Hort/Agron 603
Practice Problems 2
Sampling, Factorials, Split-plots etc.

Write out the ANOVA (Source and df) for the experiments described below. Indicate the F tests on the fixed model, unless stated otherwise.

1. In an experiment with cabbage, 2 plants were sampled from each of 4 varieties. 3 leaves were taken from each plant, 2 samples were taken from each leaf and 2 determinations were made on each sample. Write out the components of variance for this experiment and indicate F tests on the random model.

2. An experiment was installed to test the response of 4 varieties of Zinnia to 3 levels of N and 4 seed treatments. Varieties were the mainplots, N was the subplots, and seed treatments were the subsubplots. 3 blocks were installed.

3. An experiment was installed with orchids growing in pots on a greenhouse bench. There was one plant per pot and the data collected were the number of flowers produced.

    a. Three varieties are treated with 6 types of fertilizer, and the data were collected form 2 pots (samples) per variety.
    b. The same as a, but the 2 pots are arranged in replicates.
    c. The same as b, but the 6 types of fertilizer represent 2 N treatments and 3 K treatments in complete factorial arrangement. Write out all main effects and interactions.

4. An experiment with guava was installed in a Latin square design with 2 varieties, 2 pruning methods and 2 rates of fertilizer in factorial combination. Be sure to write out all main effects and interactions.

5. An experiment was installed with sugarcane in which 3 levels of lime, 3 levels of P, and 3 levels of Zn were evaluated in factorial combination. 4 blocks were installed.

    a. Write out ANOVA for experiment installed in RCB design.
    b. Write out ANOVA for experiment installed in a split plot design with lime as the mainplots and the P x Zn treatment combinations as the subplot.
    c. Write out ANOVA for experiment installed in a split-split-plot design with lime as the mainplots, P as the subplots and Zn as the subsubplots.
    d. For <u>each of the designs above</u>, sketch two blocks of the field layout. In one block identify the plots clearly and randomize the treatments. In the second block, indicate the sources of variation with arrows.

6. An experiment was installed as a split block with varieties in one direction and K in the other direction. 3 blocks were installed.

    a. Sketch the field layout for all blocks and show the treatments randomized in the

plots.

b. Write out the analysis of variance table.

7. Please write your interpretation of the experimental results below. What recommendation would you make to the farmer regarding the variety of sorghum to use and the rate of N? Please give reasons for your recommendations.

| Source of Variation | df | MS |
|---|---|---|
| Blocks | 3 | 105* |
| Treatments | (5) | 650* |
| N | 1 | 150 |
| Variety (V) | 2 | 300* |
| N x V | 2 | 200** |
| Error | 15 | 30 |
| Total | 23 | 785 |

Table of mean sorghum yields

Varieties

| N Trt | V1 | V2 | V3 | N Means |
|---|---|---|---|---|
| N25 | 10c | 22ab | 20b | 17.3 |
| N50 | 25a | 25a | 10c | 20.0 |
| V Means | 17.5B | 23.5A | 15.0B | |

Means followed by the same letters are not significantly different at the 0.05 probability level according to Duncan's Multiple Range test.

Answers to Practice Problems #2
Sampling, Factorials and Split Plots, etc.

1.

| Source | df | |
|---|---|---|
| Bet Var | 3 | v-1 |
| Bet Plt/V | 4 | (p-1)v |
| Bet Lvs/P/V | 16 | (l-1)vp |
| Bet smpl/L/P/V | 24 | (s-1)vpl |
| Bet Det/S/L/P/V | 48 | (d-1)vpls |
| Total | 95 | (vplsd)-1 |

2.

| Source | df | |
|---|---|---|
| Total | 143 | |
| MP | (11) | |
| B | 2 | |
| V | 3 | |
| B*V (Error a) | 6 | (b-1)(v-1) |
| N | 2 | |
| N*V | 6 | |
| Error b | 16 | (b-1)[(n-1)+(n-1)(v-1)] |
| ST | 3 | |
| ST*V | 9 | |
| ST*N | 6 | |
| ST*V*N | 18 | |
| Error c | 72 | (b-1)[(st-1)+(st-1)(v-1)+(st-1)(n-1)+(st-1)(v-1)(n-1)] |

3a. Completely Randomized Design

| Source | df |
|---|---|
| Total | 35 |
| Bet. Trts | (17) |
| V | 2 |

| | | |
|---|---|---|
| F | 5 | |
| V*F | 10 | |
| Within Trts | 18 | (s-1)(vf) |

3b. Randomized Complete Block Design

| Source | df | |
|---|---|---|
| Total | 35 | |
| Rep | 1 | |
| Trts | (17) | |
| V | 2 | |
| F | 5 | |
| V*F | 10 | |
| Error | 17 | (r-1)(t-1) |

3c. Randomized Complete Block Design

| Source | df | |
|---|---|---|
| Total | 35 | |
| Rep | 1 | |
| Trts | (17) | |
| V | 2 | |
| F | (5) | |
| N | 1 | |
| K | 2 | |
| N*K | 2 | |
| V*F | 10 | |
| V*N | 2 | |
| V*K | 4 | |
| V*N*K | 4 | |
| Error | 17 | (r-1)(t-1) |

4. 2Var x 2Pruning Methods x 2Fert Rates = 8 treatment combinations. Therefore, use an 8x8 latin square design.

| Source | df |
|---|---|
| Total | 63 |

| | | |
|---|---|---|
| Rows | 7 | |
| Col | 7 | |
| Treatment | (7) | |
| Var | 1 | |
| PM | 1 | |
| FR | 1 | |
| Var*PM | 1 | |
| Var*F | 1 | |
| Pm*F | 1 | |
| Var*PM*F | 1 | |
| Error | 42 | (r-1)(c-2) |

5a. RCB

| Source | df | |
|---|---|---|
| Total | 107 | |
| Blocks | 3 | |
| Treatments | (26) | |
| Lime | 2 | |
| P | 2 | |
| L*P | 4 | |
| Zn | 2 | |
| Zn*L | 4 | |
| Zn*P | 4 | |
| Zn*P*L | 8 | |
| Error | 78 | (b-1)(t-1) |

5b. Split-plot, L=MP, P*Zn=SP

| Source | df |
|---|---|
| Total | 107 |
| MP | (11) |
| Block | 3 |
| Lime | 2 |
| B*L (Error a) | 6 |

| | | |
|---|---|---|
| P | 2 | |
| Zn | 2 | |
| P*Zn | 4 | |
| P*L | 4 | |
| Zn*L | 4 | |
| P*Zn*L | 8 | |
| Error b | 72 | (b-1)[(p-1)+(zn-1)+(p-1)(zn-1)+(p-1)(l-1)+(zn-1)(l-1)+(p-1)(zn-1)(l-1)] |

5c. Split-split plot, L=MP, P=SP, Zn=SSP

| Source | df | |
|---|---|---|
| Total | 107 | |
| MP | (11) | |
| Blocks | 3 | |
| Lime | 2 | |
| B*L (Error a) | 6 | |
| P | 2 | |
| P*L | 4 | |
| Error b | 18 | (b-1)[(p-1)+(p-1)(l-1)] |
| Zn | 2 | |
| Zn*L | 4 | |
| Zn*P | 4 | |
| Zn*P*L | 8 | |
| Error c | 54 | (b-1)[(zn-1)+(zn-1)(l-1)+(zn-1)(p-1)+(zn-1)(p-1)(l-1)] |

5d. Refer to handouts of the various designs.

6a. Refer to handout for the split-block design. Use 3 varieties and 4 levels of K.

6b. Analysis of Variance

| Source | df | |
|---|---|---|
| Total | 35 | |
| Blocks | 2 | |
| Var | 2 | |
| B*V (Error a) | 4 | (b-1)(v-1) |
| K | 3 | |
| Error b | 6 | (b-1)(k-1) |
| V*K | 6 | |
| Error c | 12 | (b-1)[(v-1)(k-1)] |

7. Interpretation of ANOVA and means.

Since Variety and the N*V interaction are significant and highly significant, respectively, one should interpret the results based on the interaction rather than on the main effects. One could plot the interaction to help understand it, but in this case with only 2 levels of N, it is fairly easy to see what is going on by studying the table of means. At the low rate of N, V2 and V3 have comparable yields that are significantly higher than the yields of V1. At the high rate of N, V1 and V2 have comparable yields that are significantly higher than the yields of V3 at both rates of N. If the farmer has adequate resources to apply the high rate of N, either V1 or V2 could be grown. V2 or V3 may be selected for growth with low N since their yields were not significantly different. V2 appears to be the best variety because it has high yields at both rates of N and its average yield is significantly higher than those of V1 and V3.