Original Research Article

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Application of T-tests for Horticulture Data (Watermelon, Mangoes) with an Example Problems and Solutions

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A B S T R A C T

This study provides an understanding of t-tests and its application in horticultural data. This article helps to readers or scientists, how to analyse the data by using t-test, what are assumptions, conditions for application of t-tests. If the sample size is greater than 30 we will go for Z-test. t-test is an inferential statistical test that determines whether there is a statistically significant difference between population mean and sample mean, or two population means.

Introduction

William Sealy Gosset, who developed the "t-statistic" and published it under the pseudonym of "Student" in 1908 (1).

Assumptions and conditions of t-test

The sample is drawn from normal population
All observations in the sample are independent
Sample size lies between 5 and 30
The hypothetical value \( \mu_0 = \mu \) is a correct value of population mean
The sample values are correctly measured and recorded (2, 3)

Materials and Methods

One sample t-test

Example problem 1

The weights of 14 watermelons in a farm in kgs are 6.4, 8.5, 5.5, 7.5, 6.5, 4.5, 5.3, 2.5, 2.4, 4.5, 5.5, 3.5, 3.2, and 4.2. As per old
records, the mean weight of watermelon of that farm is 6kg. Test for the significance.

**Sol**

Null Hypothesis \( (H_0) \): There is no significant difference between mean weight and sample mean of watermelons

i.e. \( H_0: \mu = \mu_0 \)

Alternative Hypothesis \( (H_1) \): There is significant difference between mean weight and sample mean of watermelons

i.e. \( H_1: \mu \neq \mu_0 \)

**Statistic** \((2, 4, 5)\)

\[
t = \frac{\bar{X} - \mu}{s / \sqrt{n}}
\]

Where \( \bar{X} \) is sample mean
\( \mu \) is population mean
\( s \) is sample standard deviation
\( n \) is number of observation in X data

\[
\begin{array}{|c|c|}
\hline
X_i & X_i^2 \\
6.4 & 40.96 \\
8.5 & 72.25 \\
5.5 & 30.25 \\
7.5 & 56.25 \\
6.5 & 42.25 \\
4.5 & 20.25 \\
5.3 & 28.09 \\
2.5 & 6.25 \\
2.4 & 5.76 \\
4.5 & 20.25 \\
5.5 & 30.25 \\
3.5 & 12.25 \\
3.2 & 10.24 \\
4.2 & 17.64 \\
\hline
\sum X_i = 70 & \sum X_i^2 = 392.94
\end{array}
\]

Where

\( \mu \) is population mean = 6kg
\( n \) is number of samples = 14

\[
\bar{X} = \frac{\sum X_i}{n} = \frac{70}{14} = 5
\]

\( s \) is sample standard deviation =

\[
\sqrt{\frac{1}{n-1} \left[ \sum X_i^2 - \frac{\left( \sum X_i \right)^2}{n} \right]} = \sqrt{\frac{1}{13} \left[ 392.94 - \frac{\left( 70 \right)^2}{14} \right]} = \sqrt{\frac{1}{13} \left[ 392.94 - 4900 \right]}
\]

\[
= \sqrt{\frac{42.94}{13}} = \sqrt{3.3031} = 1.8174
\]

\[
t = \frac{|s - \mu|}{s / \sqrt{n}} = \frac{|5 - 6|}{1.8174 / \sqrt{14}} = \frac{1}{0.4857} = 2.0589 \quad \text{NS}
\]

**Two Sample t - test**

**Example problem 2**

The yields of mangoes in Uttar Pradesh(X) and Andhra Pradesh(Y) in tonnes/hectar at the age of mango trees range from 15-20 years are as follows

| U.P(X) | 15 | 17 | 20 | 16 | 15 | 20 | 15 | 15 |
|--------|----|----|----|----|----|----|----|----|
| A.P(Y) | 17 | 18 | 20 | 15 | 16 | 18 | 15 | 16 |

Test whether there is significant difference in yields between two states with respect to mangoes

**Sol**

- In two sample t – test, sample sizes may or may not be equal
- Samples are not related
There is no significant difference in yields between two states with respect to mangoes i.e. \( \mu_1 = \mu_2 \)

There is significant difference in yields between two states with respect to mangoes i.e. \( \mu_1 \neq \mu_2 \)

### Statistic

\[
t = \frac{\bar{x} - \bar{y}}{\sqrt{\frac{s^2}{n_1} + \frac{s^2}{n_2}}}
\]

Where \( \bar{x} \) is first sample mean

\( \bar{y} \) is second sample mean

\( s^2 \) is Pooled variance or combined variance

\[
s^2 = \frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1 + n_2 - 2}
\]

\( n_1 \) is first sample size

\( n_2 \) is second sample size

\( s_1^2 \) is first sample variance

\( s_2^2 \) is second sample variance

\[
s_1^2 = \frac{1}{n_1-1} \left[ \sum X_i^2 - \left( \frac{\sum X_i}{n_1} \right)^2 \right]
\]

\[
s_2^2 = \frac{1}{n_2-1} \left[ \sum Y_i^2 - \left( \frac{\sum Y_i}{n_2} \right)^2 \right]
\]

### Paired t-test

#### Example problem 3

The following are the yields in tonnes/hectar obtained by 10 fields of mango trees at the age from 10-15 years and 15-20 are as follows

| Field No. | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Yield of mangoes in tonnes/ha at the age of 10-15 years of mango trees | 10  | 12  | 12  | 10  | 9   | 8   | 10  | 11  | 12  | 10  |
| Yield of mangoes in tonnes/ha at the age of 15-20 years of mango trees | 17  | 18  | 20  | 15  | 16  | 18  | 15  | 16  | 15  | 18  |
Is there any evidence that age of trees benefited the farmers significantly?

Sol

- In paired t – test, sample sizes should be equal i.e., \( n_1 = n_2 = n \)
- Samples are related i.e., dependent on each other

\( H_0: \) There is no significant difference among 10 mango fields with respect to yields at two different age periods

\( H_0: \mu_d = 0 \)

\( H_1: \) There is significant difference among 10 mango fields with respect to yields at two different age periods

\( H_1: \mu_d \neq 0 \)

Statistic

\[
t = \frac{|\bar{d}|}{\frac{s_d}{\sqrt{n}}}
\]

Where \( \bar{d} \) is mean

\( s_d \) is standard deviation

\( n \) is number of samples

\[
\begin{array}{|c|c|c|c|}
\hline
X_i & Y_i & d_i = X_i - Y_i & d_i^2 \\
\hline
10 & 17 & -7 & 49 \\
12 & 18 & -6 & 36 \\
12 & 20 & -8 & 64 \\
10 & 15 & -5 & 25 \\
9 & 16 & -7 & 49 \\
8 & 18 & -10 & 100 \\
10 & 15 & -5 & 25 \\
11 & 16 & -5 & 25 \\
12 & 15 & -3 & 9 \\
10 & 18 & -8 & 64 \\
\hline
\end{array}
\]

\[ \Sigma d_i = -64 \]

\[ \Sigma d_i^2 = 446 \]

Where

\( n \) is number of samples = 10

\[
\bar{d} = \frac{\Sigma d_i}{n} = \frac{-64}{10} = -6.4
\]

\[
s_d = \sqrt{\frac{1}{n-1} \left[ \Sigma d_i^2 - \frac{(\Sigma d_i)^2}{n} \right]}
\]

\[
= \sqrt{\frac{1}{10-1} \left[ 446 - \frac{(-64)^2}{10} \right]} = \frac{1}{\sqrt{9}} \left[ 446 - \frac{4096}{10} \right] = \sqrt{4.0444} = 2.0111
\]

\[
t = \frac{|\bar{d}|}{\frac{s_d}{\sqrt{n}}} = \frac{6.4}{2.0111} = \frac{6.4}{2.1623} = \frac{6.4}{0.6260} = 10.0634^{**}
\]

Results and Discussion

Conclusion and interpretation for one sample t-test

As \( t \)-calculated value (2.0589) \(< t \)-tabulated value with \((n-1) = (14-1) = 13\) degrees of freedom is 2.1604 (5% LOS) and 3.0123 (1% LOS) null hypotheses accepted. i.e., There is no significant difference between mean weight and sample mean of watermelons.

Conclusion and interpretation for two sample t-test

As \( t \)-calculated value (0.0892) \(< t \)-tabulated value with \((n_1+n_2-2) = (8+9-2) = 15\) degrees of freedom is 2.1314 (5% LOS) and 2.9467 (1% LOS) null hypotheses accepted. i.e., There is no significant difference in yields between two states with respect to mangoes.
Conclusion and interpretation for Paired t-test are as follows:

As t-calculated value (10.0634) > t-tabulated value with (n-1) = (10-1) = 9 degrees of freedom 2.2622(5% LOS) and 3.2498 (1% LOS). So, the null hypothesis is rejected. i.e., There is highly significant difference among 10 mango fields with respect to yields at two different age periods of mango trees.

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