

**A COMPLETE REPORT
ON
THE ANALYSIS OF PUMPKIN PLANTS**

General Testing Procedure:

H_0 : (**null hypothesis**): There is no significant difference in the average values of the parameter under consideration in plants in the control group and the treated group.

H_1 : (**alternate hypothesis**): The average value of the parameter under consideration is significantly higher in plants in the treated group, than the control group.

Level of significance (l.o.s): 0.05

Critical Region: Reject H_0 at 0.05 l.o.s iff computed p-value < 0.05.

Outline of the analysis:

- For the given data, we have first plotted the means week-wise for both treatment and control for visual comparison. A linear trend has been fitted for both (which has been shown in the graph on the right-side of the panel for each parameter), that is, we assume that the parameter under consideration increases **linearly with time**. The linear equations reflect the change in the value of the parameters with time in an ideal situation, i.e., excluding the effect of irregular factors. Multiple R^2 values are reported in percentage for each fitting. Higher the R^2 value, better is the linear fit.
- Then, tests have been carried out **week-wise** to study the differences between the control and treated group of plants for each parameter. We have opted for **two** tests, one **parametric** (Student's t-test), and the other **non-parametric** (Wilcoxon's rank-sum test). The p-values and the decisions of the tests have been tabulated for each parameter. The lower is the p-value, the more difference in the parameter between the treated and controlled groups is suggested by the data.
- The decision of any statistical testing procedure is conventionally made **with respect to the null hypothesis** H_0 . "Accept" refers to accepting H_0 , i.e., we conclude that in the light of the given data, there is no significant difference between the average values of the parameter under consideration in the control group and the treated group, whereas "Reject" refers to rejecting H_0 , i.e., we conclude that in the light of the given data, the value of the parameter under consideration is significantly higher in the treated group of plants than in the control group of plants.

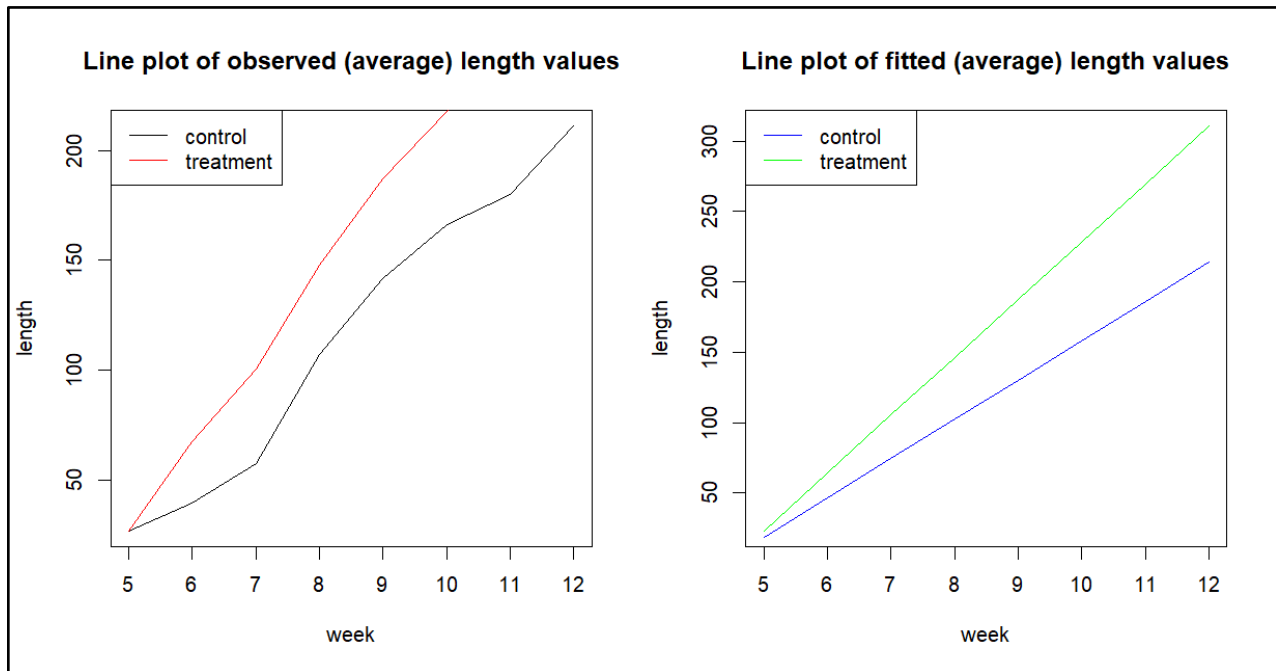
Parameters:

1. Plant length
2. Number of leaves
3. Number of nodes
4. Leaf length
5. Leaf width
6. Number of tendrils
7. Number of buds
8. Number of Flowers
9. Number of Fruits
10. Tendril Length

Analysis:

1. Plant length

Graphs:



Fitted equations:

GROUP	FITTED LINEAR EQUATION	(MULTIPLE) R^2 VALUES
CONTROL	$-9.763 + 28.006 \cdot t$ $t = 1(1)8$	98.02%
TREATED	$-17.862 + 41.045 \cdot t$ $t = 1(1)8$	99.53%

Test results:

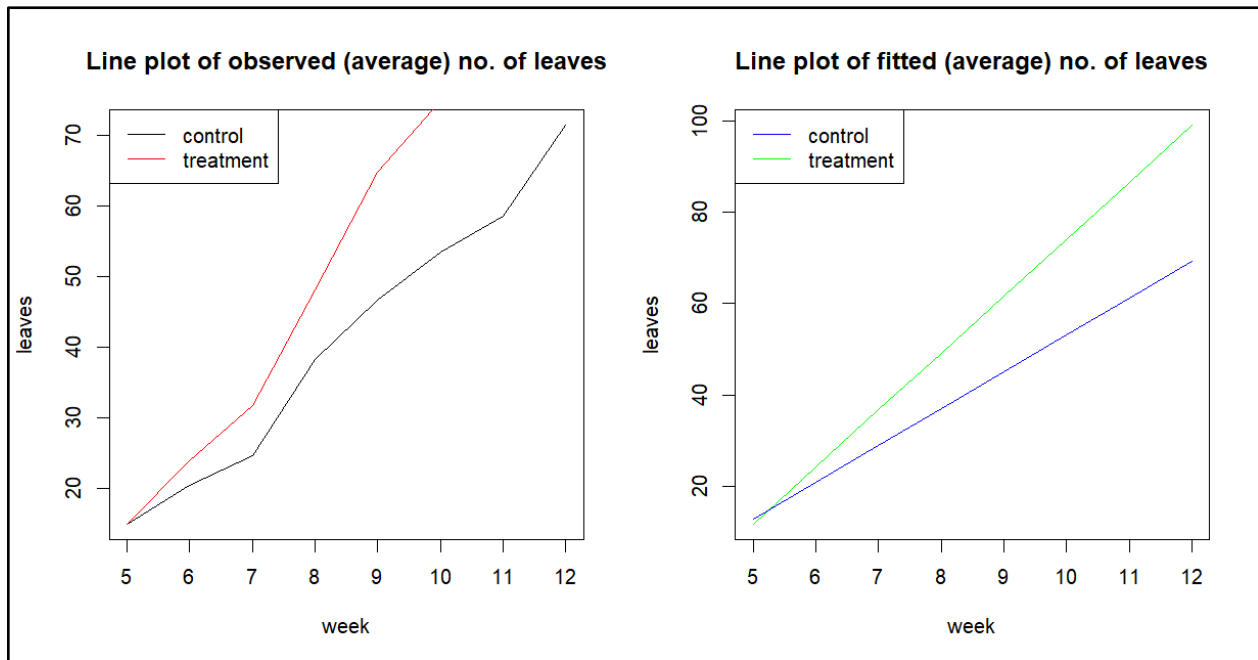
WEEK	t-TEST P VALUE	DECISION	WILCOXON P VALUE	DECISION
5	0.5116957	Accept	0.6112	Accept
6	0.002181404	Reject	0.005553	Reject
7	0.003109751	Reject	0.00741	Reject
8	0.06102977	Accept	0.1092	Accept
9	0.03508167	Reject	0.05647	Accept
10	0.02139207	Reject	0.04057	Reject
11	0.001965804	Reject	0.003275	Reject
12	0.00004783904	Reject	0.0003549	Reject

Interpretations:

- From the **plots** (both observed and fitted), we observe that the average length of the plants for the treated group is higher than that of the control group for all the weeks.
- Additionally, from the **fitted linear equations**, we can say that the rate of increase of length of plants in the treated group is higher than that of the control group, as indicated by the slope coefficients of the fitted lines.
- Both the **testing procedures** also indicate that the average length of the plant is almost always consistently higher for the treated group, compared to the control group, except for the 5th, 8th week for both tests, and the 9th week for Wilcoxon's test only.
- The possible reason for no significant difference in the 5th week may be since the treatment was administered to the plant in the 5th week itself.

2. Number of leaves

Graphs:



Fitted equations:

GROUP	FITTED LINEAR EQUATION	(MULTIPLE) R^2 VALUES
CONTROL	$4.6071 + 8.0980 \cdot t$ $t=1(1)8$	98.61%
TREATED	$-0.6868 + 12.4625 \cdot t$ $t=1(1)8$	99.08%

Test results:

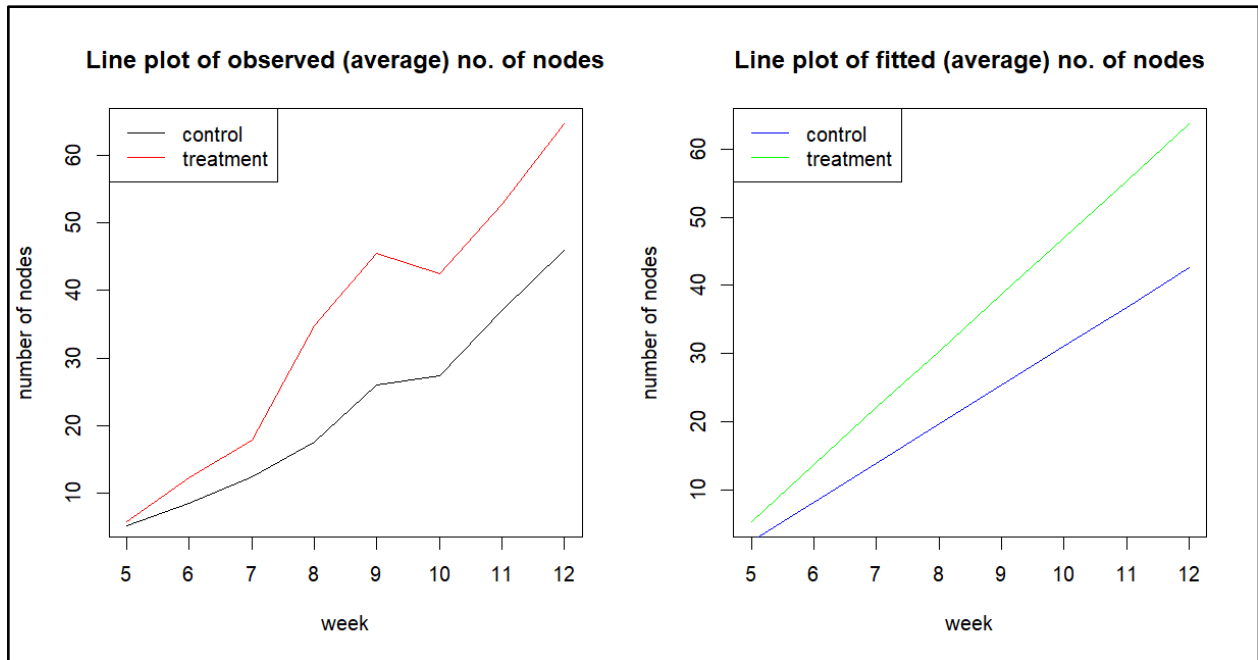
WEEK	t-TEST P VALUE	DECISION	WILCOXON P VALUE	DECISION
5	0.5	Accept	0.7056	Accept
6	0.105690833	Accept	0.1292	Accept
7	0.024833498	Reject	0.02251	Reject
8	0.148369121	Accept	0.2603	Accept
9	0.047181638	Reject	0.0651	Accept
10	0.027425244	Reject	0.05034	Accept
11	0.006799655	Reject	0.002387	Reject
12	0.003538430	Reject	0.001126	Reject

Interpretations:

- From the **plots** (both observed and fitted), we observe that the average number of leaves of the plants for the treated group is higher than that of the control group for all the weeks.
- Additionally, from the **fitted linear equations**, we can say that the rate of increase of number of leaves of plants in the treated group is higher than that of the control group, as indicated by the slope coefficients of the fitted lines.
- Both parametric (t-test) and non-parametric (Wilcoxon's rank-sum test) **testing procedures** indicate that the average number of leaves of the plant for the treated group is almost always consistently higher compared to the control group, except for the 5th and 6th week for both tests, and 9th and 10th week for Wilcoxon's test only. The differences in the results of the t-test and Wilcoxon's test are due to marginal differences in the p-values (about the value 0.05) computed in both procedures.
- The possible reason for no significant difference in the 5th week may be since the treatment was administered to the plant in the 5th week itself.

3. Number of nodes

Graphs:



Fitted equations:

GROUP	FITTED LINEAR EQUATION	(MULTIPLE) R^2 VALUES
CONTROL	$-3.2582 + 5.7262 \cdot t$ $t=1(1)8$	97.19%
TREATED	$-2.9066 + 8.3168 \cdot t$ $t=1(1)8$	96.19%

Test results:

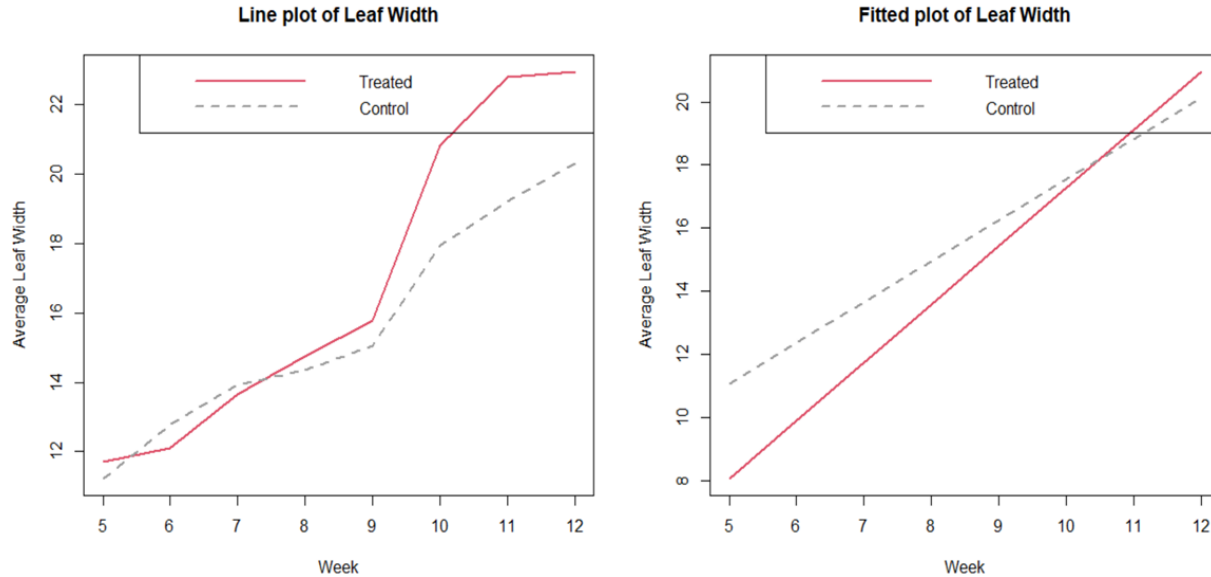
WEEK	t-TEST P VALUE	DECISION	WILCOXON P VALUE	DECISION
5	0.219475483	Accept	0.25	Accept
6	0.001367694	Reject	0.002408	Reject
7	0.001387608	Reject	0.002277	Reject
8	0.003513790	Reject	0.0064	Reject
9	0.011604460	Reject	0.00741	Reject
10	0.033979636	Reject	0.02126	Reject
11	0.052483028	Accept	0.065	Accept
12	0.030230997	Reject	0.03051	Reject

Interpretations:

- From the **plots** (both observed and fitted), we observe that the average number of nodes of the plants for the treated group is higher than that of the control group for all the weeks.
- Additionally, from the **fitted linear equations**, we can say that the rate of increase of number of nodes of plants in the treated group is higher than that of the control group, as indicated by the slope coefficients of the fitted lines.
- Both parametric (t-test) and non-parametric (Wilcoxon's rank-sum test) **testing procedures** indicate that the average number of leaves of the plant for the treated group is almost always consistently higher than that of the control group, except for the 5th and 11th week.
- The possible reason for no significant difference in the 5th week may be since the treatment was administered to the plant in the 5th week itself.

4. Leaf Length

Graphs



INTERPRETATION

- 1) From the fitted plot of Leaf Length, the treated group is higher, which indicates higher rate of increase of leaf length in the treated group
- 2) From both the plot of observed and fitted leaf width, it seems that although there is an increase in leaf length after application of the treatment but the increase is not so significant.

TIME SERIES ANALYSIS - FITTED LINEAR EQUATION

<u>TREATMENT</u>	<u>FITTED LINEAR TREND EQUATION (ON WEEKLY AVERAGES)</u>	<u>MULTIPLE (R-SQUARED) VALUES</u>
TREATED	$-1.9883 + 1.9174 \times t$	0.9234
CONTROL	$0.4077 + 1.6269 \times t$	0.9406

t-TEST AND WILCOXON RANK SUM TEST RESULT

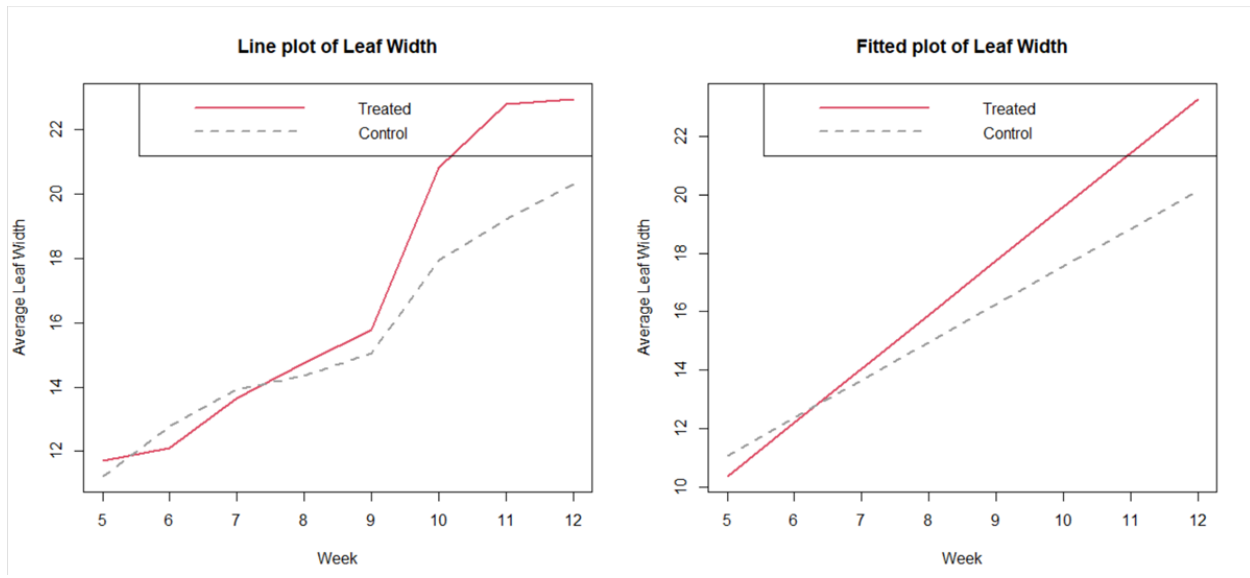
WEEK	t TEST \$ p- VALUES	DECISION	WILCOXON TEST \$ p - VALUES	DECISION
5	0.6277	ACCEPT	0.7566	ACCEPT
6	0.9737	ACCEPT	0.9702	ACCEPT
7	0.7967	ACCEPT	0.8561	ACCEPT
8	0.7979	ACCEPT	0.7078	ACCEPT
9	0.5416	ACCEPT	0.5522	ACCEPT
10	0.1471	ACCEPT	0.1515	ACCEPT
11	0.08395	ACCEPT	0.08582	ACCEPT
12	0.3713	ACCEPT	0.4077	ACCEPT

INTERPRETATION:

Both t-test and Wilcoxon Rank-Sum test indicate that there seems no significant difference in the length of leaf in the control and treated group throughout the 8 weeks of observation.

5. LEAF WIDTH

Graphs



INTERPRETATION

- 1) From the fitted and observed plot of Leaf Width, the slope of treated group is higher indicating higher rate of increase in leaf width of the treated group.
- 2) From the observed plot, It seems that there is an increase in the width of leaf due to treatment in the first 4-5 weeks of application, although not significantly.
- 3) Significant increase in width of leaf is observed in both the fitted and observed plot from 10th week onwards.

TIME SERIES ANALYSIS-FITTED LINEAR TREND EQUATION

<u>TREATMENT</u>	<u>FITTED LINEAR TREND EQUATION (ON WEEKLY AVERAGES)</u>	<u>MULTIPLE (R-SQUARED) VALUES</u>
TREATED	$1.1536 + 1.8431x$	0.9304
CONTROL	$4.60842 + 1.29267x$	0.9675

t-TEST AND WILCOXON RANK- SUM TEST RESULT

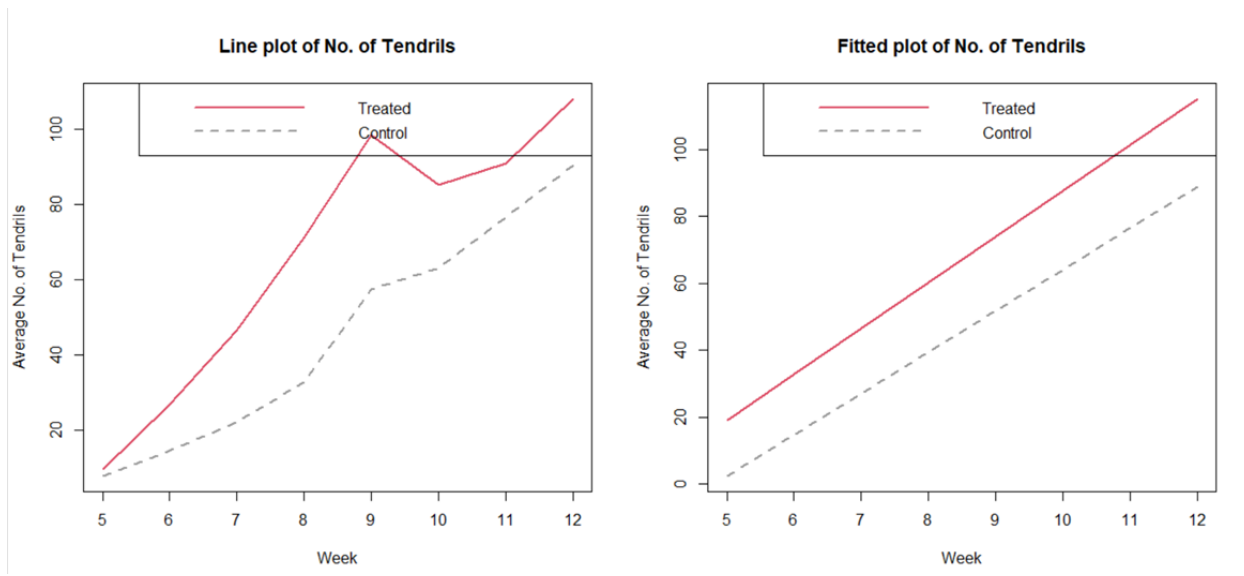
WEEK	t TEST \$ p- VALUES	DECISION	WILCOXON TEST \$ p - VALUES	DECISION
5	0.28735	ACCEPT	0.3984	ACCEPT
6	0.80106	ACCEPT	0.9225	ACCEPT
7	0.64697	ACCEPT	0.8181	ACCEPT
8	0.35826	ACCEPT	0.3596	ACCEPT
9	0.22365	ACCEPT	0.2763	ACCEPT
10	0.01516	REJECT	0.01263	REJECT
11	0.00426	REJECT	0.00686	REJECT
12	0.01438	REJECT	0.01691	REJECT

INTERPRETATION

Based on the t-test and Wilcoxon Rank Sum test, it seems that the treatment doesn't significantly affect the width of the leaves initially. It starts affecting the width of the leaves from 10th week onwards. Thus, the treatment results in significant increase in the width of leaves after 5 weeks of application.

6. No. of Tendrils

Graphs



INTERPRETATION

- 1) From the observed and fitted plot, it seems that the no. of tendrils increases significantly due to the treatment over the 8 weeks of observation.
- 2) The peak is observed around 9-10 weeks in the observed plot, after which the tendrils fall, still giving a better result on treated plants.

TIME SERIES ANALYSIS-FITTED LINEAR TREND EQUATION

TREATMENT	FITTED LINEAR TREND EQUATION (ON WEEKLY AVERAGES)	MULTIPLE (R-SQUARED)VALUES
TREATED	$-49.598 + 13.730 \times t$	0.8868
CONTROL	$-59.2198 + 12.3324 \times t$	0.9792

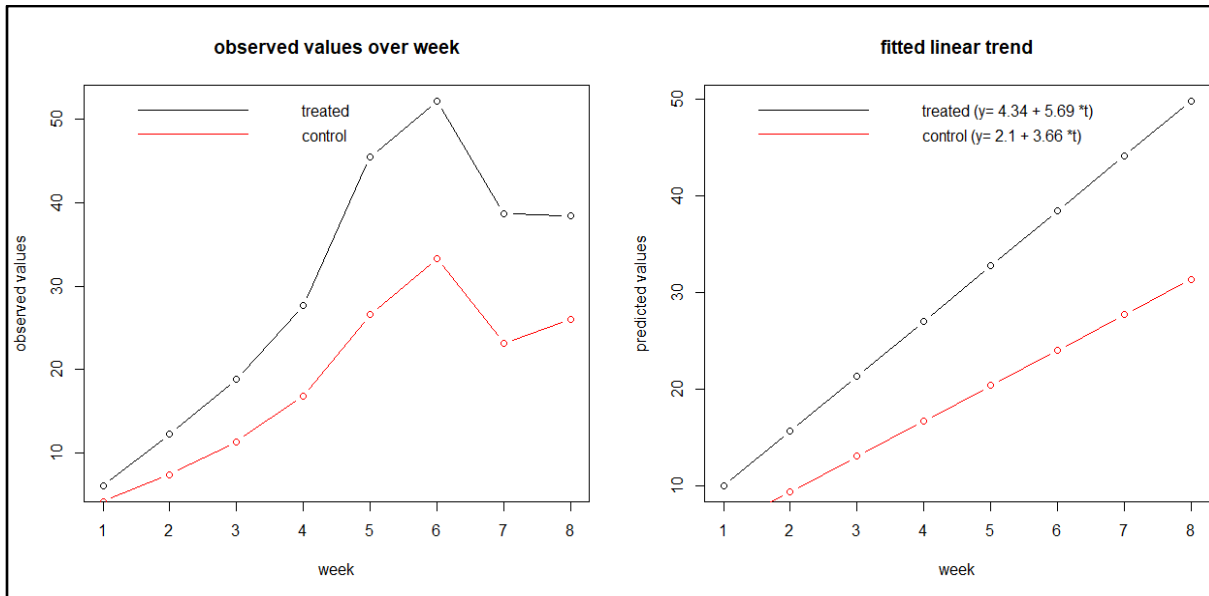
t-TEST AND WILCOXON RANK-SUM TEST RESULT

<u>WEEK</u>	<u>t TEST \$ p-VALUES</u>	<u>DECISION</u>	<u>WILCOXON TEST \$ p-VALUES</u>	<u>DECISION</u>
5	0.17426	ACCEPT	0.1624	ACCEPT
6	0.001737	REJECT	0.0017	REJECT
7	0.00749	REJECT	0.00297	REJECT
8	0.02153	REJECT	0.01649	REJECT
9	0.03928	REJECT	0.02874	REJECT
10	0.03838	REJECT	0.0323	REJECT
11	0.13106	ACCEPT	0.1648	ACCEPT
12	0.08689	ACCEPT	0.1239	ACCEPT

INTERPRETATION:

Based on the t-test and Wilcoxon Rank-Sum test, it seems that the number of tendrils increases significantly from week 6 to week 10 after providing the treatment. After 10th week, the treatment has no significant effect over control on on tendrils of the plant.

7. No. of Buds:



R^2 values

Treated	71.3%
Control	75.48%

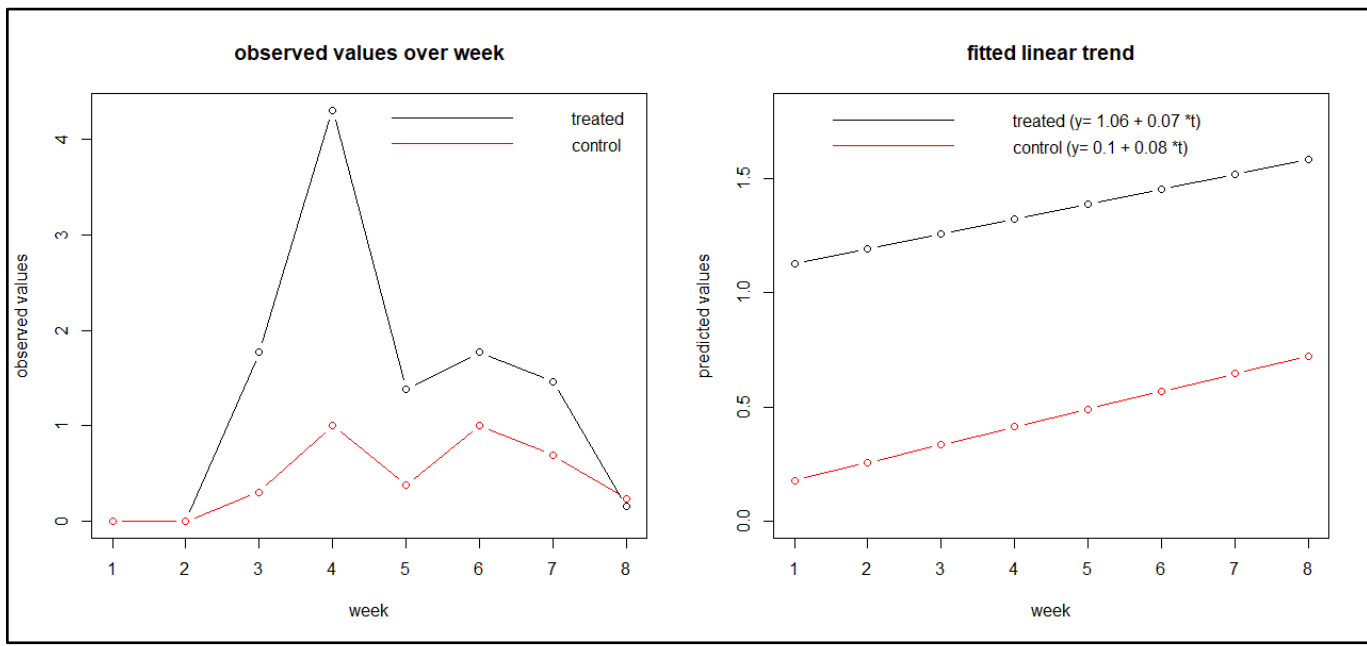
week	t test\$pval	t test\$dec	wilcox\$pval	wilcox\$dec
5	0.0570276	Accept	0.05987	Accept
6	0.0010077	Reject	0.001901	Reject
7	0.0048669	Reject	0.005491	Reject
8	0.0035314	Reject	0.002379	Reject
9	0.0084649	Reject	0.003021	Reject

10	0.0022486	Reject	0.005153	Reject
11	0.0039057	Reject	0.003499	Reject
12	0.0257654	Reject	0.01758	Reject

Interpretations:

- Both plots of observed and fitted mean values indicate that the increase in number of buds seems to be more when the plants are treated with the treatment than that of the control plants.
- The plot of linearly fitted mean values reveal that the rate of increase in number of buds over time (slope parameter) is more in the treated group than that in the controlled group.
- Both t-test (parametric) and Wilcoxon Rank-sum test indicates that in light of the given data there is no significant difference in the no. of buds in the control group and the treated group initially, whereas the no. of buds becomes significantly higher in the treated group of plants than in the control group of plants as time progresses.

8. No of Flowers:



R^2 values

Treated	1.25%
Control	22.3%

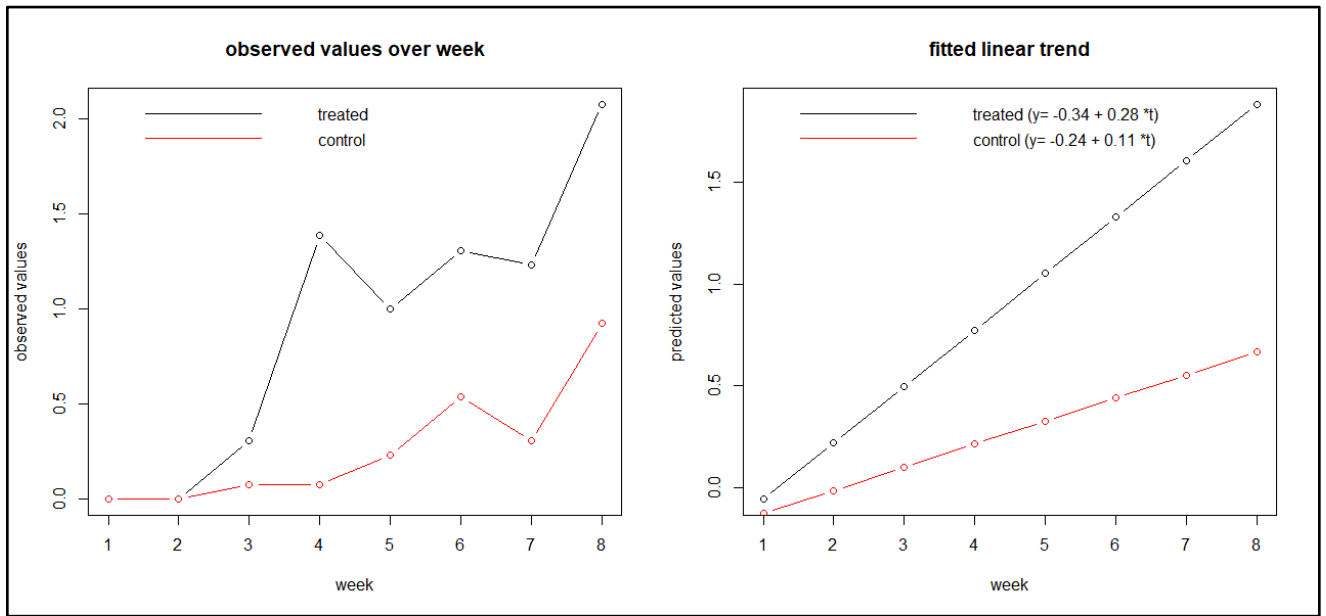
week	t test\$pval	t test\$dec	wilcox\$pval	wilcox\$dec
5	1	Accept	1	Accept
6	1	Accept	1	Accept
7	0.025574	Reject	0.1048	Accept
8	0.002938	Reject	0.006385	Reject

9	0.006953	Reject	0.009714	Reject
10	0.031557	Reject	0.03537	Reject
11	0.020994	Reject	0.03652	Reject
12	0.682348	Accept	0.7004	Accept

Interpretations:

- The plot of observed mean values of number of flowers of treated and controlled plants reveal that the number of flowers first increases and then decreases in both the groups. But the rate of increase in the number of flowers over time in treated plants is much more than that in controlled plants.
- From the plot of observed mean values the trend present in both the time series (treated and controlled) seem not to be linear. The R^2 values of the linear fit reveal the same. Hence no conclusion can be made from the fitted linear plots.
- Both t-test (parametric) and Wilcoxon Rank-sum test indicates that in light of the given data there is no significant difference in the no. of flowers in the control group and the treated group initially, whereas the no. of flowers becomes significantly higher in the treated group of plants than in the control group of plants as time progresses. It is also to be noted that since the number of flowers decreases in the end in both the groups, hence there is no significant difference in the no. of buds in the controlled group and the treated group in the 12th week.

9. No of Fruits:



R^2 values

Treated	83.45%
Control	75.02%

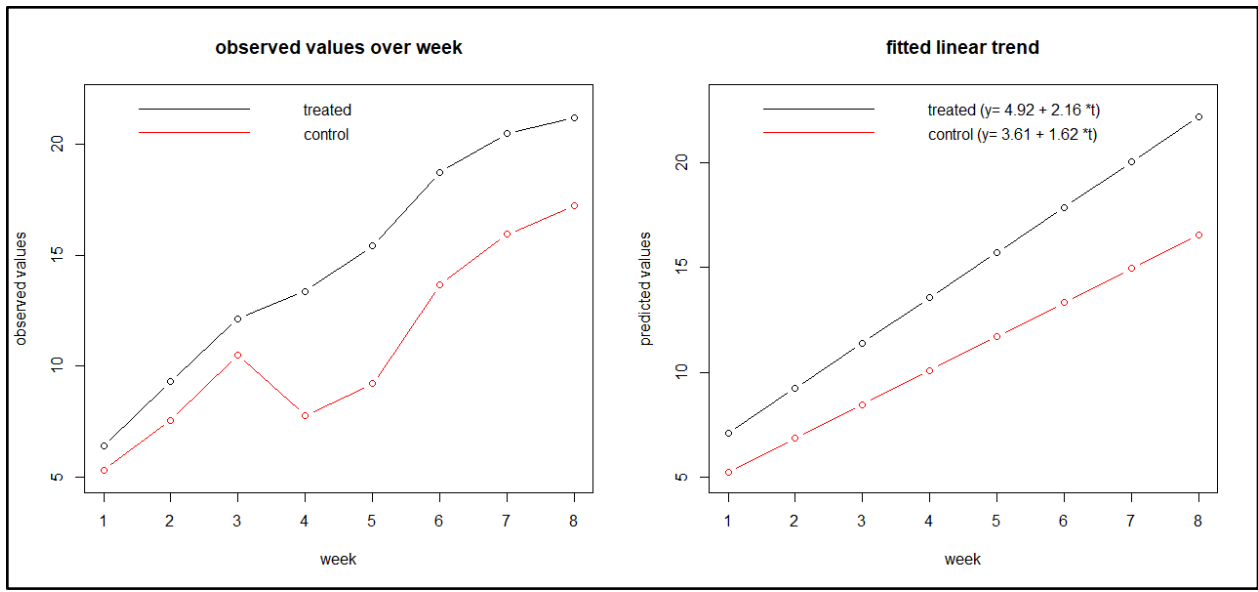
week	t test\$pval	t test\$dec	wilcox\$pval	wilcox\$dec
5	1	Accept	1	Accept
6	1	Accept	1	Accept
7	0.119393	Accept	0.1438	Accept
8	0.0120373	Reject	0.002167	Reject

9	0.0854126	Accept	0.03315	Reject
10	0.1496273	Accept	0.6464	Accept
11	0.0458682	Reject	0.01953	Reject
12	0.0458682	Reject	0.04177	Reject

Interpretations:

- Both plots of observed and fitted mean values indicate that the increase in number of fruits is more when the plants are treated with the treatment than that of the control plants.
- The plot of linearly fitted mean values reveal that the rate of increase in number of fruits over time (slope parameter) is much more in the treated group than that in the controlled group.
- Both t-test (parametric) and Wilcoxon Rank-sum test indicates that in light of the given data there is no significant difference in number of fruits of the control group and the treated group initially, whereas tendril length becomes significantly higher in the treated group of plants than in the control group of plants as time progresses.

10. Tendrils Length



R^2 values

Treated	98.43%
Control	86.14%

week	t test\$pval	t test\$dec	wilcox\$pval	wilcox\$dec
5	0.19337270	Accept	0.2946	Accept
6	0.06600632	Accept	0.1024	Accept
7	0.19464930	Accept	0.2361	Accept
8	0.00022965	Reject	0.0007158	Reject

9	0.00000203	Reject	2.95E-05	Reject
10	0.00056936	Reject	0.002	Reject
11	0.00243620	Reject	0.004358	Reject
12	0.00822402	Reject	0.01981	Reject

Interpretations:

- Both plots of observed and fitted mean values indicate that the increase in tendril length (slope parameter) is more when the plants are treated with the treatment than that of the control plants.
- The plot of linearly fitted mean values reveal that the rate of increase in tendril length over time is more in the treated group than that in the controlled group.
- Both t-test (parametric) and Wilcoxon Rank-sum test indicates that in light of the given data there is no significant difference in tendril length of the control group and the treated group initially, whereas tendril length becomes significantly higher in the treated group of plants than in the control group of plants as time progresses.