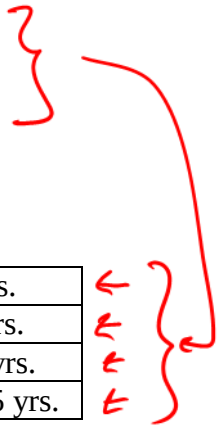
STAT 5200 Handout #20

Split Plot [and Strip-Plot] Example (Ch. 16)

Example 1 : Grass Clippings (as a Split Plot Design)

(From Example 14.1 in Kuehl (1994) Statistical Principles of Research Design and Analysis)

An experiment is carried out to assess the effects of two treatment factors (nitrogen source and years of thatch accumulation) on the chlorophyll content of grass clippings of golf greens. Nitrogen sources of interest are Urea, Ammonium Sulphate, IBDU, and Urea SC. Years of thatch accumulation levels of interest are 2, 5, and 8 years. Two separate locations (fields) are available for this experiment. Both fields are divided into four parts (whole-plot units), with each part receiving a randomly-assigned nitrogen source (with all nitrogen sources represented once in each field). Each part is divided into three regions, and the 3 regions in each part are randomly assigned to have thatch accumulate for a certain number of years (with all three levels of years of thatch accumulation represented once in each part).



Field #1 is divided with treatment assignments as follows (NSource @ Thatch):

Part #1: Urea	Urea @ 5 yrs.	Urea @ 8 yrs.	Urea @ 2 yrs.
Part #2: IBDU	IBDU @ 8 yrs.	IBDU @ 2 yrs.	IBDU @ 5 yrs.
Part #3: SCUrea	SCUrea @ 8 yrs.	SCUrea @ 5 yrs.	SCUrea @ 2 yrs.
Part #4: AmmSulph	AmmSulph @ 2 yrs.	AmmSulph @ 8 yrs.	AmmSulph @ 5 yrs.

Field #2 is divided with treatment assignments as follows (NSource @ Thatch):

Part #1: IBDU	IBDU @ 5 yrs.	IBDU @ 8 yrs.	IBDU @ 2 yrs.
Part #2: AmmSulph	AmmSulph @ 5 yrs.	AmmSulph @ 2 yrs.	AmmSulph @ 8 yrs.
Part #3: SCUrea	SCUrea @ 5 yrs.	SCUrea @ 2 yrs.	SCUrea @ 8 yrs.
Part #4: Urea	Urea @ 8 yrs.	Urea @ 2 yrs.	Urea @ 5 yrs.

The response variable is the chlorophyll content (mg/g) of the grass clippings from the sub-region of each field. (Chlorophyll content can be used to quantify the turfgrass canopy density; higher is more desirable on golf greens.)

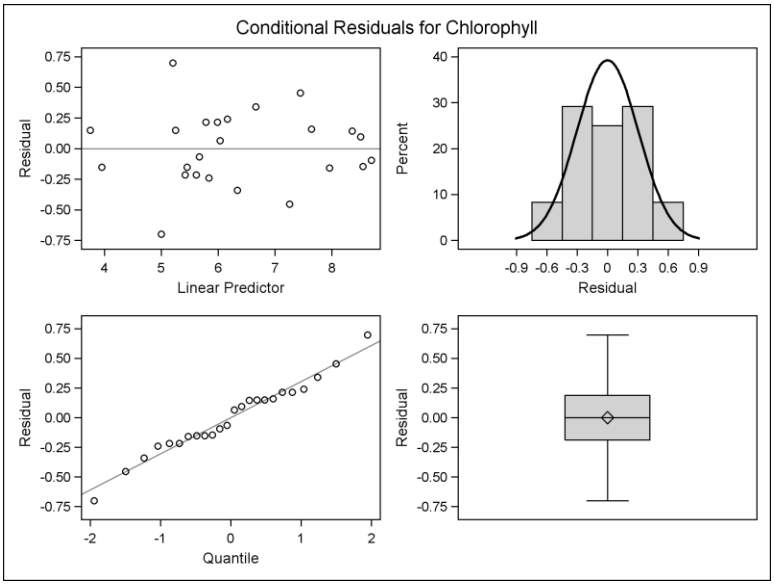
This is a split-plot design, with nitrogen source as the whole plot factor. At the whole-plot level, there is a randomized complete block (meaning the whole-plot units are randomly assigned to nitrogen source levels independently within block). Years of thatch is the split plot factor. (This is assigned to subregions [split-plot unit] within field part [whole-plot unit].)

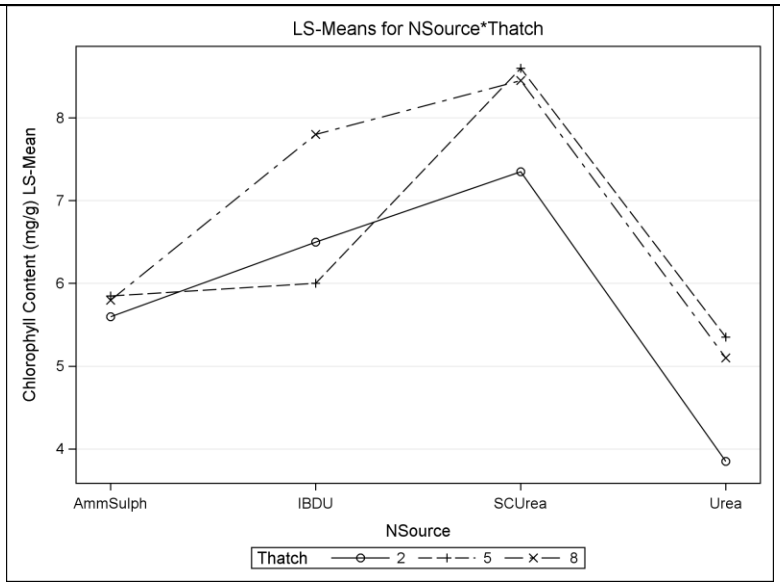
```
/* STAT 5200
   split plot design (with one whole-plot factor,
   one split-plot factor, and RCB at the whole-plot level;
   see text Example 16.4)
   grass data
 */



/* Read in data */
data grass;
  input NSource $ Field Thatch Chlorophyll @@;
  label NSource = 'Source of Nitrogen';
  label Thatch = 'Years of Thatch Accumulation';
  label Chlorophyll = 'Chlorophyll Content (mg/g)';
  cards;
  Urea      1  2  3.8  Urea      1  5  5.3  Urea      1  8  5.9
  Urea      2  2  3.9  Urea      2  5  5.4  Urea      2  8  4.3
  AmmSulph  1  2  5.2  AmmSulph  1  5  5.6  AmmSulph  1  8  5.4
  AmmSulph  2  2  6.0  AmmSulph  2  5  6.1  AmmSulph  2  8  6.2
  IBDU      1  2  6.0  IBDU      1  5  5.6  IBDU      1  8  7.8
  IBDU      2  2  7.0  IBDU      2  5  6.4  IBDU      2  8  7.8
  SCUrea    1  2  6.8  SCUrea    1  5  8.6  SCUrea    1  8  8.5
  SCUrea    2  2  7.9  SCUrea    2  5  8.6  SCUrea    2  8  8.4
  ;
run;



/* Fit this as a split-plot design, with NSource as the
   whole plot factor (and at the whole-plot level, there is
   a randomized complete block model) and  Thatch as the
   split plot factor.
   Use GLIMMIX to fit mixed model and
   look at nice interaction plots */
proc glimmix data=grass plots=residualpanel;
  class NSource Field Thatch;
  model Chlorophyll = NSource|Thatch;
  random Field Field*NSource;
  lsmeans NSource*Thatch /
     plot=mean(sliceby=Thatch join);
  lsmeans NSource Thatch NSource*Thatch /
          pdiff=all adjust=tukey lines;
  title1 'Grass Data as Split Plot Design';
  title2 '(Handout 20 Example 1)';
run; /* Note: could also look at CONTRAST here */
```

Convergence criterion (ABSGCONV=0.00001) satisfied.

Covariance Parameter Estimates		
Cov Parm	**Estimate**	**Standard Error**
Field	0.007593	0.06658
NSource*Field	0.06824	0.1196
Residual	0.2146	0.1073

Type III Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
NSource	3	3	29.67	0.0099
Thatch	2	8	8.89	0.0093
NSource*Thatch	6	8	3.23	0.0646





Tukey-Kramer Grouping for NSource Least Squares Means (Alpha=0.05)			
LS-means with the same letter are not significantly different.			
Source of Nitrogen	**Estimate**		
SCUrea	8.1333		A
IBDU	6.7667	B	A
AmmSulph	5.7500	B	C
Urea	4.7667		C

Tukey-Kramer Grouping for Thatch Least Squares Means (Alpha=0.05)			
LS-means with the same letter are not significantly different.			
Years of Thatch	**Estimate**		
8	6.7875		A
5	6.4500	B	A
2	5.8250	B	

Tukey-Kramer Grouping for NSource*Thatch Least Squares Means (Alpha=0.05)					
LS-means with the same letter are not significantly different.					
Source of Nitrogen	**Years of Thatch Accumulation**	**Estimate**			
SCUrea	**5**	8.6000		A	
SCUrea	**8**	8.4500		A	
IBDU	**8**	7.8000	B	A	
SCUrea	**2**	7.3500	B	A	C
IBDU	**2**	6.5000	B	A	C
IBDU	**5**	6.0000	B	D	C
AmmSulph	**5**	5.8500	B	D	C
AmmSulph	**8**	5.8000	B	D	C
AmmSulph	**2**	5.6000	B	D	C
Urea	**5**	5.3500		D	C
Urea	**8**	5.1000		D	C
Urea	**2**	3.8500		D	

Example 2: Grass Clippings (as a Strip Plot Design)

Same as Example 1, but here [fundamental change in design], suppose the field is divided into three strips, and the three strips in each field are each randomly assigned a level of thatch. (Note fundamental difference in here in how Thatch is assigned to strips rather than to regions within field.)

Field #1 is divided with treatment assignments as follows (NSource @ Thatch):

	Strip #1: 8 yrs.	Strip #2: 2 yrs.	Strip #3: 5 yrs.
Part #1: Urea	Urea @ 8 yrs.	Urea @ 2 yrs.	Urea @ 5 yrs.
Part #2: IBDU	IBDU @ 8 yrs.	IBDU @ 2 yrs.	IBDU @ 5 yrs.
Part #3: SCUrea	SCUrea @ 8 yrs.	SCUrea @ 2 yrs.	SCUrea @ 5 yrs.
Part #4: AmmSulph	AmmSulph @ 8 yrs.	AmmSulph @ 2 yrs.	AmmSulph @ 5 yrs.

Field #2 is divided with treatment assignments as follows (NSource @ Thatch):

	Strip #1: 8 yrs.	Strip #2: 5 yrs.	Strip #3: 2 yrs.
Part #1: IBDU	IBDU @ 8 yrs.	IBDU @ 5 yrs.	IBDU @ 2 yrs.
Part #2: AmmSulph	AmmSulph @ 8 yrs.	AmmSulph @ 5 yrs.	AmmSulph @ 2 yrs.
Part #3: SCUrea	SCUrea @ 8 yrs.	SCUrea @ 5 yrs.	SCUrea @ 2 yrs.
Part #4: Urea	Urea @ 8 yrs.	Urea @ 5 yrs.	Urea @ 2 yrs.

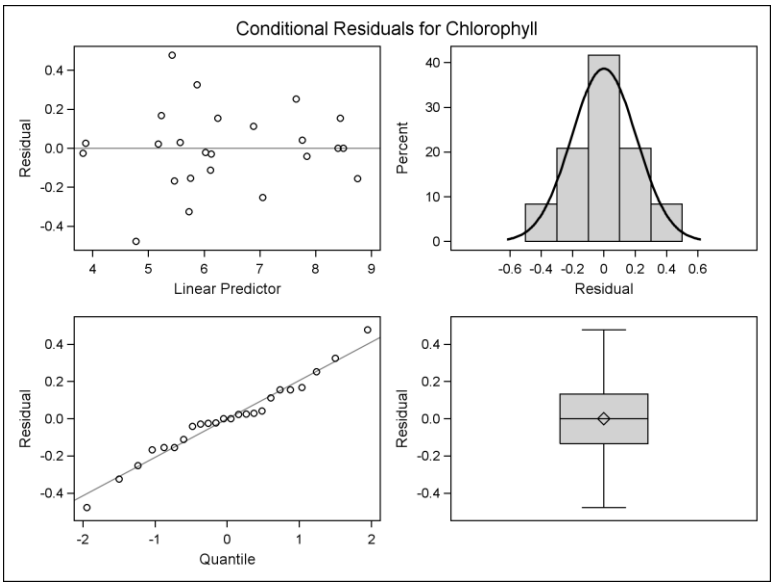
This is a strip-plot design (or a split block design) with nitrogen source as the whole plot factor and years of thatch as the split plot factor. There are two types of units here: field part (whole plot unit; randomized to NSource level) and field strip (strip plot unit; randomized to Thatch level). Because these two units cross, this is different from the split plot design in Example 1.

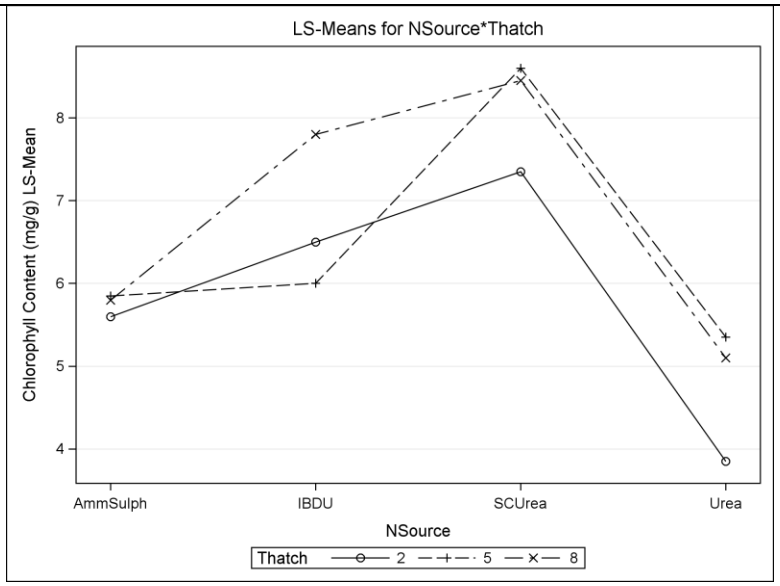
```
/* Fit this as a strip plot (split block) design, with
   NSource as the whole plot factor and Thatch as the split
   plot factor. The difference here is that we can have
   Thatch (the split plot factor) cross with a blocking
   factor.
 */
proc glimmix data=grass plots=residualpanel;
  class NSource Field Thatch;
  model Chlorophyll = NSource|Thatch;
  random Field Field*NSource Field*Thatch;
  lsmeans NSource*Thatch /
    pdiff=all adjust=tukey lines
     plot=mean(sliceby=Thatch join);
  title1 'Grass Data as Strip Plot Design';
  title2 '(Handout 20 Example 2)';
run;
```

Convergence criterion (GCONV=1E-8) satisfied.

Covariance Parameter Estimates		
Cov Parm	**Estimate**	**Standard Error**
Field	0	.
NSource*Field	0.09040	0.1039
Field*Thatch	0.07863	0.1000
Residual	0.1270	0.07390

Type III Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
NSource	3	3	31.24	0.0092
Thatch	2	2	4.32	0.1879
NSource*Thatch	6	6	5.45	0.0291





Tukey-Kramer Grouping for NSource*Thatch Least Squares Means (Alpha=0.05)						
Source of Nitrogen	**Years of Thatch**	**Estimate**	**LS-means with the same letter are not significantly different.**			
SCUrea	**5**	8.6000			A	
SCUrea	**8**	8.4500	B		A	
IBDU	**8**	7.8000	B		A	C
SCUrea	**2**	7.3500	B	D	A	C
IBDU	**2**	6.5000	B	D	A	C
IBDU	**5**	6.0000	B	D	E	C
AmmSulph	**5**	5.8500	B	D	E	C
AmmSulph	**8**	5.8000		D	E	C
AmmSulph	**2**	5.6000		D	E	C
Urea	**5**	5.3500		D	E	C
Urea	**8**	5.1000		D	E	
Urea	**2**	3.8500			E	