Getting a Handle on Variation

Quantifying differences in plant height

The system which guides generation after generation of species through the spiral of life has in its design the ability to generate sufficient variation to accommodate an ever-changing environment. *Variation* is a fundamental attribute of life; understanding its nature is important to us all.

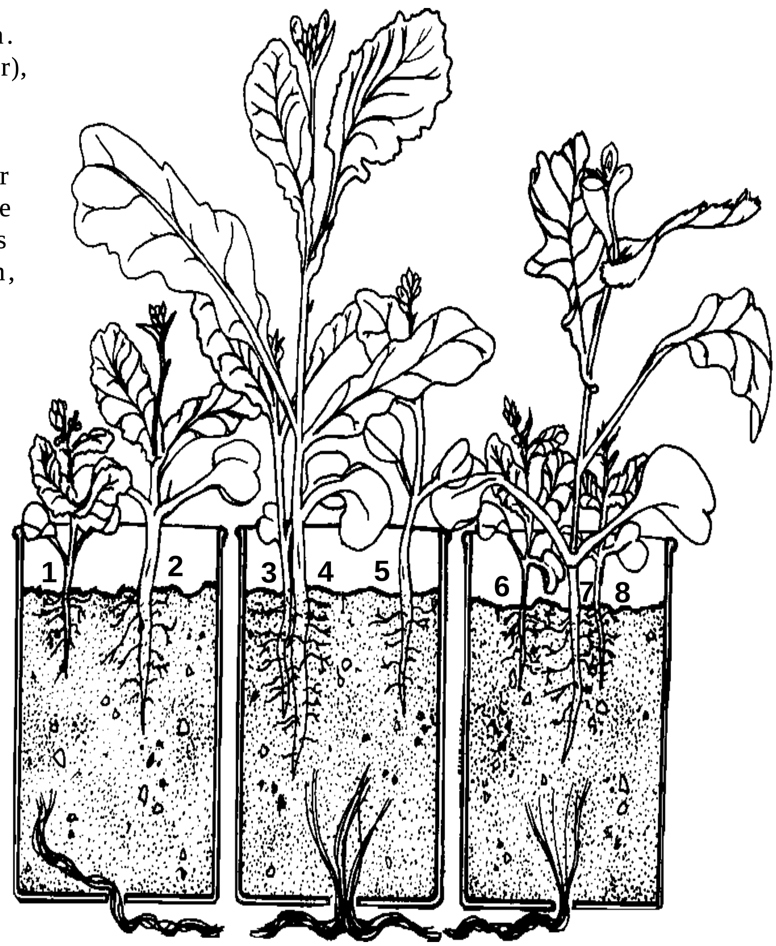
This article is designed to help students and teachers think about the nature of various determinants underlying biological variation. Fast Plants, rapid cycling *Brassica rapa* (Rbr), are ideally suited for getting a handle on variation.

Variation between individuals of a particular visible trait *(phenotype)* is conditioned by the genetic makeup *(genotype)* of the individuals and their environment. To identify variation, a trait must be observed, described, and measured or quantified. Some of these traits, such as plant height, cotyledon width, or the intensity of purple anthocyanin pigment in the stems, can vary from plant to plant of the same age. When, for example, the height of many plants of the same age is recorded and organized (graphed), the population expresses a variety of heights within a range from the shortest to the tallest.

Another way to view variation is to determine whether the trait is present or absent. For example, the purple color in the Rbr stem may be present or absent and, if it is present, the intensity of the purple may vary. Other traits vary in their degree of expression or numbers. Your students will notice in a Rbr population that the total number of hairs on the stems and leaves varies considerably from plant to plant and varies with respect to hair location. Just as with height, the number of hairs can be quantified by counting and graphing them to show the extent of variation in the Rbr population's hairiness.

Variation occurs at all stages of the life cycle. The data collected and graphed in Figure 1 (page 2) is an example of height variation within a population of approximately 200 Fast Plants.

The graph in Figure 1 is a *frequency histogram*: it organizes the height measurements of each plant into categories (classes or intervals) according to the height in millimeters and the number of plants in each height class (frequency). Notice that the outline of the histogram roughly depicts a curve known as the *frequency curve*.



One way to describe variation is in terms of *range*. For plant height, the range would extend from the shortest to the tallest plant. Looking at the frequency histogram (Figure 1), is there much variation in the height range of 5 day old plants as compared to the range of 10 day old plants? By the time the plants are 14 days old and beginning to flower, has the range widened even further?

Department of Plant Pathology, 1630 Linden Drive, Madison, WI 53706 1-800-462-7417 wfp@fastplants.cals.wisc.edu

What is the range from shortest to tallest plant by Day 14? *

Another way to describe variation is in terms of averages. Continuing with our examples, the average (arithmetic mean) height of the plants increased from 13.4 mm on day 5 to 100 mm on day 14. The *mean* is the sum of the height of all plants divided by the number of plants.

Did you notice that as the plant population ages, the shape of the frequency curve changes? This variation results from the environment and genetic make-up of individual plants.

Could you change the shape of the population curves by altering environmental or genetic factors? For instance, if you grew the plants under stress — with low nutrients or in the presence of salt or other pollutants would the shape of the frequency curve change when you measured the plants — on days 5, 10, and 14?

Could you change the frequency curve by altering the genetic base of the population? For example, what if you selected the tallest 10% of the plants and crossed them, do you think the curves describing plant height of the progeny would differ from the curve of the parents? How could you investigate this?

Are there other plant characteristics that can be quantified?

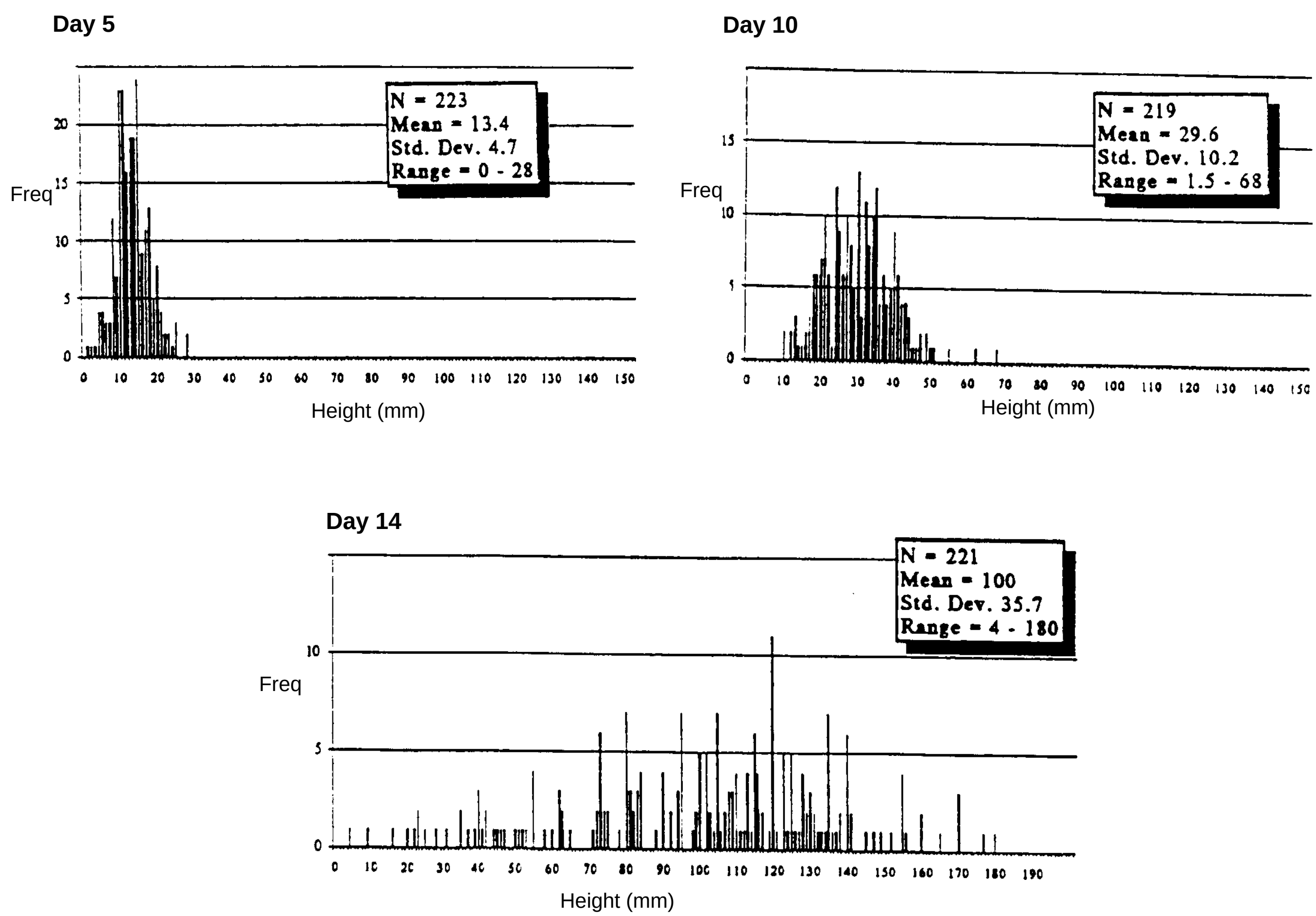
- the number of true leaves on a plant
- the number of days it takes for the first flower to appear
- the number of pods a plant produces
- the length of the seed pods

Additional questions to ponder:

- is the length of the pod related to the number of seeds it produces?
- is the number of seeds produced related to the number of times you pollinate?

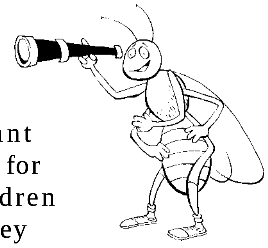
* The range on Day 5 is 27 mm (29-2); the range on Day 10 is 58 mm (68-10); the range on Day 14 is 176 mm (180-4).

Figure 1: Frequency Histograms for Rbr at 5, 10, 14 days old



Let your students try to quantify variation

Activity 1:
Observing and measuring

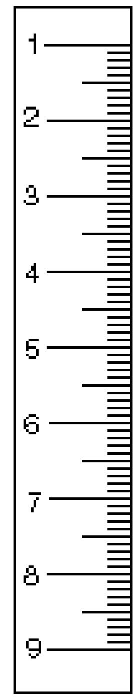


Learning how to measure plants is a basic plant science skill, and one that can be challenging for small fingers! This activity gives younger children the opportunity to practice this skill before they measure live plants in lab.

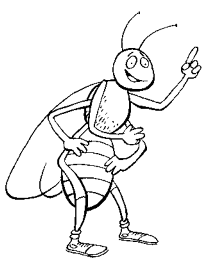
Photocopy the drawing which appears on page 1 and the ruler at the right of this column.

Students can practice measuring plant height with their drawing using the ruler. Measure from soil level to tip of bud. Then, they can find the range and average of the heights.

After your class gets the hang of plant measuring, students can color or paint their Fast Plant pictures and you can have a Fast Plants Gallery opening!



Metric ruler



Activity 2:
Analyzing and predicting

1. Pick a small (approximately 20%) random sample of students from your class. Measure each student; calculate the average height and range from tallest to shortest.
2. Now, make a prediction: do you think the variation as expressed in average and range of height for the sample will accurately predict the average and range for the full class?
3. If you wish, select another random sample of students. Is the average height and range of this sample different from the first group? If you combine the data from both samples, will your prediction of variation among the entire class improve?
4. Measure all of the students and calculate the class mean and range. How accurate were each of your samples? Was the combined data from both samples more accurate in predicting the variation of the total class than either sample used alone? Organize the class data into a frequency histogram.
5. Finally, do you think the variation in student height in your classroom is typical for all students in the same grade in your school? How confident are you of your prediction? (____ very ____ somewhat ____ not confident) How could you improve your prediction further?