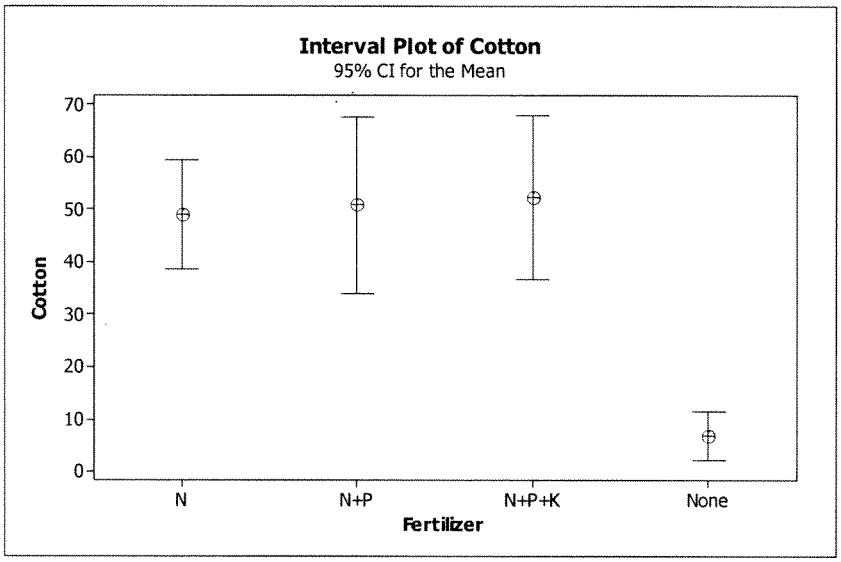
Statistical Ecology
Stat 555

Randomized Block Designs

Purpose: To determine the effects of fertilizer treatments on cotton grass in five tundra locations in northern Alaska

	Location				
Fertilizer	B	M	R	S	Q
None	10	6	11	2	5
N	58	45	55	50	37
N+P	63	43	68	41	39
N+P+K	63	47	63	43	40



Completely Randomized Design

```
MTB > ANOVA 'Cotton' = Fertilizer.
```

ANOVA: Cotton versus Fertilizer

```
Factor     Type Levels Values
Fertiliz   fixed      4     N   N+P N+P+K  None


Analysis of Variance for Cotton

Source      DF         SS         MS        F      P
Fertiliz     3     7241.8     2413.9    22.71  0.000
Error       16     1700.4      106.3
Total       19     8942.2
```

Model: $X = \mu + A + \varepsilon$

H_0: $A_1 = A_2 = A_3 = A_4$
H_A: at least one A different

Randomized Block Design

Model: $X = \mu + A + B + \varepsilon$

Fertilizers:
H_{01}: $A_1 = A_2 = A_3 = A_4$
H_{A1}: at least one A different

Blocks:
H_{02}: $\sigma^2_B = 0$
H_{A2}: $\sigma^2_B \neq 0$

```
MTB > ANOVA 'Cotton' = Fertilizer Location;
SUBC>   Random 'Location'.
```

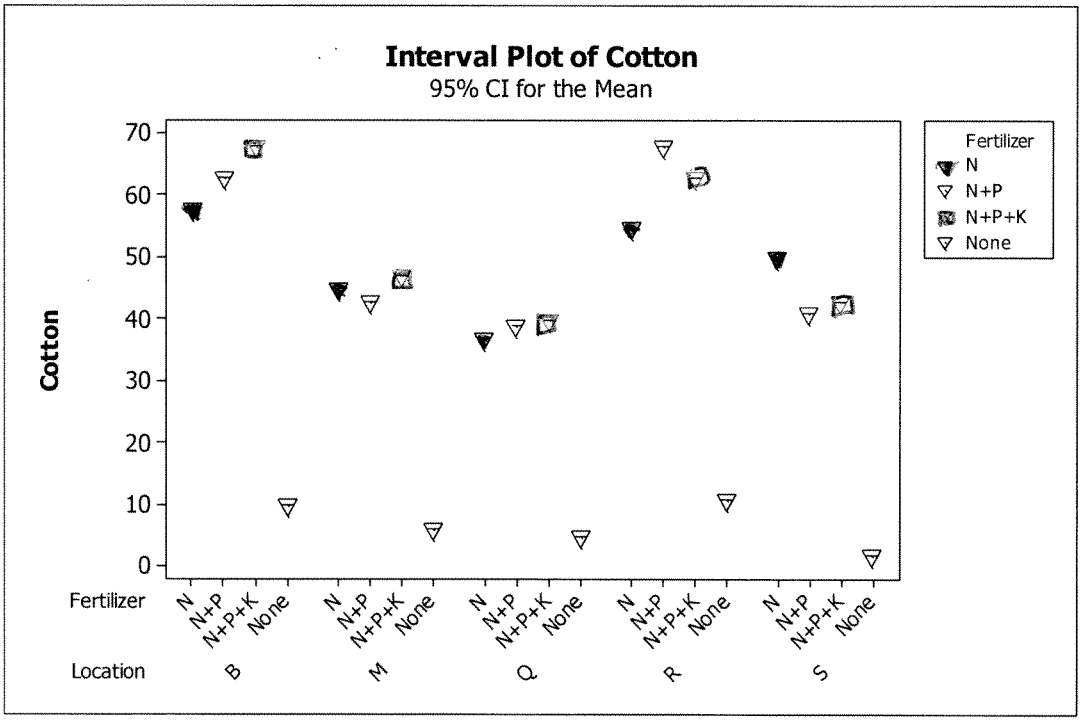
ANOVA: Cotton versus Fertilizer, Location

```
Factor      Type    Levels  Values
Fertilizer  fixed        4  N, N+P, N+P+K, None
Location    random       5  B, M, Q, R, S

Analysis of Variance for Cotton

Source      DF      SS      MS      F      P
Fertilizer   3  7241.8  2413.9  79.32  0.000
Location     4  1335.2   333.8  10.97  0.001
Error       12   365.2    30.4
Total       19  8942.2

S = 5.51664   R-Sq = 95.92%   R-Sq(adj) = 93.53%
```




```
MTB > %tukey c1 c2 c3
Executing from file: C:\Program Files\Minitab 15\English\Macros\tukey.MAC
```

Tukey's 1 DF Test of Nonadditivity

```
SS(Nonadditivity):    193.575
SS(Error):            171.625
MS(Error):            15.602

Significance Level:    0.050
Test Statistic:       12.407
Critical Value:        4.844


The test statistic is greater than the critical value, so there is significant
evidence of interaction.
```

Relative Efficiency (Krebs, 1999)

$$RE = 100 \left(\frac{MS\,error_{CR}}{MS\,error_{RB}} \right) \frac{(n_1 + 1)(n_2 + 1)}{(n_1 + 3)(n_2 + 1)}$$

Where, n_1 = error df randomized block

n_2 = error df complete randomized

$$= 100 \left(\frac{1700}{365} \right) \frac{(12 + 1)(16 + 3)}{(12 + 3)(16 + 1)} = 451\% \text{ increase in efficiency}$$

Krebs, C. J. 1999. Ecological Methodology. 2nd Edition. Addison Westley & Benjamin Cummings. Pages 358-359.

Purpose: to determine the effects of grazers on marine algae in the Oregon intertidal zone (Olson, 1993, PhD OSU). (File: **Olson 1993.mpj**)

Data: A researcher scraped rocks free of seaweeds and observed seaweed regeneration across varying numbers of grazers excluded by cages. The grazers were limpets (L), small fishes (f) and large fishes (F). The treatments included:

LfF: all grazers present
fF: limpets excluded
Lf: large fish excluded
f: limpets and large fish excluded
L: small and large fish excluded
C: all grazers excluded

Because the responses of seaweed growth to grazers was likely to vary across the intertidal zone, the researcher applied eight blocks of 12 plots each. Blocks covered a wide range of tidal conditions. Within each block she randomly assigned treatments to plots so that each treatment was applied to two plots. (from Ramsey, F. and D. W. Schafer. 2002. The Statistical Sleuth. 2nd Edition. Duxbury Press.)

```
MTB > ANOVA  C4 = Treatment!Block.
```

ANOVA: C4 versus Treatment, Block

```
Factor     Type   Levels  Values
Treatment  fixed       6  Control, L, Lf, LfF, f, fF
Block      fixed       8  1, 2, 3, 4, 5, 6, 7, 8

Analysis of Variance for C4

Source           DF       SS      MS      F      P
Treatment         5  48.6945  9.7389  56.31  0.000
Block             7  34.3239  4.9034  28.35  0.000
Treatment*Block  35   6.3087  0.1802   1.04  0.442
Error            48   8.3023  0.1730
Total            95  97.6294
```

Model: $X = \mu + A + B + AB + \varepsilon$

Treatment:
H_{01}: $A_1 = A_2 = A_3 = A_4 = A_5 = A_6$
H_{A1}: at least one A different

Blocks:
H_{02} $B_1 = B_2 = B_3 = B_4 = B_5 = B_6$
H_{A2} at least one B different

Treatment x Blocks:
H_{03} AB interaction not significant
H_{A3} AB interaction significant

.1 Six treatments excluding three kinds of intertidal grazers from regenerating seaweed on the Oregon coast