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

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ABSTRACT

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)

$$t = \frac{|\bar{x} - \mu|}{\frac{s}{\sqrt{n}}}$$

Where $\bar{X}$ is sample mean

μ is population mean

s is sample standard deviation

n is number of observation in X data

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
$\sum X_i =$ **70**	$\sum X_i^2 =$ **392.94**

Where

μ is population mean = 6kg

n is number of samples = 14

$\bar{X}$ is sample mean = $\frac{\sum x_i}{n} = \frac{70}{14} = 5$

s is sample standard deviation = $\sqrt{\frac{1}{n-1}\left[\sum x_i^2 - \frac{(\sum x_i)^2}{n}\right]}$

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

$$= \sqrt{\frac{1}{13}[392.94 - 350]}$$

$$= \sqrt{\frac{42.94}{13}} = \sqrt{3.3031} = 1.8174$$

$$t = \frac{|\bar{x}-\mu|}{\frac{s}{\sqrt{n}}} = \frac{|5-6|}{\frac{1.8174}{\sqrt{14}}} = \frac{1}{0.4857} = 2.0589$$

NS

Two Sample t - test

Example problem 2

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

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

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

H_0: There is no significant difference in yields between two states with respect to mangoes

i.e. $H_0: \mu_1 = \mu_2$

H_1: There is significant difference in yields between two states with respect to mangoes

i.e. $H_1: \mu_1 \neq \mu_2$

Statistic

$$t = \frac{|\bar{x} - \bar{y}|}{\sqrt{s^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

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

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

s_2^2 is second sample variance

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

X_i	Y_i	X_i^2	Y_i^2
15	17	225	289
17	18	289	324
20	20	400	400
16	15	256	225
15	16	225	256
20	18	400	324
16	15	256	225
15	16	225	256
--	15	--	225
$\sum X_i = 134$	$\sum Y_i = 150$	$\sum X_i^2 = 2276$	$\sum X_i^2 = 2524$

$$\bar{x} = \frac{\sum X_i}{n_1} = \frac{134}{8} = 16.75$$

$$\bar{y} = \frac{\sum Y_i}{n_2} = \frac{150}{9} = 16.6667$$

$$s_1^2 = \frac{1}{n_1-1}\left[\sum X_i^2 - \frac{(\sum X_i)^2}{n_1}\right] = \frac{1}{8-1}\left[2276 - \frac{(134)^2}{8}\right] = \frac{1}{8-1}[2276 - 2244.5]$$

$$= \frac{1}{8-1}[31.5] = \frac{31.5}{7} = 4.5$$

$$s_2^2 = \frac{1}{n_2-1}\left[\sum Y_i^2 - \frac{(\sum Y_i)^2}{n_2}\right] = \frac{1}{9-1}\left[2524 - \frac{(150)^2}{9}\right] = \frac{1}{9-1}[2524 - 2500]$$

$$= \frac{1}{9-1}[24] = \frac{24.0}{8} = 3.0$$

$$s^2 = \frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1+n_2-2} = \frac{(8-1)4.5 + (9-1)3.0}{8+9-2} = \frac{(7)4.5 + (8)3.0}{15} = \frac{55.5}{15} = 3.7$$

$$t = \frac{|16.75 - 16.6667|}{\sqrt{3.7\left(\frac{1}{8}+\frac{1}{9}\right)}} = \frac{|16.75 - 16.6667|}{\sqrt{3.7\left(\frac{1}{8}+\frac{1}{9}\right)}} = \frac{|0.0833|}{\sqrt{3.7\left(\frac{1}{8}+\frac{1}{9}\right)}} = \frac{|0.0833|}{\sqrt{3.7(0.2361)}}$$

$$= \frac{|0.0833|}{\sqrt{0.8736}} = \frac{|0.0833|}{0.9347} = 0.0892\ NS$$

Paired t-test

Example problem 3

The following are the yields in tonnes/hector 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 theage 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

X_i	Y_i	$d_i = X_i - Y_i$	d_i^2
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
		$\sum d_i = -64$	$\sum d_i^2 = 446$

Where

n is number of samples = 10

$\bar{d}$ is sample mean = $\frac{\sum d_i}{n} = \frac{-64}{10} = -6.4$

s_d is sample standard deviation = $\sqrt{\frac{1}{n-1}\left[\sum d_i^2 - \frac{(\sum d_i)^2}{n}\right]}$

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

$$= \sqrt{\frac{1}{9}[446 - 409.6]}$$

$$= \sqrt{\frac{36.4}{9}} = \sqrt{4.0444} = 2.0111$$

$$t = \frac{|\bar{d}|}{\frac{s_d}{\sqrt{n}}} = \frac{|-6.4|}{\frac{2.0111}{\sqrt{10}}} = \frac{6.4}{\frac{2.0111}{3.1623}} = \frac{6.4}{0.6360} = 10.0634^{**}$$

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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