Does Temperature Effect the Germination of Mustard Seeds?

Biological Problem:

"A keen gardener found an old packet of mustard seeds lodged behind some plant pots in the greenhouse and wondered whether the same number of seeds would germinate as from a recently purchased packet. He tried to germinate them but found fewer seeds grew compared to the newly purchased packet. He thought that this might be related to the temperature in the greenhouse".

Aim:

The aim of my investigation is to see if temperature does actually influence the germination of mustard seeds.

Method:

- I am going to test the germination of mustard seeds at five different temperatures, these will be; -10°C, 10°C, 20°C, 30°C and 40°C
- To do this I will use five separate petri dishes of the same size.
- In each dish I will put just enough cotton wool in the dish as to cover the bottom.
- On top of the cotton wool, I will place 20 mustard seeds in each petri dish as evenly spaced out as I can.
- The seeds will need water to survive, so, I will pour 20 cm^3 of distilled water into each dish.
- I will have to wrap each petri dish in aluminium foil totally covered so that heat does not escape and so that light is not a variable in this experiment.
- At the same time, I will place my dishes in their temperature set environments and leave them there for 3 days.
- After 3 days I will unwrap the petri dishes and record my findings in a results table, showing how many mustard seeds germinated out of 20 for each temperature.
- To make this investigation more accurate I will analyse some of my classmates results because they are doing the same experiment as me so, I can also prove that my results are not just fluke.
- I will produce 4 sets of results and an average set of results and analyse them all, using line graphs and the chi-squared test.

The chi-squared test enables us to assess the significance of differences between expected and observed data. The chi-squared value is a measure of the degree of

deviation between expected and observed results; the larger the chi-squared value the larger the deviation.

$$\text{Chi-squared} = \chi^2 = \Sigma (O-E)^2/E$$

Key:
- Σ = sum of
- O = observed results
- E = expected results

I am going to use this test to prove my hypothesis.

Diagram:

My Results:

Temp (°C)	-10	10	20	30	40
No. of seeds that have germinated, out of 20.	0	18	14	20	8
	0	5	16	19	0
	0	10	12	20	6
	0	8	13	20	4
Average	0	10.25	13.75	19.75	4.5

Analysis:

I have decided to analyse my results gathered, as a result of my investigation, by using a combination of the chi-squared test and line graphs.

The chi-squared test (χ^2) is commonly used in biological sciences. It is used to test data that falls into distinct categories, in the form of discrete random variables. It is a

measure of how closely the observed results correspond with the expected ones on the basis of the hypothesis; the larger the deviation between the expected and observed results the larger the chi-squared value.

For this reason, before calculating the chi-squared values, I must make a null hypothesis, which states chance alone produces, any deviation between the observed and expected results. So my null hypothesis is that temperature does not effect the germination of mustard seeds.

My Results:

Temp (°C)	-10	10	20	30	40
No. of seeds that have germinated, out of 20.	0	18	14	20	8
	0	5	16	19	0
	0	10	12	20	6
	0	8	13	20	4
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Calculations:

The formula to be used is $\chi^2 = \Sigma (O-E)^2/E$

Key:
- Σ = sum of
- O = observed results
- E = expected results

Temp (°C)	-10	10	20	30	40
O	0	10.25	13.75	19.75	4.5
E	9.65	9.65	9.65	9.65	9.65
O - E	-9.65	0.6	401	10.1	-5.14
$(O-E)^2$	93.1225	0.36	16.81	102.01	26.5225
$(O-E)^2/E$	9.65	0.0373	1.742	10.571	2.75
SUM OF (O-E)2/E			24.75		

The values for O (observed) are the average number of seeds that have germinated at each temperature.
The values for E (expected) in this case will be the average of the observed results (assuming that temperature has no effect on germination).
The final row in the table is just the sum of all the values in the previous row, this give you the Chi-squared value. So my Chi-squared value is 24.75.

I now have to look it up in the Chi-squared table.

Table 1 Table of Chi-squared values (based on Fisher)

Degrees of freedom	**Number of classes**	Chi-Squared Values									
1	2	0.016	0.064	0.15	0.46	1.07	1.64	2.71	3.84	5.41	6.64
2	3	0.21	0.45	0.71	1.39	2.41	3.22	4.61	5.99	7.82	9.21
3	4	0.58	1.01	1.42	2.37	3.67	4.64	6.25	7.82	9.84	11.34
4	5	1.61	2.34	3.00	4.35	6.06	7.29	9.24	11.07	13.39	15.09
Probability (P) that chance alone could produce the deviation.		0.9	0.8	0.7	0.5	0.3	0.2	0.1	0.05	0.02	0.01
		90%	80%	70%	50%	30%	20%	10%	5%	2%	1%

On the Chi-Squared table I need to look at the row I have circled because there are 5 classes in my results table (5 different temperatures) and so 4 degrees of freedom.

My Chi-squared result would mean that the probability chance alone could produce a deviation of less that 1% - this is regarded as significant since the probability that the difference between observed and expected results is less than 0.05 (5%). So therefore I need to reject my null hypothesis. In other words temperature does have a significant effect of the germination of mustard seeds.

Line Graph Results:

Please see graph paper.

Analysis of Results: