Notes 5 – Activity – Intro to Latin Square Designs Name/Date:

The word of your budding expertise in experimental design is spreading, and you have been called upon to help a farmer plan an experiment on her corn field. The farmer has five different fertilizers, and she wants to know which will work best (produce the greatest corn yield) for her farm. She has broken her farm into a 5 by 5 grid as pictured below.



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There are many different ways that you could assign the five fertilizers to these 25 plots of land, so how do you decide which is the best? Remember, **your goal is to help the farmer accurately decide which fertilizer(s) to use or not use**.

For each of the methods below, you can use the link that has been provided on the course Moodle page to apply fertilizers to the field and to observe the pounds of corn that are produced on each of the 25 plots of land.

**Method 1: Apply the fertilizers to the columns of the plots.**

Typically, the farmer applies fertilizer by going down each of the columns in order from left to right. Thus, one of the methods that will be simplest for the farmer to execute is to just provide the same fertilizer to an entire column of the field and then apply another fertilizer to the next column, and so on. Carry out a test where the columns from left to right receive fertilizers A, B, C, D, and E respectively.

To do this, you will enter: ABCDE into each blank on the link.

For each of the fertilizers, fill in the average yield from that fertilizer, and calculate the estimated effect (fertilizer mean minus grand mean).

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| --- | --- | --- |
| **Fertilizer** | **Average Yield** | **Estimated Effect**  **From Fertilizer** |
| **A** |  |  |
| **B** |  |  |
| **C** |  |  |
| **D** |  |  |
| **E** |  |  |

Based on ***this*** experiment, which fertilizer(s) would you suggest the farmer use for her whole field in the future?

Based on ***this*** experiment, which fertilizer(s) would you suggest the farmer **not** use in the future?

What is a possible problem (hint: confounder) with this method? Discuss with those around you.

**Method 2: Apply the fertilizers randomly to the plots.**

One of the bedrocks of statistics is that we should always randomize when possible. In method 1, the treatment assignments were not randomized. For method 2, you will randomly assign each of the fertilizers to five plots on the field with no other restrictions. Choose the “Random” option available from the dropdown menu to do this.

Record the resulting treatment assignments below. In other words, fill in the letters under “Your Fertilizer Assignments”

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What do you notice about the fertilizer assignments that you ended up with? Are there any patterns? Check with people near you to see if their assignments are similar to / different from yours.

Do you think your assignment will give you an accurate assessment of the effectiveness of each fertilizer? Why or why not?

Record the average yields for each of the five fertilizers below along with the estimated effect (fertilizer mean minus grand mean).

|  |  |  |
| --- | --- | --- |
| **Fertilizer** | **Average Yield** | **Estimated Effect**  **From Fertilizer** |
| **A** |  |  |
| **B** |  |  |
| **C** |  |  |
| **D** |  |  |
| **E** |  |  |

Based on ***this*** experiment, which fertilizer(s) would you suggest the farmer for use her whole field in the future?

Based on ***this*** experiment, which fertilizer(s) would you suggest the farmer **not** use in the future?

How do your estimated effects from this method compare to what you estimated using method 1? Which method do you think is better? Why?

What is a possible problem with this method? Discuss with those around you.

**Method 3: Apply the fertilizers using a new design called a Latin Square.**

Below is an example of what is known as a Latin Square design.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **A** | **B** | **C** | **D** | **E** |
| **B** | **C** | **D** | **E** | **A** |
| **C** | **D** | **E** | **A** | **B** |
| **D** | **E** | **A** | **B** | **C** |
| **E** | **A** | **B** | **C** | **D** |

Observe the Latin Square design above. How many times does each fertilizer appear in each row? How many times does each fertilizer appear in each column? Why might this set-up be desirable?

Change the treatment assignment method back to “User-Defined” and enter the treatment assignment above to observe the yields for this Latin Square Design.Complete the following table with your results from this design.

|  |  |  |
| --- | --- | --- |
| **Fertilizer** | **Average Yield** | **Estimated Effect**  **From Fertilizer** |
| **A** |  |  |
| **B** |  |  |
| **C** |  |  |
| **D** |  |  |
| **E** |  |  |

Based on ***this*** experiment, which fertilizer(s) would you suggest the farmer for use her whole field in the future?

Based on ***this*** experiment, which fertilizer(s) would you suggest the farmer **not** use in the future?

How do your estimated effects from this method compare to what you estimated in the previous two methods? Which method do you think is best for determining the best/worst fertilizer? Why?

**Looking at the “true” yields**

Choose “User-Defined” form the dropdown menu and for each row, enter: xxxxx

This will show you the “true” yield of the field if no fertilizer is used. What do you notice about the yields of the plots? Why wasn’t a completely random treatment assignment a good choice for this experiment?

How did using a Latin Square design help address the deficiencies of the random treatment assignment?

There are no real row effects in this data (only column effects), so the Latin Square design wasn’t *completely* necessary. Thus, if you had randomly assigned treatments to rows in this case, you would have been okay. But what are the chances you would know this in advance? If there were both row and column effects or the potential for both, why would the Latin Square design be the most desirable experimental design?