days without showing any enlargment in ovary. Flowering period is from April to December in Mohali.

2.0.2 Application

Floweres of PI attract different bees. There is one family of bee Anthumurgus passiflorae, who eat only the yellow pollen of passion flower. Extracts of PI can be classified into several categories of chemical activity anxiolytic, spasmolytic, sedative.

Chapter 3

Fast Fourier Transform

Fourier transform is a mathematical tool to convert time domain data *S(t)* to frequency domain*I(w)*[10]:

$$I(w) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} S(t) e^{iwt} dt \tag{3.1}$$

.

3.0.3 Application of fast fourier transform

The Fourier transform has many applications. In communications theory the signal is usually a voltage, and Fourier theory is essential to understand how a signal behaves when it passes through filters, amplifiers and communications channels. For example in a telephone line, whenever you dial a number on a " touch-tone " phone you hear a series of different tones. Each of these tones is composed of two different frequencies that add together to produce the sound you hear. There is a lot of examples in astronomy in which fast fourier transform(FFT) used. One recent example of this technique was the NASA Magellan satellite, which was released from the space shuttle Atlantis on 4th May 1989 and sent to Venus on a 15 month journey that took it one and a half times around the sun. The image sent by this satellite was analysed with the help of FFT. In electromagnetic theory, the intensity of light is proportional to the square of the oscillating electric field which exists at any point in space. The Fourier transform of this signal is the equivalent of breaking of the light into it's component

parts of the spectrum which is very much useful in various studies.So these are the some of the applications of Fast Fourier Transform technique.

Chapter 4

Opening and closing of flowers of *Passiflora Incarnata.*

In this study we have collected the data on the opening and closing of flowers of *Passiflora Incarnata*. The picture of a typical flower is shown in Fig. It opens in the morning and closes in the evening. The life period of each flower is one day. Time taken for opening and closing for the flower is 13-20 minutes and 60-90 minutes respectively. The observations for this study were made in the begining of flowering

Figure 4.1: Picture of a flower of *Passiflora Incarnata*

season(june-july), 2013 in the campus of **Indian Institute of Science Education**

and Research, Mohali. Opening and closing of three flowers were studied starting on 22 June, 2013. Studies revealed that the flowers opened around 8:30-8:53am and closed around 6:23-7:23pm.It took more time to close than to open . Movement of anthers at the time of opening was also observed. It was seen that initially two anthers turned then the third and then the fourth and fifth.The time gap between each movement was around 1 minute. This figure shows the opening and closing of

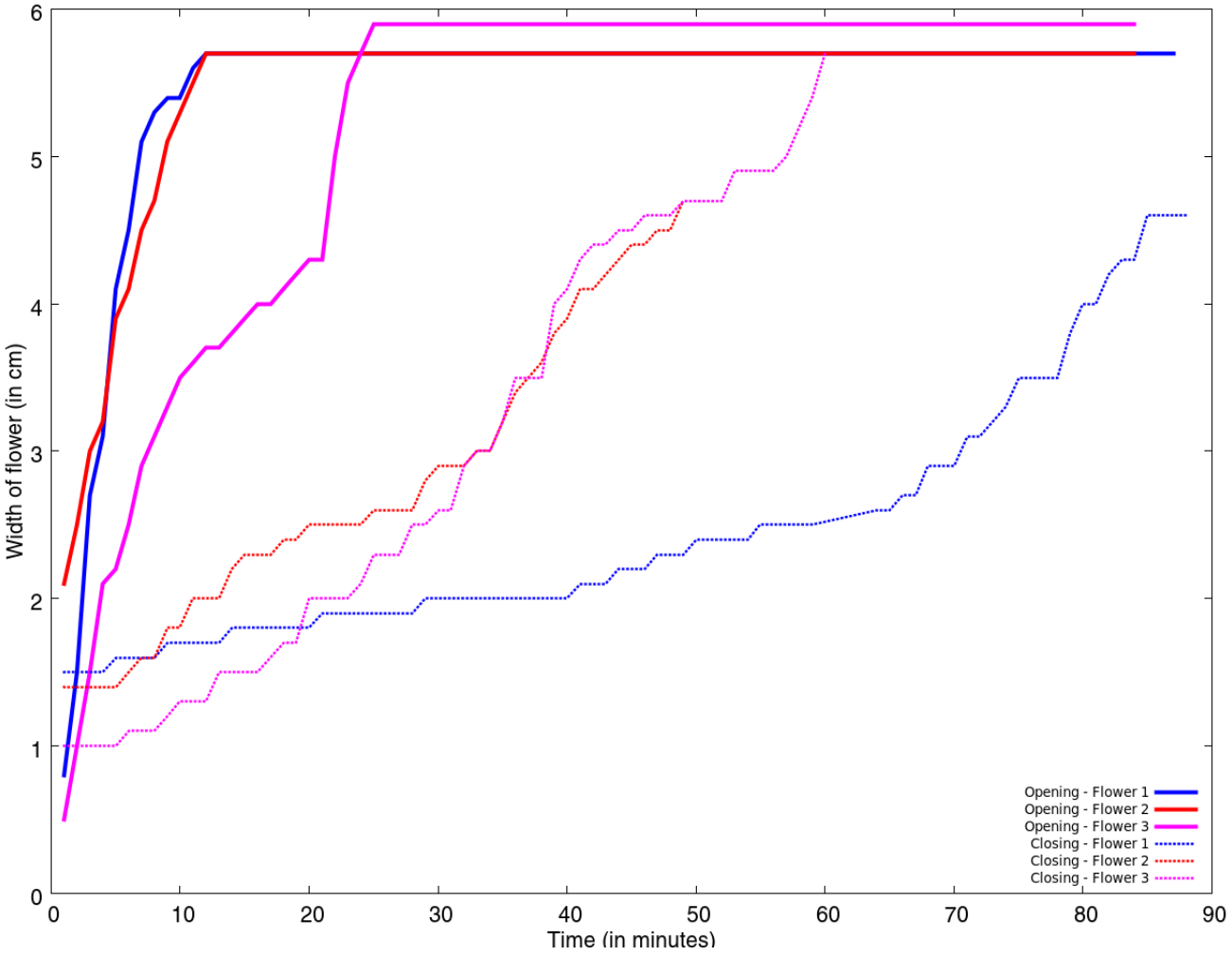

Figure 4.2: Opening and Closing in flowers of *Passiflora Incarnata*

three flowers of *Passiflora Incarnata*.Blue, orange and magenta are three consiquitive opening and closing of flowers. If we start by blue one it was 0.9 cm when it starts opening and it opens till the width of 5.7 cm. After the whole day it starts closing in the evening and went through 1.5 cm. Same phenominon happens with other flowers

also.

Chapter 5

Temporal Oscillations in flowering in *Passiflora Incarnata*

In this study we counted the number of flowers from a single plant of *Passiflora Incarnata* every day starting from 21 April,2014. After collecting the data we plotted them against the number of days.Result in figure 5.1 show a periodic behaviour in the system. We can see that after every 30 days oscllation repeats and the fast fourier of the data confirms the **Time Period** of oscillation to be 30 days.Similar data were collected for the year 2015 and plotted in Figure-5.3

This graph is showing the result for 2015.This FFT is showing that this system is showing periodicity and the **Time period** of Oscillation is 30 days.

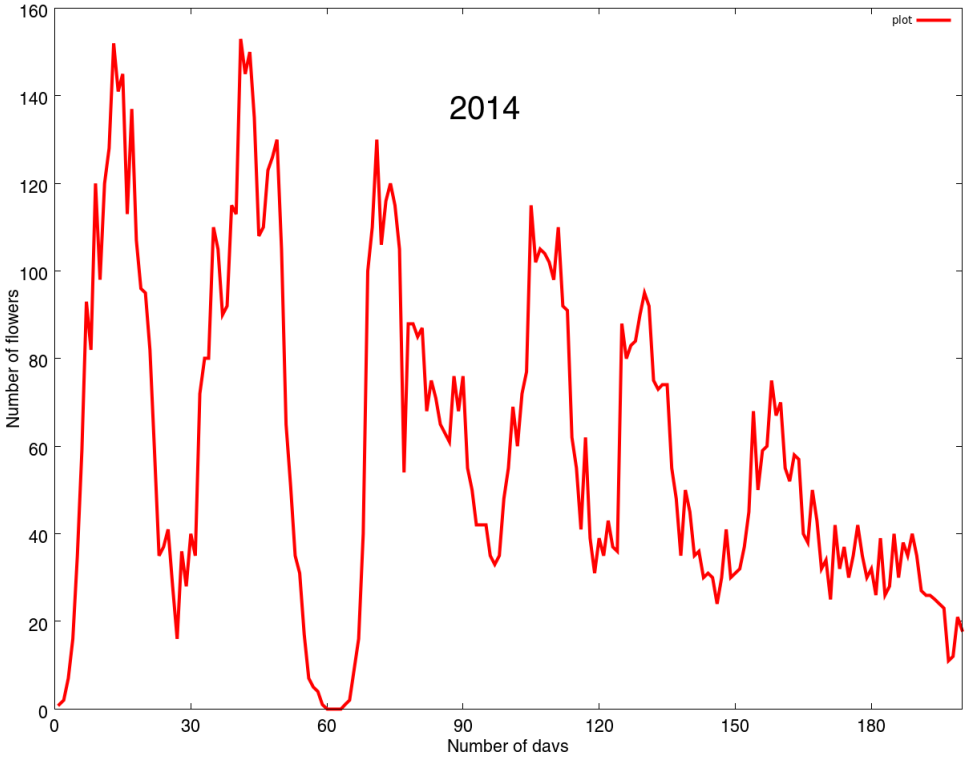

Figure 5.1: Graph between the number of days and the number of flowers of *Passiflora Incarnata* for the year 2014

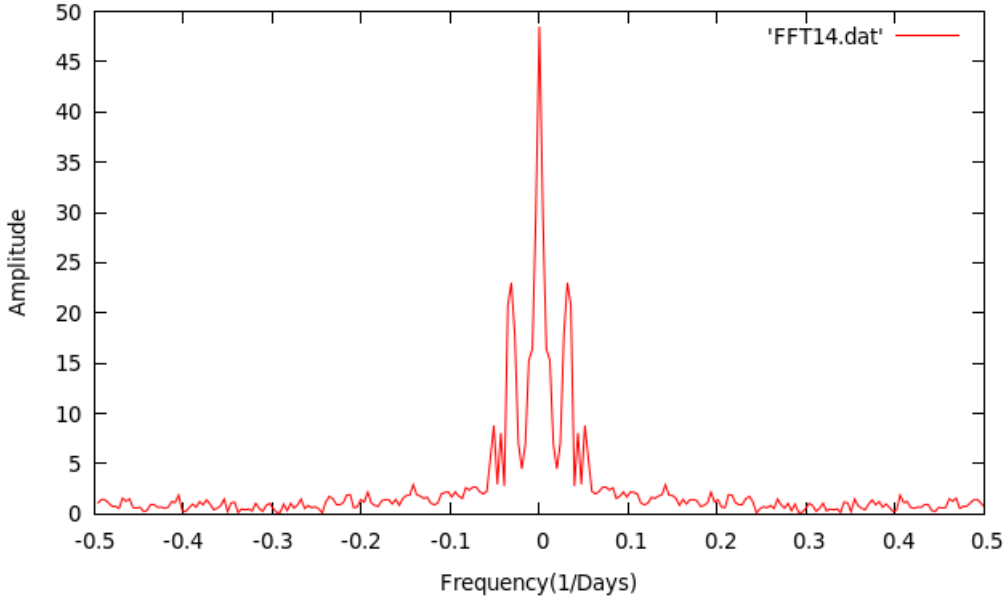

Figure 5.2: Fast fourier transform of the data for the year 2014

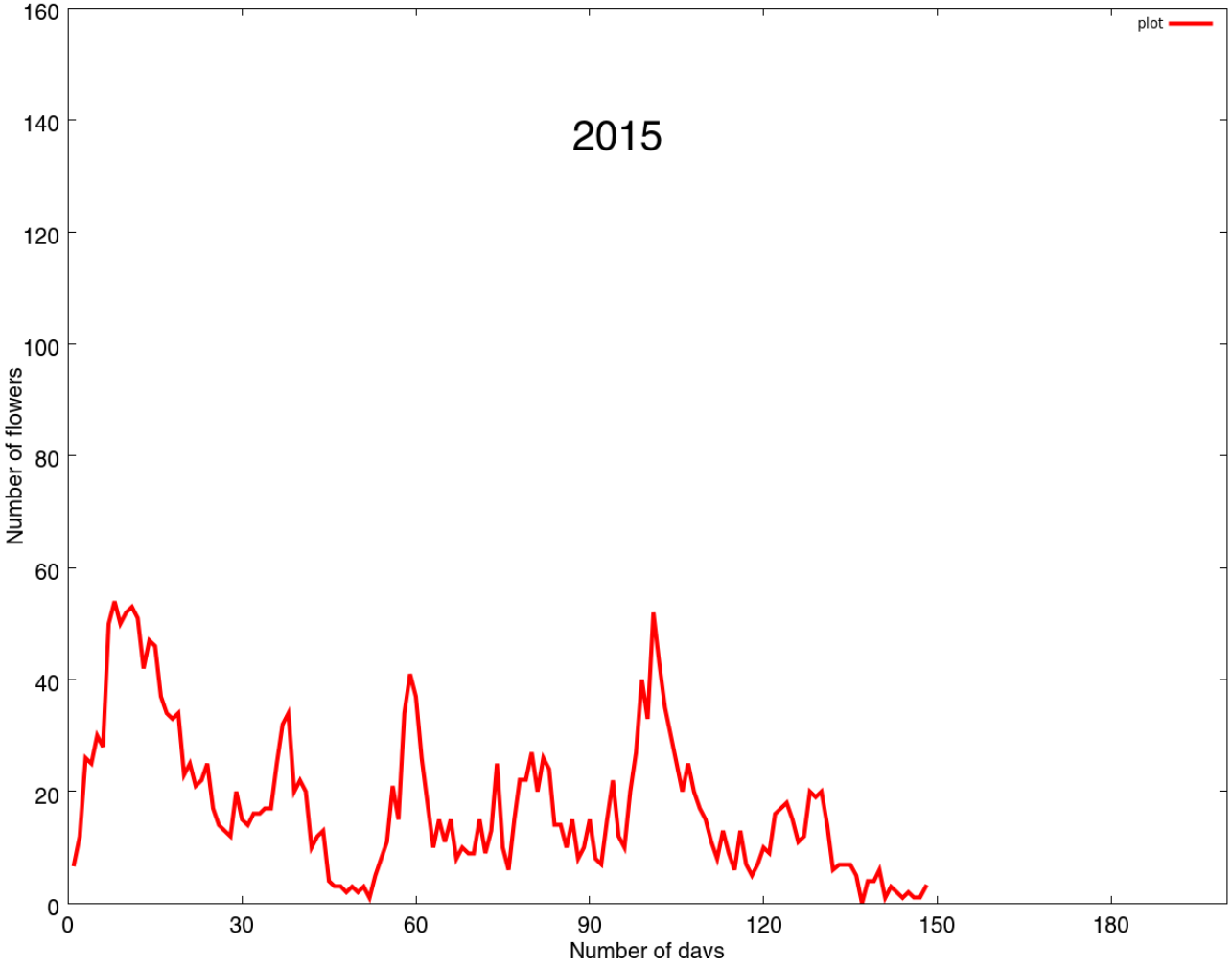

Figure 5.3: Graph between the number of days and the number of flowers of *Passiflora Incarnata* for the year 2015

Chapter 6

Correlation between the number of flowers of *Passiflora Incarnata* with temperature and humidity for the years 2014 and 2015

Flower production of plant can be influenced by local weather conditions. However long term monitoring studies conducted at a sufficient temporal scale to capture climatic oscillations and unpredictability of extreme weather events and their influence on plant reproduction remain scarce [8]. In this study from the data we collected for the number of flowers of *Passiflora Incarnata* we try to find out a correlation with change in temperature and humidity. Data of temperature and humidity were collected from **Dr.Vinayak Sinha's** lab at **Institute of Science Education and Research Mohali**.Temperature data was available for every minute of the day. The maximum and minimum temperatures for each day were obtained for whole year. Same was done with the Humidity data. The number of flowers show some correlation with temperature variation for the year 2014. The results are shown below:

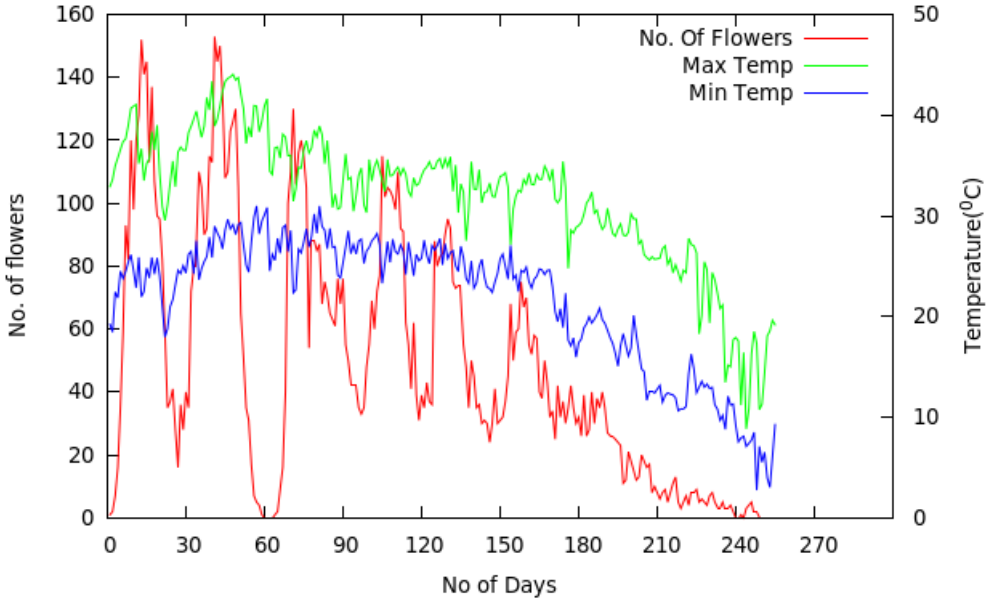

Figure 6.1: Correlation Graph between the number of flowers of *Passiflora Incarnata* and temperature for the year 2014

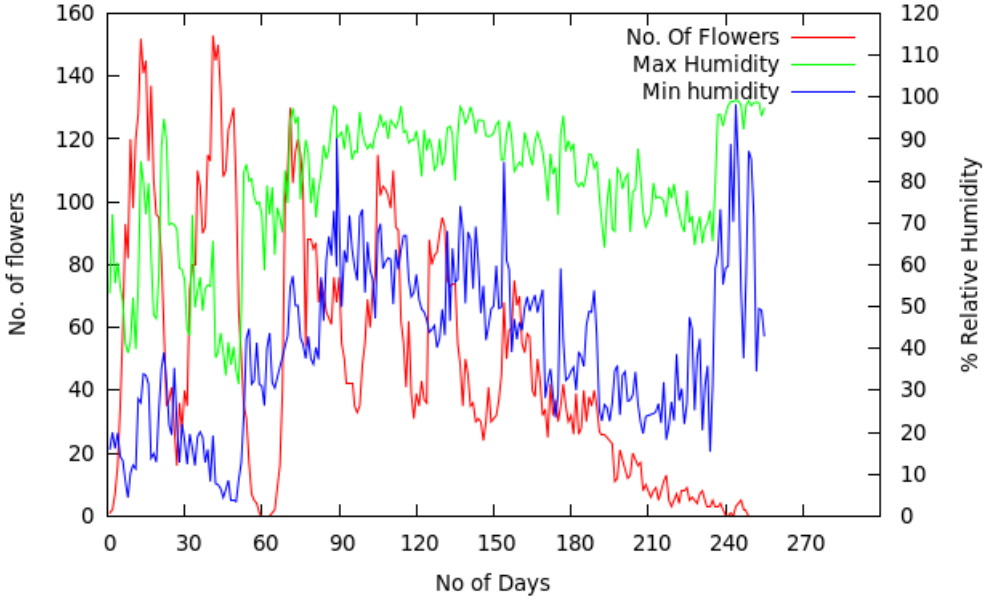

Figure 6.2: Correlation Graph between the number of flowers of*Passiflora Incarnata* and Humidity for the year 2014

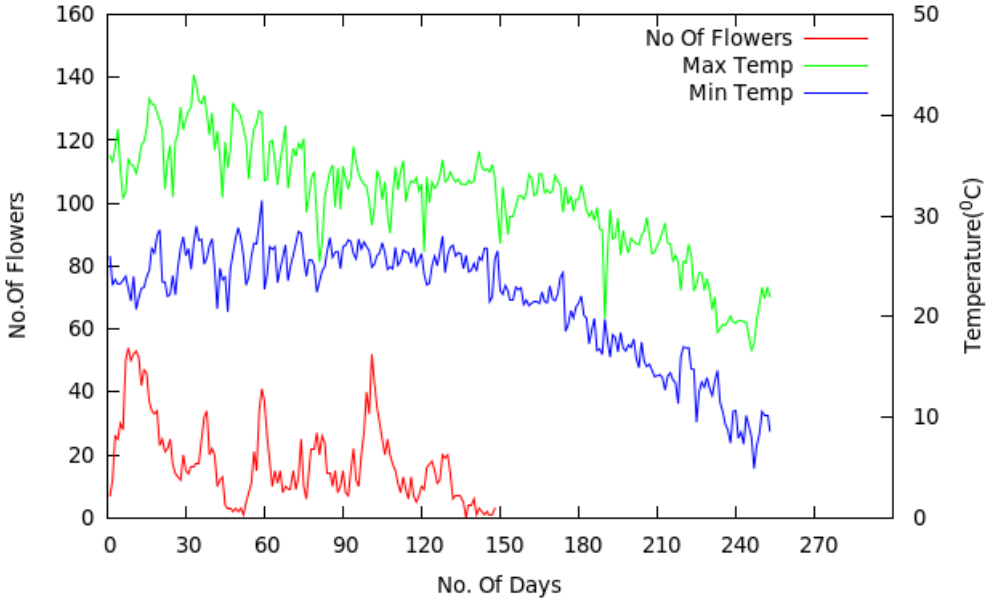

Figure 6.3: Correlation Graph between the number of flowers of*Passiflora Incarnata* and temperature for the year 2015

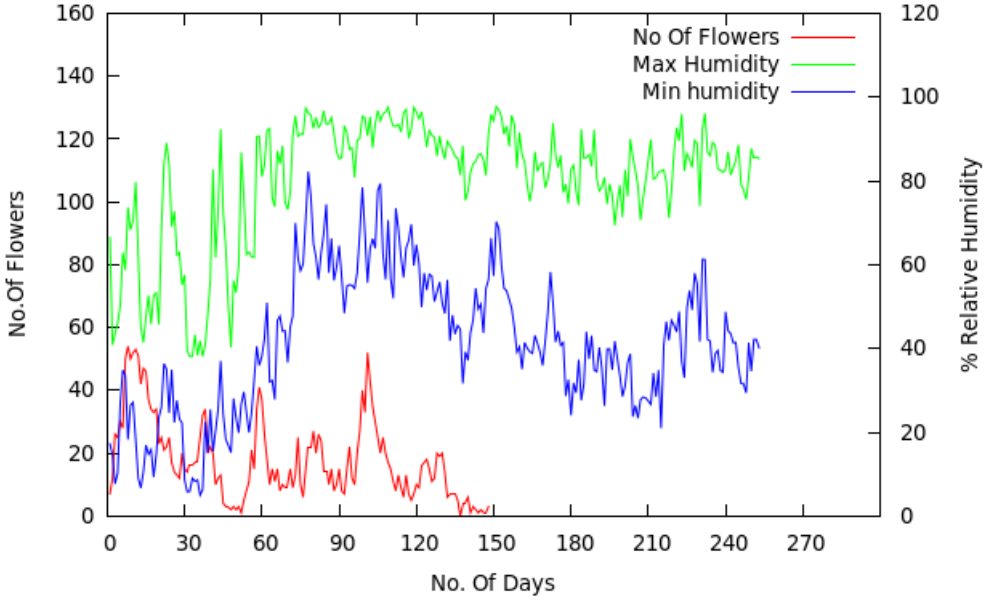

Figure 6.4: Correlation Graph between the number of flowers of *Passiflora Incarnata* and Humidity for the year 2015

Chapter 7

Investigation of individual pollens of *Passiflora Incarnata* under a microscope

We collected the pollens in a glass bottle containing 70 per cent ethanol. slides were made and observed under binocular stereomicroscope. Some photographs were taken by Carl Zeiss fluorescence microscopy and area measured by **Image j** software. The area observe was 161.92 um^2.There were a lot of ovules in the ovary. The average area measured was 368.54um^2.

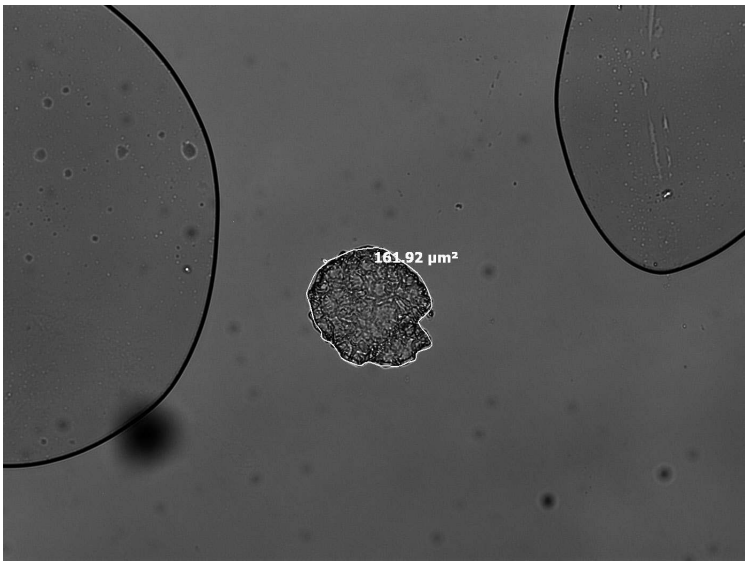

Figure 7.1: Microscopic image of individual pollens of *Passiflora Incarnata*

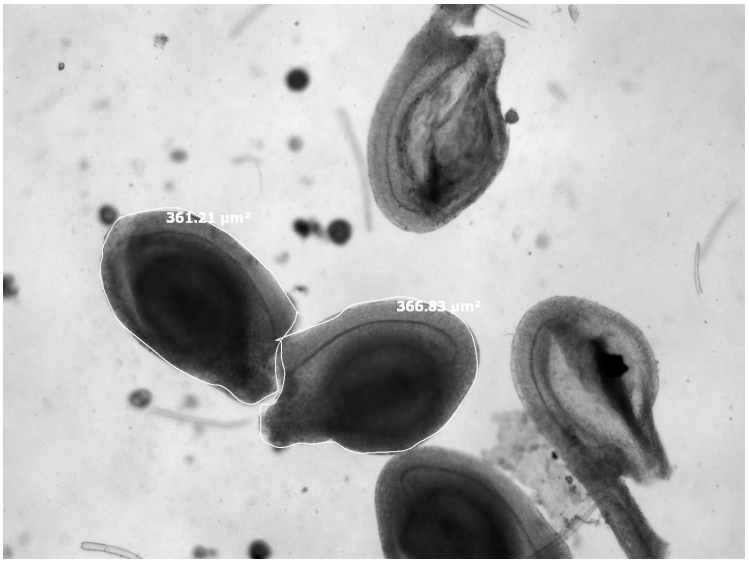

Figure 7.2: Microscopic image of individual ovules of *Passiflora Incarnata*

Chapter 8

Biochemical Pathway

In this study we try to understand the Biochemical pathway of the production of anthocyanin. After reading some papers we become able to understand the biochemical pathways for the synthesis of anthocyanin. Most of the plant pigments ranging from red to purple colors belong to the anthocyanin group of flavonoids.The biosynthetic pathway of anthocyanins has been well characterized biochemically and genetically in species with different floral morphology, pigmentation pattern, and pollination syndromes such as Petunia hybrida.[8]. There are 15 putative coding sequences in *Passiflora Incarnata* which is responsible for the biochemical pathway of anthocyanin in this.

Genetics and biochemistry of anthocyanin also has been explored[14]. In this,flavanoid is found as the secondary plant metabolites in which anthocyanin is the most important class. are water-soluble vacuolar pigments that may appear red, purple, or blue depending on the pH.They belong to a parent class of molecules called flavonoids synthesized via the phenylpropanoid pathway; they are odorless and nearly flavorless, contributing to taste as a moderately astringent sensation. Anthocyanins occur in all tissues of higher plants, including leaves, stems, roots, flowers, and fruits. Anthoxanthins are clear, white to yellow counterparts of anthocyanins occurring in plants. Anthocyanins are derived from anthocyanidins by adding sugars.

The Biochemical Pathway are shown in the figure-

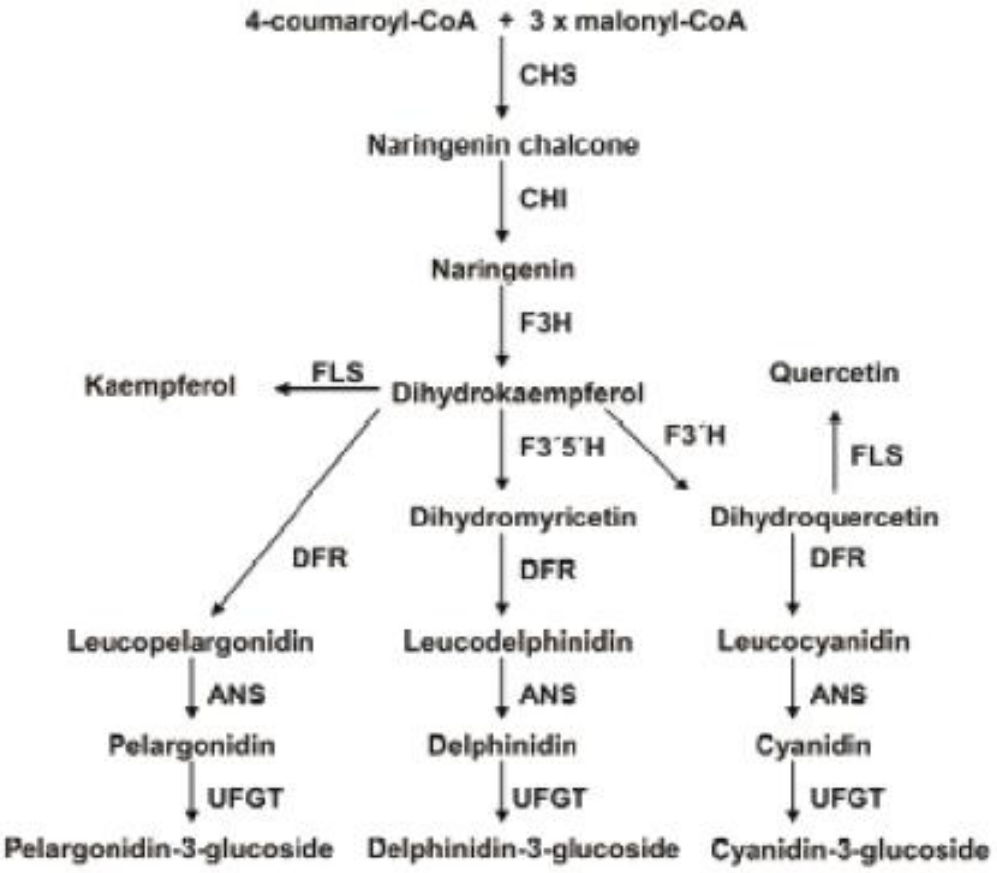

Fig. 3. Anthocyanin biosynthesis pathway in plants. CHS: chalcone synthase; CHI: chalcone isomerase; F3H: flavanone 3-hydroxylase; F3'H: flavonoid 3'-hydroxylase; F3'5'H: flavonoid-3',5'-hydroxylase; DFR: dihydroflavonol 4-reductase; ANS: anthocyanidin synthase; UFGT: UDP-Glc-flavonoid 3-*O*-glucosyl transferase; and FLS: flavonol synthase (Modified from [12]).

Figure 8.1: Microscopic image of individual ovules of *Passiflora Incarnata*

Chapter 9

Conclusion and Outlook

We have discussed in detail the opening and closing of flower of *Passiflora Incarnata*.Flower stating opening around 8:30-8:53 AM and closed around 6:23-7:23 pm.In peak season we have also studied the temporal oscillations in flowering in *Passiflora Incarnata*. In this study we counted the Number of flowers from a single plant of *Passiflora Incarnata* every day starting from 21 April,2014. After Collecting the data we ploted the data as the function of the number of days.Data clearly reveals the periodic oscillations that get damped as the season progresses.

We plan to continue our work to explore the time series analysis of the data. It will be good if we can find out corelation between the number of flowers and temperature, humidity data.

Chapter 10

Appendix

The Data of the No.of flowers is reported here which is collected from a single plant of *Passiflora Incarnata* in the campus of **Indian Institute of Science Education and Research Mohali** from 21 April,2014 to December 2015.

The Data for Temperature and Humidity for the two years is tabulated with the day and number of flowers on each day. The width of opening and closing of *Passiflora Incarnata* is tabulated with time. For the FFT data frequency and Amplitude are tabulated against frequency.

Table 10.1: **Data of Number of flowers, temperature , humidity, openning and closing time for the year 2014**

Days	Flowers	O.T. (min)	C.T. (min)	Min.T (^{o}C)	Max.T (^{o}C)	Min (R.H)	Max (R.H.)
1	1			19.22	32.91	16.01	53.34
2	2			18.45	33.6	19.98	72.05
3	7			22.44	34.98	16.13	55.55
4	16			21.85	35.77	19.82	60.5
5	35			24.5	36.58	14.18	54.79
6	59			23.78	37.37	13.22	51.24
7	93			24.47	37.66	8.4	41.35
8	82			25.39	38.97	4.38	38.93
9	120			26.14	40.68	10.29	41.65
10	98	7.5	21.4	24.59	40.89	12.15	52.16
11	120	7.58	21.39	22.85	41.06	11.26	39.83
12	128	7.66	21.4	25.89	35.19	28.02	55.3
13	152	8.85	21.34	21.96	36.67	27.05	84.77
14	141	8.74	21.34	22.48	33.5	33.93	79.7
15	145	8.85	21.3	24.83	35.18	33.56	72.05
16	113	8.86	21.3	23.84	35.68	31.53	79.5
17	137	8.5	21.32	25.87	38.37	13.81	62.2
18	107	8.5	21.34	24.21	36.55	14.89	48.1
19	96	8.39	21.34	25.82	39.01	12.87	47.14
20	95	8.34	21.4	24.05	34.25	25.04	57.21
21	82	8.37	21.34	21.01	30.93	35.09	87.9
22	59	8.85	21.34	17.96	29.54	39.06	94.83
23	35	8.5	21.3	18.78	31.06	31.65	89.66
24	37	8.39	21.25	20.99	33.25	21.76	69.55
25	41	8.42	21.29	21.68	35.45	19.39	69.9

Days	Flowers	O.T. (min)	C.T. (min)	Min.T (^{o}C)	Max.T (^{o}C)	Min (R.H)	Max (R.H.)
26	28	8.56	21.17	23.13	32.89	35.37	69.55
27	16	8.57	21.17	24.6	36.35	21.35	68.4
28	36	8.39	21.17	24.26	36.83	12.73	59.19
29	28	8.34	21.25	25.05	36.51	22	58.89
30	40	8.34	21.25	24.32	36.53	17.88	56.3
31	35	8.25	21.34	26.18	38.29	12.36	44.69
32	72	8.25	21.34	26.47	38.89	19.57	43.08
33	80	8.25	21.35	24.23	39.63	16.04	71.86
34	80	8.42	21.3	27.52	40.41	12.05	49.78
35	110	8.25	21.34	23.65	39.04	18.87	53.64
36	105	8.25	21.3	24.77	37.79	20.08	56.98
37	90	8.25	21.34	25.47	38.93	18.81	48.97
38	92	8.25	21.34	25.95	41.75	12.76	54.2
39	115	8.34	21.3	27.88	40.52	15.89	55.18
40	113	8.34	21.34	25.85	43.37	8.21	54.84
41	153	8.34	21.5	28.97	38.91	19.2	65.76
42	145	8.42	21.46	28.31	39.6	7.76	37.78
43	150	8.42	21.5	27.78	40.88	7.45	39.18
44	135	8.34	21.17	26.72	42.35	6.52	43.69
45	108	8.37	21.08	28.61	43.35	4.39	39.29
46	110	8.34	21.93	29.65	43.66	6.3	33.55
47	123	8.36	21	28.7	43.8	8.52	41.52
48	126	8.4	21.17	29.13	44.05	3.64	36.03
49	130	8.4	21.08	28.15	43.5	3.63	40.42
50	105	8.42	21.93	29.15	43.73	3.44	34.79

Days	Flowers	O.T. (min)	C.T. (min)	Min.T (^{o}C)	Max.T (^{o}C)	Min (R.H)	Max (R.H.)
51	65	8.39	21.93	29.34	42.09	8.61	31.5
52	51	8.46	21	27.12	40.66	12.8	49.16
53	35	8.5	21.68	25.1	37.18	24.08	82.01
54	31	8.63	21.76	24.41	38.84	42.38	84
55	17	8.39	21	27.4	37.83	44.73	80
56	7	8.47	21	29.86	40.96	31.5	80.52
57	5	8.5	21	30.99	40.89	32.31	76.26
58	4	8.47	21	28.21	38.35	41.36	74.49
59	1	8.5		29.49	39.42	31.5	74.97
60				30.09	40.9	30.98	71.78
61				30.83	41.63	26.37	58.67
62				24.53	34.46	40.06	78.97
63				26.18	34.1	43.7	71.96
64	1	8.5	21	25.58	36.76	31.9	78.52
65	2	8.5	21	27.77	36.84	30.58	62.37
66	9	8.5	20.85	26.29	35.74	33.11	73.63
67	16	8.5	20.85	28.84	38.11	35.63	71.32
68	40	8.5	20.85	29.06	37.82	37.89	67.69
69	100	8.6	20.6	26.45	35.97	40.56	82.54
70	110	8.6	21	28.56	36.01	43.06	74.69
71	130	8.5	21.17	22.37	31.45	54.66	94.55
72	106	8.7	21.5	22.65	32.68	57.29	97.44
73	116	8.5	21.5	26.69	34.82	50.26	93.69
74	120	8.6	21.46	26.33	34.75	50.21	95.35
75	115	8.64	21.46	27.39	36.49	42.47	75.56

Days	Flowers	O.T. (min)	C.T. (min)	Min.T (^{o}C)	Max.T (^{o}C)	Min (R.H)	Max (R.H.)
76	105	8.42	21.5	28.7	37.48	40.94	82.91
77	54	8.34	20	26.91	36.24	37.59	89.83
78	88	8.41	20.78	27.96	36.75	42.89	86.6
79	88	8.34	20.7	30.18	38.51	37.59	74.7
80	85	8.41	20.78	28.27	37.83	36.23	80.76
81	87	8.4	20.75	30.99	38.93	40.3	71.3
82	68	8.5	20.7	28.95	38.08	37.38	77.84
83	75	8.5	20.78	28.58	35.18	57	81.7
84	71	8.61	20.71	26.73	37.48	46.61	88.57
85	65	8.58	20.5	28.76	34.24	61.2	85.21
86	63	8.7	20.46	26.86	30.82	66.76	87.48
87	61	8.58	20.46	26.94	32.17	62.17	93.64
88	76	9	20.7	24.11	30.68	72.89	97.91
89	68	8.7	20.7	23.84	30.83	59.6	97.04
90	76	8.5	20.68				
91	55	8.5	20.5	26.87	36.14	49.96	91.61
92	50	8.48	20.58	28.5	33.62	63.43	87.56
93	42	8.5	20.7	26.25	33.82	60.5	93.55
94	42	8.5	20.58	27.15	30.45	71.77	90.96
95	42	8.48	20.7	26.21	32	63.81	85.08
96	35	8.52	20.5	27.5	34.04	59.36	87.15
97	33	8.5	20.46	27.69	34.75	56.26	86.85
98	35	9	20.47	25.27	31.08	71.53	96.47
99	48	8.75	20.5	26.51	30.32	73.2	91.53
100	55	8.5	20.5	26.86	35.59	53.34	89.08

Days	Flowers	O.T. (min)	C.T. (min)	Min.T (^{o}C)	Max.T (^{o}C)	Min (R.H)	Max (R.H.)
101	69	8.5	20.46	27.52	33.45	65.43	87.69
102	60	8.5	21	27.82	34.88	58.74	88.81
103	72	8.52	20.75	28.24	35.51	56.45	87.85
104	77	8.5	20.78	27.12	34.51	47.15	91.38
105	115	8.63	20.78	23.3	33.47	67.48	92.78
106	102	8.7	21.25	25.27	32.41	69.8	95.91
107	105	8.5	21.33	27.45	35.61	59.09	93.04
108	104	8.48	21.33	25.38	33.98	60.68	94.12
109	102	8.5	21.25	27.68	34.05	61.63	90.07
110	98	8.52	21.25	26.45	34.51	61.23	94.51
111	110	8.4	21.33	26.22	34.83	50.57	93.67
112	92	8.53	21.25	27.11	34.06	63.63	92.7
113	91	8.5	21.7	26.48	34.71	58.88	94.32
114	62	8.5	21.5	24.18	34.14	63.65	97.89
115	55	8.47	21.58	27.38	32.45	66.96	91.6
116	41	8.5	21.16	25.72	31.96	66.97	91.97
117	62	8.52	20.91	24.04	33.78	56.55	89.08
118	39	8.58	21	26.18	33.01	52.34	89.79
119	31	8.5	21	25.54	33.23	53.37	89.74
120	39	8.48	21.16	25.79	33.98	57.68	92.01
121	35	8.5	20.78	27.58	34.58	51.71	87.79
122	43	8.5	21	26.08	34.86	49.41	81.1
123	37	8.5	20.91	25.25	35.37	48.69	92.26
124	36	8.5	20.75	27.04	34.67	46.87	87.27
125	88	8.58	20.91	26.6	34.72	43.87	90.15

Days	Flowers	O.T. (min)	C.T. (min)	Min.T (^{o}C)	Max.T (^{o}C)	Min (R.H)	Max (R.H.)
126	80	8.58	20.75	27.04	35.41	44.51	87.96
127	83	8.5	20.7	27.77	35.7	45.49	82.7
128	84	8.5	21	25.14	34.69	40.21	83.73
129	90	8.58	20.83	27.24	35.68	42.52	90.1
130	95	8.7	21	25.76	34.9	49.31	83.71
131	92	8.58	20.91	26.35	35.86	43.16	86
132	75	8.56	21	26.53	32.43	68.06	92.66
133	73	8.7	21	25.05	35.04	46.56	93.1
134	74	8.75	21.25	24.48	30.3	63.91	91.3
135	74	8.7	21.7	26.99	33.18	55.85	80.04
136	55	8.7	21.78	25.83	32.38	56.51	91.16
137	48	8.75	22	23.8	27.52	74.05	97.74
138	35	8.75	21.76	23.31	30.53	68.13	96.58
139	50	8.58	21.75	25.51	35.38	50.77	93.74
140	45	8.7	21.77	22.83	32.67	67.84	95.04
141	35	8.7	21.78	23.34	32.62	66.05	97.73
142	36	8.59	22.16	24.96	34.59	54.24	95.67
143	30	8.75	22.16	25.69	31.29	69.11	91.32
144	31	8.56	21.75	23.95	32.34	60.45	94.52
145	30	8.5	21.7	22.92	32.41	48.43	94.54
146	24	8.72	21.58	22.77	33.26	54.97	94.39
147	30	8.59	21.55	22.4	31.96	42	90.79
148	41	8.7	21.68	23.43	31.88	45.38	90.62
149	30	8.7	21.7	24.27	32.98	49.42	90.83
150	31	8.5	21.91	25.73	33.93	50.15	91.44

Days	Flowers	O.T. (min)	C.T. (min)	Min.T (^{o}C)	Max.T (^{o}C)	Min (R.H)	Max (R.H.)
151	32	8.59	21.83	26.21	34.02	59.78	93.52
152	37	9	22.16	24.97	34.28	49.56	94.24
153	45	8.72	21.75	23.72	32.88	49.89	85.06
154	68	8.58	21.83	27.06	27.1	84.52	85.09
155	50	8.52	21.88	23.72	30.71	61.09	91.3
156	59	8.59	21.7	24.11	31.97	58.83	94.37
157	60	8.72	21.79	22.47	32.56	39.13	90.25
158	75	8.47	21.91	24.58	32.36	47.01	82.33
159	67	8.58	21.72	24.4	33.61	42.14	83.5
160	70	8.55	21.9	24.91	33.14	46.22	84.49
161	55	8.7	21.91	23.47	34.24	44.38	83.63
162	52	8.63	21.53	22.83	33.12	49.68	91.63
163	58	8.58	21.83	23.7	33.09	52.34	89.2
164	57	8.7	21.91	24.01	34.11	48.9	86.12
165	40	8.75	21.85	24.73	33.62	51.09	83.75
166	38	8.7	22	24.61	33.64	52.75	89.39
167	50	8.75	22.16	24.17	34.94	48.54	91.6
168	43	8.5	21.91	24.58	34.41	51.42	89.62
169	32	8.58	21.95	24.61	33.46	54.07	87.04
170	34	8.7	21.75	22.96	34.66	28.16	82.42
171	25	8.75	22	20.51	31.65	32.06	75.2
172	42	8.83	21.83	19.48	31.29	35.14	86.53
173	32	8.5	21.58	20.78	31.72	28.91	81.68
174	37	8.58	22	18.9	35.4	23.54	83.33

Days	Flowers	O.T. (min)	C.T. (min)	Min.T (^{o}C)	Max.T (^{o}C)	Min (R.H)	Max (R.H.)
175	30	8.48	21.91	22.3	32.79	29.01	71.82
176	35	8.91		17.63	24.78	59.13	91.14
177	42	9		17.09	28.58	41.88	95.64
178	35	8.58		17.88	28.28	32.4	87.02
179	30	8.5		15.96	28.86	33.03	89.65
180	32	8.48		17.4	29.04	34.56	87.34
181	26	8.58		17.77	29.35	35.57	88.94
182	39	8.7		18.88	30.16	30.03	79.71
183	26	8.58		19.28	31.28	39.22	78.67
184	28	8.5		19.97	31.65	37.95	79.64
185	40	8.5		19.36	32.35	35.7	78.75
186	30	8.58		19.74	30.26	45.52	81.65
187	38	8.5	22.16	20.18	30.57	48.85	86.46
188	35	8.5	22	20.82	29.42	48.71	86.23
189	40	8.58	21.91	19.7	28.65	53.87	83.09
190	35	8.58	22.15	19.32	29.01	43.15	84.7
191	27	8.5	21.83	18.64	30.73	25.39	76.73
192	26	8.58	21.83	17.9	29.37	22.69	69.97
193	26	8.58		17.33	28.25	26.59	64.13
194	25	8.7		16.34	27.98	25.83	74.57
195	24	8.58		15.07	28.71	22.62	80.57
196	23	8.7		17.1	29.2	27.02	68.58
197	11	8.83		18.29	28.1	34.62	68.01
198	12	8.7		17.14	28	35.94	82.92
199	21	8.88		16.08	28.38	24.1	81.88
200	18	8.83		16.89	30.18	33.56	78.04
201	15	8.58		20.12	29.7	34.46	80.51

Table 10.2: **Data of FFT analysis for the Oscillations in *Passiflora Incarnata* in 2014**

Frequency	Amplitude	Frequency	Amplitude	Frequency	Amplitude
-0.49606	1.11424	-0.49213	1.44444	-0.48819	1.39979
-0.48425	1.09968	-0.48031	0.76813	-0.47638	0.75065
-0.47244	0.5568	-0.4685	1.5676	-0.46457	1.2685
-0.46063	1.50251	-0.45669	0.63865	-0.45276	0.6079
-0.44882	0.6687	-0.44488	0.24327	-0.44094	0.36311
-0.43701	0.93426	-0.43307	0.93935	-0.42913	0.66213
-0.4252	0.68298	-0.42126	0.5629	-0.41732	0.65808
-0.41339	1.2156	-0.40945	1.14151	-0.40551	1.87562
-0.40157	0.39017	-0.39764	0.22227	-0.3937	0.63334
-0.38976	0.98108	-0.38583	0.68692	-0.38189	1.21689
-0.37795	0.91493	-0.37402	1.40102	-0.37008	0.98164
-0.36614	0.42143	-0.3622	0.56505	-0.35827	0.81966
-0.35433	1.47383	-0.35039	0.2368	-0.34646	1.10009
-0.34252	1.18012	-0.33858	0.15196	-0.33465	0.5046
-0.33071	0.41262	-0.32677	0.4996	-0.32283	0.30551
-0.3189	1.05668	-0.31496	0.55714	-0.31102	0.26773
-0.30709	0.84831	-0.30315	1.05747	-0.29921	0.53728
-0.29528	0.16823	-0.29134	0.15908	-0.2874	0.98665
-0.28346	0.32817	-0.27953	1.06374	-0.27559	0.58614
-0.27165	0.92765	-0.26772	1.47131	-0.26378	0.54639
-0.25984	0.845	-0.25591	0.61704	-0.25197	0.71773
-0.24803	0.52596	-0.24409	0.10771	-0.24016	1.17072
-0.23622	1.74625	-0.23228	1.54565	-0.22835	0.88051
-0.22441	0.88287	-0.22047	1.11412	-0.21654	1.87072
-0.2126	1.92871	-0.20866	0.61792	-0.20472	0.68936
-0.20079	1.42338	-0.19685	1.18557	-0.19291	2.17871

Frequency	Amplitude	Frequency	Amplitude	Frequency	Amplitude
-0.19685	1.18557	-0.19291	2.17871	-0.18504	0.84734
-0.1811	0.76809	-0.17717	1.31673	-0.17323	1.42604
-0.16929	1.4135	-0.16535	0.99934	-0.16142	1.45403
-0.15748	0.86478	-0.15354	1.54632	-0.14961	1.84045
-0.14567	1.88292	-0.14173	2.89771	-0.1378	1.93088
-0.13386	1.78195	-0.12992	1.56153	-0.12598	1.65863
-0.12205	1.08234	-0.11811	0.91932	-0.11417	1.09026
-0.11024	1.9799	-0.1063	2.1424	-0.10236	2.2028
-0.09843	1.69309	-0.09449	2.19062	-0.09055	1.77607
-0.08661	1.54397	-0.08268	2.59635	-0.07874	2.38048
-0.0748	2.60595	-0.07087	2.60773	-0.06693	2.20957
-0.06299	2.01293	-0.05906	2.23409	-0.05512	5.44182
-0.05118	8.80998	-0.04724	2.93874	-0.04331	8.07018
-0.03937	2.78311	-0.03543	20.77258	-0.0315	23.00339
-0.02756	17.80602	-0.02362	7.06928	-0.01575	6.94169
-0.01181	15.28204	-0.00787	16.42572	-0.00394	29.80087
0	48.48031	0.00394	29.80087	0.00787	16.42572
0.01181	15.28204	0.01575	6.94169	0.01969	4.48392
0.03543	20.77258	0.03937	2.78311	0.04331	8.07018
0.04724	2.93874	0.05118	8.80998	0.05512	5.44182
0.05906	2.23409	0.06299	2.01293	0.06693	2.20957
0.07087	2.60773	0.02756	17.80602	0.0315	23.00339
0.08268	2.59635	0.08661	1.54397	0.09055	1.77607

Frequency	Amplitude	Frequency	Amplitude	Frequency	Amplitude
0.09449	2.19062	0.09843	1.69309	0.10236	2.2028
0.1063	2.1424	0.11024	1.9799	0.11417	1.09026
0.11811	0.91932	0.12205	1.08234	0.12598	1.65863
0.12992	1.56153	0.13386	1.78195	0.1378	1.93088
0.14173	2.89771	0.14567	1.88292	0.14961	1.84045
0.15354	1.54632	0.15748	0.86478	0.16142	1.45403
0.16535	0.99934	0.16929	1.4135	0.17323	1.42604
0.17717	1.31673	0.1811	0.76809	0.18504	0.84734
0.18898	1.12204	0.19291	2.17871	0.19685	1.18557
0.20079	1.42338	0.20472	0.68936	0.20866	0.61792
0.2126	1.92871	0.21654	1.87072	0.22047	1.11412
0.22441	0.88287	0.22835	0.88051	0.23228	1.54565
0.23622	1.74625	0.24016	1.17072	0.24409	0.10771
0.24803	0.52596	0.25197	0.71773	0.25591	0.61704
0.25984	0.845	0.26378	0.54639	0.26772	1.47131
0.27165	0.92765	0.27559	0.58614	0.27953	1.06374

Table 10.3: **Data of No.of flowers,Temperature Data,humidity Data, are shown For the year 2015**

No.of Days	No. of Flowers	Min.Temp(C)	Max.Temp(C)	Min(R.H)	Max(R.H.)
1	7	25.94	35.97	17.25	66.51
2	12	23.11	35.39	14.69	40.83
3	26	23.67	36.73	7.66	43.5
4	25	23.21	38.63	10.19	46.08
5	30	23.27	34.55	26.79	50.2
6	28	23.6	31.81	34.82	62.87
7	50	24	32.33	33.55	58.74
8	54	22.8	35.68	18.27	73.69
9	50	21.54	35.13	26.47	68.31
10	52	23.99	34.95	27.14	70.49
11	53	20.7	34.22	18.13	79.72
12	51	21.84	35.3	9.04	62.12
13	42	22.8	37.01	6.68	44.95
14	47	22.89	37.39	10.55	41.42
15	46	23.9	38.64	16.94	47.6
16	37	24.57	41.65	14.74	52.69
17	34	26.75	41.12	15.87	45.83
18	33	26.32	41.04	9.27	52.66
19	34	28.03	40.25	14.74	53.28
20	23	28.62	39.5	23.64	45.7
21	25	23.45	38.6	25.97	68.5
22	21	23.41	32.64	36.37	84.06
23	22	22	35.56	35	89.08
24	25	22.22	36.98	24.6	83.75
25	17	24.07	31.88	34.92	69.11

No.of Days	No. of Flowers	Min.Temp(C)	Max.Temp(C)	Min(R.H)	Max(R.H.)
26	14	22.14	37.41	22.31	72.76
27	13	24.99	38.22	27.59	62.32
28	12	26.8	40.81	23.14	62.92
29	20	27.92	38.56	22.21	55.14
30	15	26.03	39.57	8.61	57.59
31	14	26.75	40.39	5.8	39.51
32	16	24.69	40.79	5.88	38.04
33	16	27.3	44.01	9.01	38.11
34	17	28.98	42.96	8.28	43.25
35	17	27.57	41.4	8.61	38.32
36	25	27.68	41.16	4.99	41.82
37	32	25.2	41.96	6.26	38.08
38	34	25.81	40.25	22.47	40.82
39	20	27.04	38.01	15.1	48.23
40	22	27.72	40.25	25.44	56.32
41	20	24.82	36.53	15.4	82.73
42	10	20.75	38.41	20.31	61.69
43	12	24.8	35.84	25.42	72.78
44	13	23.64	31.82	37	92.36
45	4	23.93	37.35	24.27	72.33
46	3	20.47	34.75	18.25	63.94
47	3	24.73	36.55	16.85	50.16
48	2	26.29	41.22	15.15	40.26
49	3	27.8	40.6	28.08	56.24
50	2	28.82	40.41	23.31	53.35

No.of Days	No. of Flowers	Min.Temp(C)	Max.Temp(C)	Min(R.H)	Max(R.H.)
51	3	27.74	39.77	19.85	59.81
52	1	25.98	38.65	26.73	86.84
53	5	23.11	37.42	29.64	76.24
54	8	23.93	33.65	24.78	62.46
55	11	25.96	36.82	19.91	63.04
56	21	27.28	38.63	24.8	61.84
57	15	27.21	39.26	32.5	61.76
58	34	29.25	40.44	40.51	90.58
59	41	31.53	40.18	35.95	90.7
60	37	22.69	33.49	38.15	81.03
61	26	24.16	33.62	42.31	83.9
62	18	26.93	37.34	50.93	92.06
63	10	26.68	37.48	32.02	92.52
64	15	26.94	35.42	32.36	75.91
65	11	23.36	33.07	27.83	73.85
66	15	24.71	35.37	46.6	87.17
67	8	25.87	37.08	47.74	84.07
68	10	27.11	38.96	44.16	88.41
69	9	23.55	32.72	44.24	75.03
70	9	25.08	34.79	36.64	73.16
71	15	26.1	36.72	45.16	77.26
72	9	27.26	35.92	47.75	90.87
73	13	28.45	37.19	69.97	95.6
74	25	28.27	36.69	61.65	90.66
75	10	25.88	37.67	58.57	91.26

No.of Days	No. of Flowers	Min.Temp(C)	Max.Temp(C)	Min(R.H)	Max(R.H.)
76	6	23.99	30.34	60.12	91.12
77	15	25.62	31.95	70.89	97.41
78	22	25.63	33.83	82.25	96.3
79	22	25.08	34.4	76.3	95.69
80	27	22.43	29.74	65.08	92.53
81	20	23.47	25.43	61.84	95.16
82	26	24.51	27.34	56.47	92.79
83	24	24.96	31.81	62.78	93.63
84	14	26.58	33.13	67.3	96.79
85	14	27.83	34.42	74.4	93.54
86	10	25.88	35.06	58.07	93.7
87	15	26.39	30.86	66.32	95.2
88	8	26.46	34.74	56.27	91.36
89	10	24.73	30.63	59.47	86.96
90	15	26.93	34.93	64.55	85.31
91	8	27.08	33.63	57.13	85.53
92	7	27.61	32.64	48.43	93.21
93	15	27.44	33.8	54.89	91.58
94	22	26.24	36.89	55.22	87.59
95	12	25.72	35.28	55.05	87.92
96	10	27.7	34.15	54.34	80.82
97	20	26.7	33.54	58.08	89.73
98	27	27.41	33.15	67.5	90.14
99	40	26.94	32.89	78.48	95.45
100	33	26.54	31.34	67.45	95.14

No.of Days	No. of Flowers	Min.Temp(C)	Max.Temp(C)	Min(R.H)	Max(R.H.)
101	52	24.91	29.05	55.71	90.78
102	43	25.2	30.83	63.89	95.34
103	35	26.04	34.5	66.23	87.91
104	30	26.34	33.59	63.92	93.67
105	25	27.33	31.6	77.69	96.85
106	20	26.36	33.37	79.38	94.4
107	25	24.68	30.05	62.65	96.03
108	20	24.94	28.28	56.49	96.45
109	17	24.73	32.03	70.64	97.64
110	15	26.88	34.86	56.64	94.93
111	11	25.09	32.58	51.97	93.12
112	8	25.51	34.41	73.52	93.04
113	13	26.61	35.47	68.53	93.49
114	9	26.38	31.41	61.81	91.7
115	6	26.31	32.76	56.93	96.27
116	13	25.31	33.47	64	97.05
117	7	26.8	33.32	65.79	90.16
118	5	25.04	33.82	69.64	92.45
119	7	25.65	32.46	59.77	97.54
120	10	26.25	33.14	64.77	96.47
121	9	24.2	26.4	60.12	94.88
122	16	23.14	33.88	49.89	96.51
123	17	23.29	31.3	58.03	92.48
124	18	25.05	33.34	53.92	88.13
125	15	25.99	32.73	57.72	92.03

No.of Days	No. of Flowers	Min.Temp(C)	Max.Temp(C)	Min(R.H)	Max(R.H.)
126	11	25.04	33.06	57.3	90.93
127	12	26.36	33.99	51.22	90.44
128	20	27.98	35.55	53.47	85.95
129	19	24.35	33.38	55.86	90.8
130	20	26.09	33.6	50.88	87.35
131	14	26.88	34.33	48.34	85.24
132	6	27.08	33.76	56.39	89.47
133	7	26	33.38	41.85	88.46
134	7	26.33	33.62	47.99	87.43
135	7	26.24	33.15	43.44	85.89
136	5	24.75	33.18	45.48	85.48
137	0	26.07	33.11	44.62	81.43
138	4	24.44	33.54	31.65	88.41
139	4	24.6	33.25	39.22	75.35
140	6	25.28	33.45	37.15	77.52
141	1	24.51	35.05	43.8	82.04
142	3	25.9	36.41	46.74	84.12
143	2	25.6	34.83	54.39	84.72
144	1	26.78	34.51	49.37	86.2
145	2	26.77	34.66	50.6	86.51
146	1	21.48	34.36	43.69	85.05
147	1	21.94	35.1	54.38	81.34
148	3	25.7	33.79	56.46	91.46
149	6	26.53	30.31	66.36	95.93
150		22.59	27.24	57.31	94.39

Table 10.4: **Data of width of opening and closing of *Passiflora Incarnata***

	Flower I		Flower II		Flower III	
Time (min)	W. Opening (cm)	W. Closing (cm)	W. Opening (cm)	W. Closing (cm)	W. Opening (cm)	W. Closing (cm)
0	0.8	1.5	2.1	1.4	0.5	1
1	1.5	1.5	2.5	1.4	1	1
2	2.7	1.5	3	1.4	1.5	1
3	3.1	1.5	3.2	1.4	2.1	1
4	4.1	1.6	3.9	1.4	2.2	1
5	4.5	1.6	4.1	1.5	2.5	1.1
6	5.1	1.6	4.5	1.6	2.9	1.1
7	5.3	1.6	4.7	1.6	3.1	1.1
8	5.4	1.7	5.1	1.8	3.3	1.2
9	5.4	1.7	5.3	1.8	3.5	1.3
10	5.6	1.7	5.5	2	3.6	1.3
11	5.7	1.7	5.7	2	3.7	1.3
12	5.7	1.7	5.7	2	3.7	1.5
13	5.7	1.8	5.7	2.2	3.8	1.5
14	5.7	1.8	5.7	2.3	3.9	1.5
15	5.7	1.8	5.7	2.3	4	1.5
16	5.7	1.8	5.7	2.3	4	1.6
17	5.7	1.8	5.7	2.4	4.1	1.7
18	5.7	1.8	5.7	2.4	4.2	1.7
19	5.7	1.8	5.7	2.5	4.3	2
20	5.7	1.9	5.7	2.5	4.3	2
21	5.7	1.9	5.7	2.5	5	2
22	5.7	1.9	5.7	2.5	5.5	2
23	5.7	1.9	5.7	2.5	5.7	2.1
24	5.7	1.9	5.7	2.6	5.9	2.3
25	5.7	1.9	5.7	2.6	5.9	2.3

	Flower I		Flower II		Flower III	
Time (min)	W. Opening (cm)	W. Closing (cm)	W. Opening (cm)	W. Closing (cm)	W. Opening (cm)	W. Closing (cm)
26	5.7	1.9	5.7	2.6	5.9	2.3
27	5.7	1.9	5.7	2.6	5.9	2.5
28	5.7	2	5.7	2.8	5.9	2.5
29	5.7	2	5.7	2.9	5.9	2.6
30	5.7	2	5.7	2.9	5.9	2.6
31	5.7	2	5.7	2.9	5.9	2.9
32	5.7	2	5.7	3	5.9	3
33	5.7	2	5.7	3	5.9	3
34	5.7	2	5.7	3.2	5.9	3.2
35	5.7	2	5.7	3.4	5.9	3.5
36	5.7	2	5.7	3.5	5.9	3.5
37	5.7	2	5.7	3.6	5.9	3.5
38	5.7	2	5.7	3.8	5.9	4
39	5.7	2	5.7	3.9	5.9	4.1
40	5.7	2.1	5.7	4.1	5.9	4.3
41	5.7	2.1	5.7	4.1	5.9	4.4
42	5.7	2.1	5.7	4.2	5.9	4.4
43	5.7	2.2	5.7	4.3	5.9	4.5
44	5.7	2.2	5.7	4.4	5.9	4.5
45	5.7	2.2	5.7	4.4	5.9	4.6
46	5.7	2.3	5.7	4.5	5.9	4.6
47	5.7	2.3	5.7	4.5	5.9	4.6
48	5.7	2.3	5.7	4.7	5.9	4.7
49	5.7	2.4	5.7		5.9	4.7
50	5.7	2.4	5.7		5.9	4.7

	Flower I		Flower II		Flower III	
Time (min)	W. Opening (cm)	W. Closing (cm)	W. Opening (cm)	W. Closing (cm)	W. Opening (cm)	W. Closing (cm)
51	5.7	2.4	5.7		5.9	4.7
52	5.7	2.4	5.7		5.9	4.9
53	5.7	2.4	5.7		5.9	4.9
54	5.7	2.5	5.7		5.9	4.9
55	5.7	2.5	5.7		5.9	4.9
56	5.7	2.5	5.7		5.9	5
57	5.7	2.5	5.7		5.9	5.2
58	5.7	2.5	5.7		5.9	5.4
59	5.7	2.6	5.7		5.9	5.7
60	5.7	2.6	5.7		5.9	
61	5.7	2.7	5.7		5.9	
62	5.7	2.7	5.7		5.9	
63	5.7	2.9	5.7		5.9	
64	5.7	2.9	5.7		5.9	
65	5.7	2.9	5.7		5.9	
66	5.7	3.1	5.7		5.9	
67	5.7	3.1	5.7		5.9	
68	5.7	3.2	5.7		5.9	
69	5.7	3.3	5.7		5.9	
70	5.7	3.5	5.7		5.9	
71	5.7	3.5	5.7		5.9	
72	5.7	3.5	5.7		5.9	
73	5.7	3.5	5.7		5.9	
74	5.7	3.8	5.7		5.9	
75	5.7	4	5.7		5.9	

	Flower I		Flower II		Flower III	
Time (min)	W. Opening (cm)	W. Closing (cm)	W. Opening (cm)	W. Closing (cm)	W. Opening (cm)	W. Closing (cm)
76	5.7	4	5.7		5.9	
77	5.7	4.2	5.7		5.9	
78	5.7	4.3	5.7		5.9	
79	5.7	4.3	5.7		5.9	
80	5.7	4.6	5.7		5.9	
81	5.7	4.6	5.7		5.9	
82	5.7	4.6	5.7		5.9	
83	5.7	4.6	5.7		5.9	

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