Lab Report: Genetics Lab

TS Biology | Winter 2022

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Introduction:
Inheritance is the way organisms' traits are passed from one generation to the other. Gregor Mendel discovered dominant and recessive inheritance, in which the dominant allele masks the effect of the recessive allele located on the same locus. Different combinations of genes, each with their own alleles, can be crossed in a Punnett square to predict the probabilities of genotypes, and thus phenotypes, of the offspring.

In this genetic lab experiment, we explored Mendelian genetics by observing the inheritance of the plant *Brassica rapa*. Our main question was: do the stem color (*ANL* gene) and stem height (*ROS* gene) genes of *B. rapa* follow the rules of Mendelian genetics? We grew P1, F1, and F2 generations of the *B. rapa* plants and observed the inheritance patterns to conclude whether or not they followed the rules of Mendelian genetics. We knew beforehand that P1 and an unknown parent P2 mated to create the F1 offspring, and F1 self-fertilized to produce the F2 generation. Our goal was to observe the phenotypes of each of these generations as they grew in petri dishes and determine what the genotypes of each were.

Materials & Methods:

Materials:

- *Brassica rapa* P1 seeds
- *Brassica rapa* F1 seeds
- *Brassica rapa* F2 seeds
- Petri dishes
- Paper towel or similar absorbent paper
- Pipette
- Fluorescent lamp and bulb
- Dechlorinate Tap Water

Procedure:

1. Preparing seeds for germination
    a. Label the edge of the bottom side of the petri dishes: "P1", "F1" and "F2".

b. Place the paper towel in the lid of the petri dish and add water until it is completely soaked. Pour off any excess water not absorbed by the filter paper.
c. Place seeds on the paper, taking care of spreading them evenly.
d. Place the bottom of the petri dish and label—make sure to match seeds and labels.
e. Place the petri dish in a germination cup and add water until the water level reaches the edge of the paper towel (approx 1 cm) (Figure 1 in Appendix).
f. Place the cup approximately 7 inches below the lamp and place a "DO NOT TURN OFF LIGHT" sign.
g. Keep the cup at room temperature (22°C).

2. Germinating seed and Data collection
    a. Maintain the dishes under constant light and temperature (optional: monitor temperature in the room).
    b. Every 12 hours inspect the water level in the cup and check the filter paper for moisture—add water to the cup as needed. Do not let the paper dry out.
    c. Every 12 hours inspect the seedlings and record observations in the Data Collection Sheet. Take a picture of each dish.
3. Clean up
    a. Discard paper and seedlings as compostable.
    b. Discard dishes and cup as Recyclable waste.
    c. Lamp and bulb should be returned to the instructor.

Results:

Our group's data is shown in Table 1. We found that the plants in the P1 generation all had green stems, and there was a 24:4 ratio of standard height to rosette-dwarf stems. In the F1 generation, there was a 29:2 ratio of purple to non-purple stems, and a 30:1 ratio of standard height to rosette-dwarf stems. Figures 2A and 2B are images of the P1 and F1 generations.

In the F2 generation, there was a 27:4 ratio of standard height to rosette-dwarf stems, and a 24:7 ratio of purple to non-purple stems. Figure 2C is an image of the F2 generation plants.

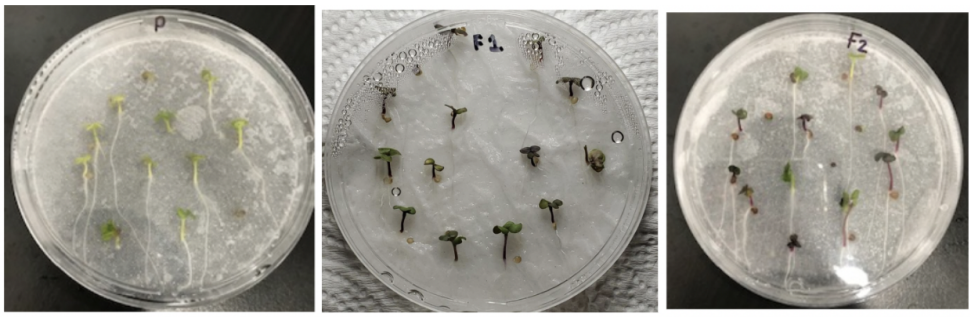
Table 1. Results for Height and Color of Plant Stems for Group Data

Generations	# of Rosette-Dwarf, Purple Stem	# of Rosette-Dwarf, Non-Purple Stem	# Standard Height, Purple Stem	# Standard Height, Non-Purple Stem

P1	0	4	0	24
F1	1	0	28	2
F2	3	1	21	6

Table 1 shows our group's P1, F1, and F2 generation plant stems' heights and colors at 96 hours. Rosette-Dwarf indicates a very short or no stem, and non-purple indicates either a green or white stem.

Figure 2. Images of P1, F1, and F2 plants at 96 Hours



2A 2B 2C

Figures 2A, B, and C show the P1, F1, and F2 generation plants, respectively, after 96 hours. In 2A, all the plants had standard height and green stems. In 2B, 12 plants had standard height and purple stems, and 1 plant was rosette-dwarf with a purple stem. In 2C, there was 1 rosette-dwarf and purple-stemmed plant, 8 plants with standard height and purple stem, and 4 plants with standard height and non-purple stem.

For the class data, Table 2 shows that the P1 generation did not have any purple stems, and there was a 153:17 ratio of standard height to rosette-dwarf stems. Conversely, the F1 generation consisted almost entirely of purple-stemmed plants. It had only 15 non-purple stems. There was a 134:37 ratio of standard height to rosette-dwarf stems. In the F2 generation, there was a 155:47 ratio of purple to non-purple stems. There was a 129:73 ratio of standard height to rosette-dwarf stems. Figure 3 illustrates this data and helps visualize the difference in the values.

Table 2. Results for Height and Color of Plant Stems for Class Data

Generations	# of Rosette-Dwarf, Purple Stem	# of Rosette-Dwarf, Non-Purple Stem	# Standard Height, Purple Stem	# Standard Height, Non-Purple Stem
P1	0	17	0	153
F1	33	4	123	11

F2	57	16	98	31

Table 2 shows our class's P1, F1, and F2 generation plant stems' heights and colors at 96 hours. Rosette-Dwarf indicates a very short or no stem, and non-purple indicates either a green or white stem.

Figure 3. Results of Stem Heights and Color for Class Data

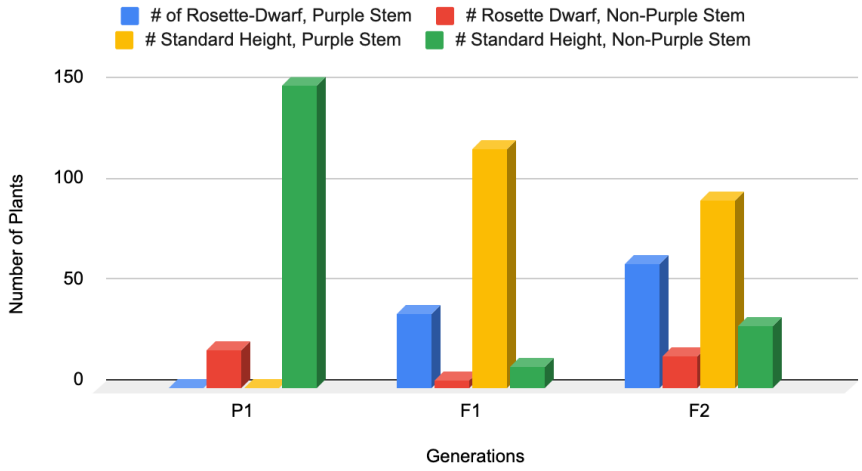


Figure 3 is a bar graph of our class's data, as given in Table 2.

Discussion and Conclusion:

In this lab, we explored whether or not the *B. rapa* plant follows Mendelian genetics. The purpose of the lab was to examine and determine the genotypes of three generations of *B. rapa* plants to answer this question. We analyzed our group's data to answer the research question. The *B. rapa* plants do follow Mendelian genetics, as a dominant/recessive mode of inheritance was observed.

We analyzed two genes in this experiment: stem color (purple or non-purple) and stem height (standard or rosette-dwarf). Because F1 and F2 were made up of mostly purple standard height plants, we concluded that the purple allele is dominant to the non-purple allele and the standard height allele is dominant to the rosette-dwarf allele. We can use *P* to represent the purple allele and *p* for the non-purple allele. Similarly, we use *H* to represent the standard-height allele and *h* for the rosette-dwarf allele.

Two different parents mated to form F1 offspring. First was P1 and the second was P2, an unknown parent. To determine the genotype of P1, we use the fact that there were no purple plants in the P1 generation. Because the non-purple allele is recessive, the genotype is homozygous recessive: *pp*.

In the F2 generation, the ratio of phenotypes (purple standard height: purple rosette-dwarf: non-purple standard height: non-purple rosette-dwarf) was 21:3:6:1. This can be approximated to 18:6:6:2, or 9:3:3:1. We know that F1 seeds mated with themselves to form the F2 generation. Based on the dihybrid cross principle in Mendelian genetics, if the ratio of phenotypes of F2 is 9:3:3:1, the genotype of F1 must be heterozygous. So, the genotype of F1 is *PpHh*. From this, we can conclude that because we established that P1 is *pp*, P2 must be *PP* so that all offspring (F1) are heterozygous for the color gene (*Pp*). As for the height genes on P1 and P2, we know that they must cross in such a way that 100% of offspring (F1) are *Hh*. The only combination that ensures this is crossing *HH* and *hh*. And since most of the P1 plants had a standard height, it must carry *HH* and thus P2 must be *hh*. Combining what we have thus far, we know that P1 is *ppHH*, P2 is *PPhh*, and that F1 is *PpHh*. A Punnett square that crosses F1 with itself can support this analysis by demonstrating the 9:3:3:1 ratio of phenotypes in the F2 generation.

	PH	**Ph**	**pH**	**ph**
PH	PPHH	PPHh	PpHH	PpHh
Ph	PPHh	PPhh	PpHh	Pphh
pH	PpHH	PpHh	ppHH	ppHh
ph	PpHh	Pphh	ppHh	pphh

From the genotypes in the Punnett square, we can determine that there are 9 purple, standard height; 3 purple, rosette-dwarf; 3 non-purple, standard height; 1 non-purple, rosette-dwarf plants. This matches the ratio of phenotypes observed in F2, and thus our analysis of the genotype of F1 is correct.

Our analysis can be used for the class data as well. For the F2 results in the class data, the ratio was 98:57:31:16, which can be approximated to 90:30:30:10, or 9:3:3:1. Additionally, there were no purple stem plants in the P1 generation, and almost all standard height purple plants in the F1 generation. All this information matches our group's data, meaning it can be used to attain the same analysis that was derived.

Overall, our results are conclusive evidence to determine that the mode of inheritance is complete dominance and recessiveness - this is determined due to the fact that the purple and standard height traits are the most common in the F1 and F2 generations meaning they are dominant. Additionally. incomplete dominance and codominance can be eliminated because no plant stems had two colors or an intermediate between colors.

As a follow-up experiment, we can let the three generations of *B. rapa* grow to adult plants and observe different phenotypes, like the number of leaves and the shape of the leaves. We can determine the genotypes and the modes of inheritance for these phenotypes. Another follow up experiment could be performing our genetics lab for close relatives of *B. rapa*, such as species within the same plant family, to see if they match this experiment's conclusions.

Overall, this experiment helps observe Mendelian genetics in the passing of traits to offspring. Specifically, it proves that dominant/recessive relationships are present in a particular plant species. The experiment also displays the 9:3:3:1 phenotypic ratio in the F2 generation from a dihybrid cross, as per Mendelian genetics.

Appendix:

Figure 1. Image of Petri Dishes Placed in the Cup with Water

Figure 1 shows the 3 petri dishes placed in the cup with water, as per step 1e of the procedure.