**KLA201 KLA310 KLA439**

**Agri-food Research Methods**

**These questions are indicative of what could be in your exam.**

**Please work through them all; refer to your course notes and our textbook for help with answers. If you prepare well, then you should do well in the exam.**

**You are not allowed to bring any material into the exam.**

**To guide how much time (and page space) you should spend answering each question in exam conditions I have given indicative “marks out of 100” for each. Use your common sense.**

**I will not be distributing model answers to these questions, but ask me if you get stuck.**

**Ian Hunt**

**Critical Thinking Question.**

*Each of these questions would be worth approximately [5 marks] out of 100.*

**In this question you need to talk about the details of an agri-food research study. It can be real or imagined, something from class or something completely new. You can use plants, insects, food or animals in your answer. Refer to the details of your study in your answers to the following questions.**

Briefly describe an “experiment” in which there are two different “treatments” that may, or may not, affect the values of a continuous measurement *Y*. Define *Y* in concrete terms.

In what sense is comparing **average** results for *Y* of *practical* significance in your experiment?

In what sense is comparing **average** results for *Y* of *mathematical convenience* in your experiment?

How can you compare the results for *Y* between the two treatments? Include reference to exploratory charts, summary statistics tables and a formal hypothesis test.

How can you plan for the sample size required to tell a meaningful difference between *Y* for treatment one versus the *Y* from treatment two? Put your answer in the context of a hypothesis test.

What would be the advantages and disadvantages of doubling your experiment’s sample size?

Describe the hypothetical population to which your research is aimed. In what sense would your experiment’s results be relevant to this population? Reference decisions, predictions you might make and what future studies might be required.

**Technical questions.**

*Each of these questions would be worth approximately [5 marks] out of 100.*

What is the essence of the Central Limit Theorem and what use is it?

In your own words, define a 95% confidence interval for a mean.

In your own words, define a p-value.

In your own words, define the power of a hypothesis test.

Explain the relationship between the p-value for a hypothesis test on a mean and the corresponding 95% confidence interval for that mean.

Assume that in a research paper you make one confidence interval for a mean. What is the objective probability that the true mean is within this interval?

Can you do a valid t-test on data that is not Normally distributed? Explain, giving conditions and reasons.

In what sense is an ANOVA linear regression model related to a t-test that compares means from two treatment groups. Under what conditions would ANOVA be a more powerful option? Why – give a technical reason and the intuition behind it?

Briefly describe two interpretations of probability.

Justify the claim that “the sample mean of a random variable is random itself”. And say what are the implications for statistical inference about this fact?

How can you argue that statistical analysis (confidence intervals etc) and hypothesis tests are valid and useful, even when the sample observations are not randomly selected?

Describe two methods of estimating a confidence interval for the mean of a sample.

What is the key assumption in any bootstrapping analysis? Will a t-test work on the data if this assumption is unsound?

**Hypothesis tests and inferential errors.**

*Each of these questions would be worth approximately [5 marks] out of 100.*

What is Type 1 error (size) and why does it matter.

What is Type 2 error (power) and why does it matter.

In what technical sense is running many hypotheses (“multiplicity”) tests at the same time a problem?

Give two concrete examples of multiplicity.

How are results of running many hypothesis tests related to so-called “publication bias”?

Explain two ways the problem of multiplicity can be overcome.

**Interpretation of real data and confidence intervals**

*Total marks for each question given separately (some are 5/100 and others are 15/100).*

Table

Description automatically generated

Table

Description automatically generated with low confidence

*These questions refer to Table 3 and Table 4 above. The linear regressions referred to in Table 4 can be interpretated as straight-forward ANOVA models which include the data from all nine varieties in one model (there is model for waterlogging data and one model for the control data).*

Limiting your attention to Table 3, what is the difference in means between the yield for Planet+ and Planet under waterlogging conditions? *[5 marks]*

Limiting your attention to Table 3, what information is missing from this table that would enable you to say that there is evidence that Planet+ *truly* has a higher yield the Planet in waterlogging conditions? *[5 marks]*

What is the null hypothesis being tested for the second row of the Table 4? How could the confidence interval be used to accept or reject the null hypothesis? What would you conclude from this row about Planet+? What about in control conditions? Justify your answers. *[15 marks]*

What distribution would the residuals of the ANOVA regressions need to follow in order for the p-values in Table 4 to be valid? How could this assumption be checked using a chart? *[5 marks]*

Instead of the linear regressions (ANOVA) used, describe how a simple t-test could be used to explore the difference in mean yields between Planet+ and (Planet + Planet-)/2, under waterlogging conditions. What conditions would need to be satisfied for the t-test to be valid? *[15 marks]*

Instead of the linear regressions (ANOVA) used, describe how a bootstrap re-sampling procedure could be used to estimate the confidence interval for the difference in means between Planet+ and (Planet + Planet-)/2. What is the main condition that would need to be satisfied for this confidence interval to be valid?

*[15 marks]*

What are the main reasons that the linear regression analysis (ANOVA) might be expected to be more powerful at detecting differences between true means, compared to just simple t-tests between varieties? *[5 marks]*

If the variance of the yields of the different varieties is different is the ANOVA approach still valid? Why? What alternative analysis could help? *[5 marks]*

**Chart Interpretation and summary statistics**

*Each of these questions would be worth approximately [5 marks] out of 100.*

Describe in general how a continuous measurement can be turned into a meaningful categorical measurement. Give a concrete example.

In statistical analysis, what are the main uses of categorial variables the split numeric measurements into groups? Give a concrete example.

What types of chart display the distribution of a sample of numerical measurements? Draw an example.

List the most useful summary statistics that are fundamental in describing a distribution of numeric measurements.

How can two continuous variables be compared and contrasted with each other. Give at least one example of each of the following: charts, summary statistics and regression models.

Draw a scatter plot of *x* and *y* (assume each sample has n=10 and ranges broadly between 0 and 1) in which the true correlation coefficient is -0.95. Then draw another chart that would be indicative if the true correlation between *x* and *y* was approximately 0.5. Label each chart clearly.

**Miscellaneous questions**

*Each of these questions would be worth approximately [5 marks] out of 100.*

In what sense can statistical analysis help researchers in their quest for causation? Explain.

Give two advantages of randomly assigning treatments to sample units?

Give two concrete examples in which it would be impossible to randomly assign treatments to sample units?

Other than inferences related to causation, what use is statistical analysis in general? Explain, giving examples in the context of agri-food research.

In what sense is the “mean yield” of a new crop variety useful to a farmer?