Slide 1

Regression with Dummy Variables
Analysis of Covariance (ANCOVA)

Slide 2

Sugar Beets and Nitrogen Example

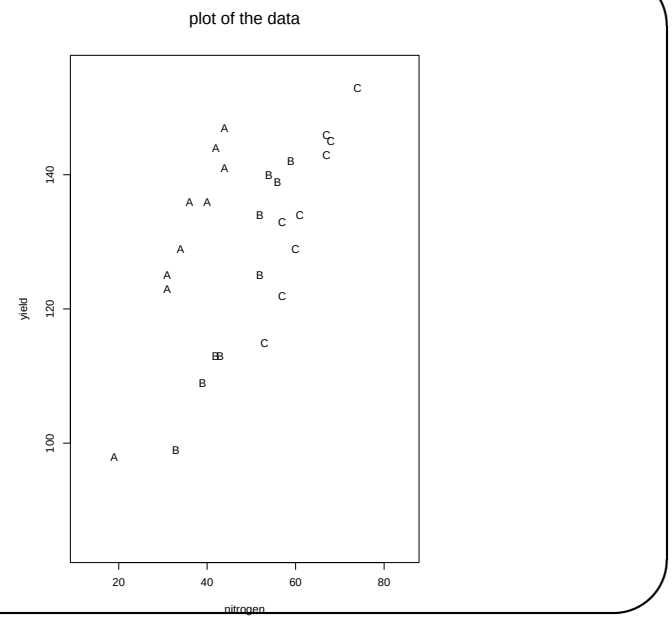
In a study of growth regulator for sugar beets, it was determined that there was substantial plot-to-plot variation in the level of available nitrogen. The amount of nitrogen in the soil can affect the yield of the beets in addition to an effect due to the growth regulators. After planting the sugar beets, the available nitrogen was measured from soil samples obtained from each plot. Since there is a lot of plot-to-plot variation in the amount available nitrogen, the experimenter wanted to be able to compare the effect of the growth regulators at specified levels of nitrogen. Thus, the available nitrogen in the soil is used as the covariate and dependent variable is the yield of the sugar beet roots per plot in pounds. The experimental design is a one-way treatment structure with three growth regulators (TRT) and 10 plots per treatment in a completely randomized design structure. The data are given below.

Slide 3

The Data

Growth Regulator (TRT)					
A		**B**		**C**	
yield	**nitrogen**	**yield**	**nitrogen**	**yield**	**nitrogen**
144	42	140	54	171	77
98	19	99	33	122	57
123	31	139	56	153	74
147	44	113	42	115	53
193	64	171	69	146	67
136	40	113	43	145	68
129	34	125	52	129	60
141	44	109	39	134	61
125	31	134	52	143	67
136	36	142	59	133	57
$\bar{y}_i = 137.2$		128.5		139.1	

Slide 4



Slide 5

Regression Approach with Dummy Variables

First, we define two dummy variables (z_1 and z_2) to account for **TRT**. Here, **TRT A** is used as the baseline.

$$Z_{i1} = \begin{cases} 1 & \text{if Regulator B is used for the } i\text{th plot;} \\ 0 & \text{Otherwise.} \end{cases}$$

$$Z_{i2} = \begin{cases} 1 & \text{if Regulator C is used for the } i\text{th plot;} \\ 0 & \text{Otherwise.} \end{cases}$$

Slide 6

SSE for Several Model Fits

Model	SSE
$y_i = \beta_0 + \beta_1 x_i + \beta_2\, z_{i1} + \beta_3\, z_{i2} + \beta_4\, x \cdot z_{i1} + \beta_5\, x \cdot z_{i2} + \varepsilon_i$	3,385.562
$y_i = \beta_0 + \beta_1 x_i + \beta_2\, z_{i1} + \beta_3\, z_{i2} + \varepsilon_i$	3,620.573
$y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$	10,946.458
$y_i = \beta_0 + \beta_1\, z_{i1} + \beta_2\, z_{i2} + \varepsilon_i$	13,236.600

It also can be found that $SST = 13,741.200$.

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Questions

1. Without adjusting for **nitrogen**, test the effect of growth regulator on sugar beet yield - ANOVA.
   ($F = .515$ and $F(.95, 2, 27) = 3.354$.)
2. After adjusting for **nitrogen**, test the effect of growth regulator on sugar beet yield - ANCOVA.
   ($F = 26.304$ and $F(.95, 2, 26) = 3.369$.)
3. Check to see whether ANCOVA is valid.
   ($F = .833$ and $F(.95, 2, 24) = 3.403$)