Parsimony and models - In class exercise

Methods of Scientific Working for Crop Science (3502-440)

Prof. Dr. Karl Schmid

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1 Constructing a predictive model

Assume that your task is to construct a predictive model for the relationship between nitrogen fertilization and crop yield.

The task is based on the following premises:

- **Theory:** Nitrogen is required for plant growth because it is an essential component of proteins.
- **Hypothesis:** More nitrogen applied during plant growth leads to a higher yield.
- **Null hypothesis:** There is no effect of nitrogen fertilization on plant growth.

In the lecture notes, we already presented three possible models, which are shown in Figure 1.

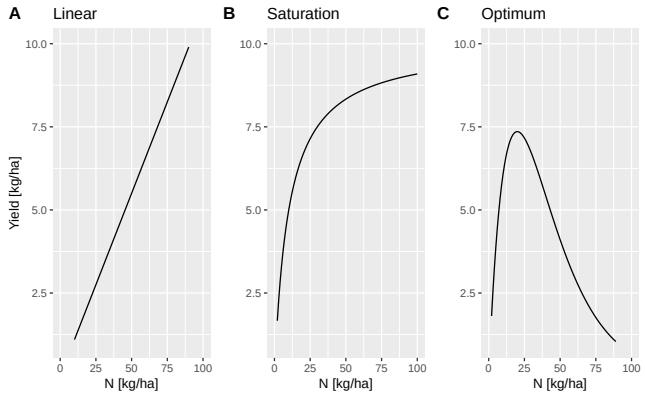

Figure 1: Three possible models to express the relationship between the amount of nitrogen fertilization and yield. (A) Linear relationship. (B) Saturation curve. (C) Optimum curve.

Please discuss the following questions:

1. One could imagine a fourth model, which describes the increase of yield with higher levels of nitrogen fertilization. Can you draw a curve for this model and describe its behaviour in words?
2. Assume that you are doing a field trial to evaluate to which model your data fit the best. Can you describe in words (without a mathematical formula) which approach you would take to fit each of the three (or four) models above to your data as shown in Figure 2? How could you use the approach to both estimate the model parameters and find the best fitting model?

2 Thinking about parsimony

2.1 Ontological and epistemiological aspects of parsimony

What are the ontological and epistemological aspects of parsimony? In which respect are both simplicity and complexity true characteristics of "nature"?

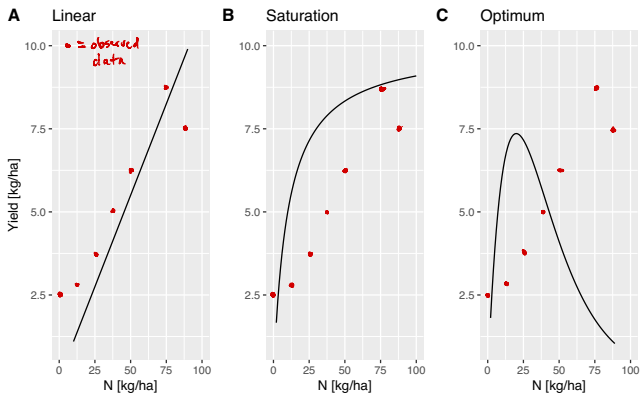

Figure 2: Three possible models with data. What are available strategies to fit the data to the model and decide on the best model in this example?

If you think about the above models:

1. Can you identify an ontological parsimony and an epistemiological parsimony in the relationship between nitrogen fertilization and yield?
2. If you differentiate between science and application (farming): When do you think it is advantageous to step away from parsimony and embrace complexity in both domains? When is it sufficient to choose a parsimonius approach?

3 Application of the parsimony principle to real biologial data

Gregor Mendel found the following ratios in his crossing experiments with peas which he conducted to study patterns of inheritance:

Table 1: The ratios reported by Gregor Mendel in his study about the inheritance of 7 plant traits

Trait	Ratio		
Round : wrinkled shape	2.96	:	1
Yellow : green endosperm	3.01	:	1
Dark : white seed coats	3.15	:	1
Inflated : constricted seed pods	2.95	:	1
Green : yellow unripe pods	2.82	:	1
Axial : terminal flower positions	3.14	:	1
Tall : short plants	2.84	:	1
Average	2.98	:	1
Dominance : Recessivity	3	:	1

He concluded: *. . . an average ratio of 2.98:1 or 3:1*

Please discuss the following questions:

1. At which levels can you apply the parsimony principle to these data?
2. Can you present parsimonious models about these data (no deep knowledge about genetics is required!)
3. Why could Mendel not reach a definite conclusion about a 2.98 or 3.0 ratio, whereas a modern geneticist can reach a final conclusion?