The Green Revolution of the late 1950s marked the advancement of agriculture technology and the development of high-yield crops became a priority in agriculture. In tropical Asia, the Green Revolution helped farmers to solve the problem of the brown planthopper (BPH), an insect pest that devastates rice crops. Prior to the Green Revolution the population density of the brown planthopper was naturally regulated by a variety of native predators, including spiders and insects. Although the development of rice cultivars and GMOS, synthetic fertilizers, and synthetic pesticides advertised increased production, farmers are facing larger problems than ever before. In fact, the end result was that an initial strategy to increase rice yields and avert crop failure has had the exact opposite effect.

New strains of rice plants were developed that produced higher yields when used with commercial fertilizer as they were selected to devote more resources to growth than other cellular processes (Evenson & Gollin, 2003). The main ingredients of the fertilizer are nitrogen (N), phosphorus (P), and potassium (K), These nutrients are vital macronutrients needed by producers, but they also have a profound effect on the herbivores feeding on plants. For example, nitrogen is one of the most important performance limiting factors of herbivores and phosphorus is needed by insect herbivores in addition to nitrogen to synthesize their proteins.

An experiment was conducted using potted rice plants that were fertilized with three levels of each nutrient commonly used in agricultural applications and was replicated four times. Brown plant hoppers (BPH) were systematically introduced to the rice plants. The amount of feeding by BPH was measured indirectly by the quantity of honeydew secretion collected in a feeding chamber. Honeydew is excreted as a byproduct from insects that feed on plant sap. The results of the experiment can be found in Figure 1.



**Figure 1**: Effect of nutrient concentration on the amount of honeydew excreted. The three nutrients were those most commonly used in synthetic fertilizer: nitrogen (A), phosphorus (B), and potassium (C).

Silicon (Si) is a nutrient used by plants that has been shown to boost plant defense mechanisms such as making more toxic compounds as well as making the plant tougher and harder to graze upon (Guntzer *et al.,* 2012). Application of the nutrients N and K was found to decrease the Si content in rice plants significantly, but remain unaffected with the application of P. This decreasing rate of Si was more than 50% with N application and about 11% with K.

**Discussion Questions**

**PART 1**

1. Briefly describe the two mechanisms that contribute to the success of brown planthopper infestation when nitrogen fertilizer is used.
2. Why would the researchers measure the amount of honeydew versus the amount of plant material eaten (or any other metric)?
3. As a farmer, what would be the best combination of fertilizer nutrients to use knowing how they affect planthoppers? Consider both the graph and the information presented in the article.
4. Identify any words, topics, acronyms, etc. that you did not know or understand from the introduction. In addition, use the space below to write **one** question that relates to the information presented.

**PART 2**

The data in table 1 below from Rashid et al. (2016) shows the effect of nitrogen treatments. where N0 = no nitrogen, N100 =100Kg/hm2 and N200=200kg/hm2, on plant damage caused by BPH, where 0 is no damage and 9 is plant death. Using the data in the table build and XY graph below showing the correlation between nitrogen and plant damage. Use a different data series for each of the nitrogen treatments.

 Time(days)

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Nitrogen | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| N0 | 0 | 0 | 0 | 0.5 | 1.5 | 2.2 | 3.8 | 5 | 7 | 8 | 9 |
| N100 | 0 | 1 | 2.5 | 4.2 | 6.2 | 8.0 | 9 |  |  |  |  |
| N200 | 0.8 | 2.1 | 4.2 | 6.2 | 8.2 | 9 |  |  |  |  |  |



Describe in your own words the data in the graph. Based on the data, what is the effect of adding nitrogen as a fertilizer on plant damage by BPH? What is the trend on plant damage through time as N concentration increases?

**PART 3**

In nature changes in predator and prey density oscillate and track each other. Using the Lotka and Volterra model for predator-prey interactions answer the following questions:

1. Play around with the model changing one of the parameters at a time and record below the effect on the amplitude of the oscillation, i.e. changes in density for predator and prey (do not change the initial population density of the predator and the prey).

2. Based on the data shown in figure 1, what coefficients in the model would be affected and how by the use N as a fertilizer? Explain your answer. Based on your answer change the coefficients and explain the outcomes.

3. Similarly what coeficient in the model would be the affected by changes in Si in the presence and absence of N fertilizer?

4. Under what conditions do predator and prey subsist at a stable equilibrium Under what conditions does the model crash, i.e. either the predator or the prey are extinguished. Explain your answers.

**References**

Evenson, R. E., & Gollin, D. (2003). Assessing the Impact of the Green Revolution, 1960 to 2000. *Science, 300*(5620), 758-762.

Guntzer, F., Keller, C., Meunier, J-D. (2012). Benefits of plant silicon for crops: a review. *Agronomy for Sustainable Development, 32*(1), 201-213.

Rashid, M.M., Jahan, M., Islam, K.S. (2016). Impact of Nitrogen, Phosphorus, and Potassium on Brown Planthopper and Tolerance of its Host Rice Plants. *Rice Science, 23*(3), 119-131. \*\*Most of this activity is excerpts from this paper.