PLANT-GROWTH EXPERIMENT

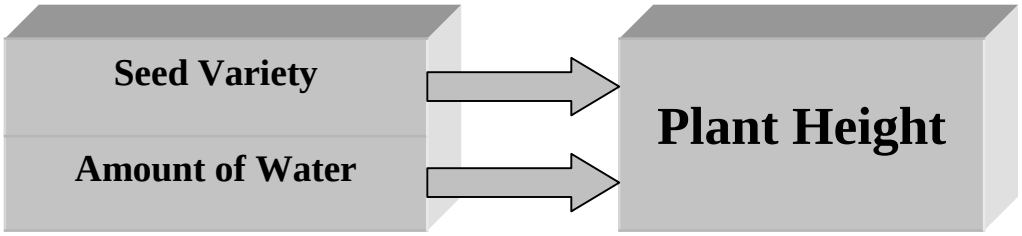
3. The Experiment Design

In this section we discuss the experiment design. In particular, we define the factors and their levels and the response variable. Moreover, the randomization process will be described in detail.

3.1 Selection of Factors

One could use several variables to describe a plant's growth. Weight, height, and number of leaves are just a few. In this experiment, we use plant height as the response variable.

You will have two controllable variables: seed variety and amount of water. These variables are the factors in the experiment.



The seed factor will be three varieties of the same type of plant, and its levels will be denoted by 1, 2, and 3. Write the names of these three varieties in the table below.

Factor	Level	Description
Seed	1	
	2	
	3	
Water	1	
	2	
	3	
	4	

Now you should decide on four reasonable watering plans. An example of possible water-factor levels is:

Level 1 of water is 1/3 cup once a week.
Level 2 of water is 1/2 cup once a week.
Level 3 of water is 1/3 cup twice a week.
Level 4 of water is 1/2 cup twice a week.

Write your four levels of the water factor in the above table.

This experiment has two factors: seed (with three levels) and the amount of water (with four levels). This creates 3 x 4 = 12 factor-level combinations, as represented by the cells in the following table. The twelve combinations will be denoted by the letters A,..., L.

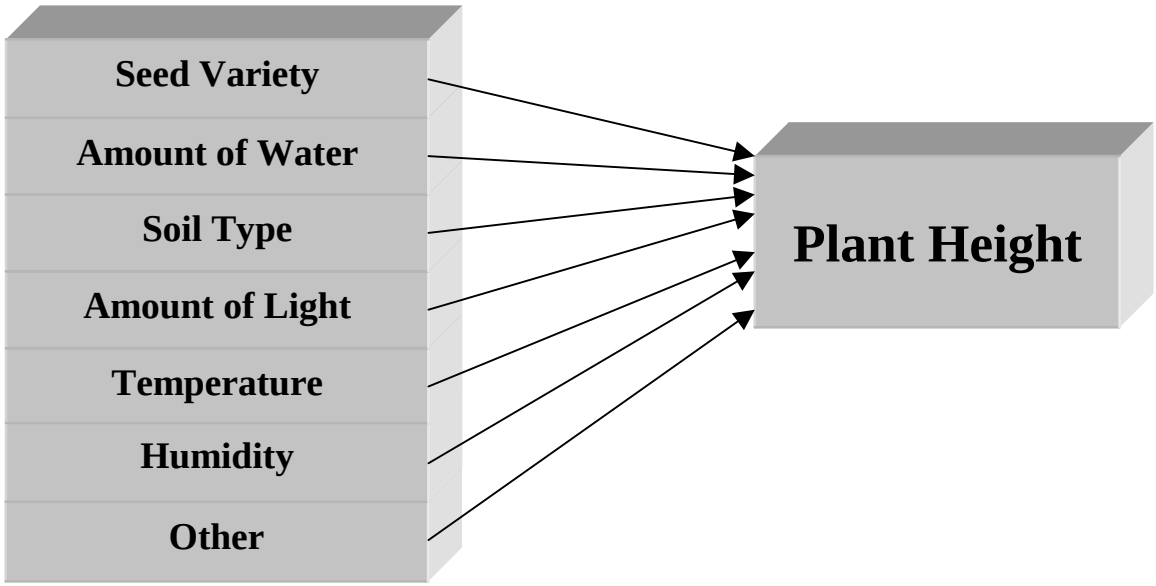
Symbol	Levels	General Description	Detailed Description
A	(1,1)		Seed variety 1 and water level 1
B	(1,2)		Seed variety 1 and water level 2
C	(1,3)		Seed variety 1 and water level 3
D	(1,4)		Seed variety 1 and water level 4
E	(2,1)		Seed variety 2 and water level 1
F	(2,2)		Seed variety 2 and water level 2
G	(2,3)		Seed variety 2 and water level 3
H	(2,4)		Seed variety 2 and water level 4
I	(3,1)		Seed variety 3 and water level 1
J	(3,2)		Seed variety 3 and water level 2
K	(3,3)		Seed variety 3 and water level 3
L	(3,4)		Seed variety 3 and water level 4

Your task will be to determine which of these twelve combinations produces the largest plants. As 24 pots are available, we shall have 2 pots for each treatment combination.

This is an example of a two-factor experiment with replication.

3.2 Randomization

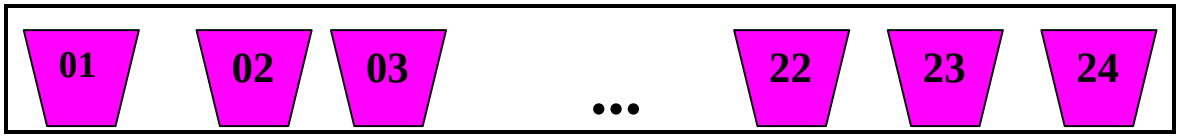
Plant growth is affected by several factors such as seed variety, amount of water, soil type, amount of light, temperature, humidity, and other. The factors are displayed in the diagram below.



Only some of the factors can be controlled. For example, we cannot control the amount of light coming through the window. The ideal situation would be for all 24 plants to receive the same amount of light, so any differences in plant growth will be due to the two controlled factors of water and seed variety.

To minimize the effect of uncontrollable factors, it is very important that the levels of the factors are assigned at random to the experimental units, the pots, in the study. Randomization is a technique for assigning treatment combinations to experimental units (in this case, pots). We will use randomization to decide the arrangement of the 24 pots in the window. Randomization gives each of the 24 pots an equal chance to be chosen to each of the 12 treatments.

In the first step of randomization, it is necessary to assign labels to the experimental units. Two digits are needed to label each of the 24 pots, so we use labels 01, 02, 03, ..., 24.



We assign the 24 pots to the twelve treatments, so that each treatment combination will be assigned randomly to exactly two pots.

Treatment Combination	Treatment Number
A (1,1)	1
B (1,2)	2
C (1,3)	3
D (1,4)	4
E (2,1)	5
F (2,2)	6
G (2,3)	7
H (2,4)	8
I (3,1)	9
J (3,2)	10
K (3,3)	11
L (3,4)	12

Now obtain a long sequence of random numbers between 1 and 12. The sequence can be obtained either from the table of random numbers (numbers different from the integers between 1 and 12 are disregarded) or by random number generation feature in the statistical software (integer uniform distribution with possible values between 1 and 12).

The first number in the sequence will assign a treatment combination to the first pot. Continue using the numbers until all the 24 pots have been assigned a treatment

combination. Remember that each treatment is to be used only twice. That is, after two 1s have appeared, skip over the remaining 1s. Use the figure below to record the treatment-combination assignments as they are determined.

Pot Number	Treatment Number	Random Numbers
1	7	7
2	4	4
3	11	11
4	8	8
5	10	10
6		
22	1	1
23	12	12
24	8	8

When you are finished, you should have 24 pots labelled as two 1s (A s), two 2s (B s),…,two 12s (L s). The random assignment of the experimental units (24 pots) to the treatment combinations is now complete.