Yalcin YAVAS
April 3, 90

10

STAT 512
C. T. GASKINS

LATIN SQUARE

An experiment was conducted to measure the dry matter digestibility of 4 diets which varied in percent crude protein as follows:

A	11.0%
B	9.5%
C	8.0%
D	6.5%

The experiment consisted of 2 replicates (I and II) which were conducted at the same time. Within each replicate 4 cows were measured in each of 4 time periods. Each cow received every treatment once during the four time periods. Furthermore, at each time all four treatments were represented, each on a different cow. The data are as follows:

Rows total

Replicate I

Cows	TIME 1	2	3	4	Row total
1	A 48.5	B 48.5	C 44.7	D 42.9	184.6
2	B 48.1	A 47.1	D 40.1	C 43.9	179.2
3	C 45.4	D 44.1	B 45.9	A 47.1	182.5
4	D 42.2	C 46.9	A 48.0	B 46.2	183.3
	184.2	186.6	178.7	180.1	729.6

Treat. Totals

A	B	C	D
190.7	188.7	180.9	169.3
$\bar{x}$ = 47.7	47.2	45.2	42.3

Replicate II

Cows	TIME 1	2	3	4	Row total
5	A 50.1	B 44.7	C 44.3	D 41.3	180.4
6	B 49.3	D 40.0	A 48.8	C 44.8	182.9
7	C 45.4	A 49.1	D 41.7	B 46.7	182.9
8	D 41.1	C 47.8	B 45.5	A 48.2	182.6
	185.9	181.6	180.3	181.0	728.8

A	B	C	D
196.2	186.2	182.3	164.1
$\bar{x}$ = 49.05	46.6	45.6	41.0

Totals: 370.1 368.2 359.10 361.1

193.45 187.5 181.6 166.7

1. Give the linear model.

2. Give the null hypothesis for treatments.

3. Perform an analysis of variance for each replicate separately and for the combined replicates.

4. Analyze the trend in dry matter digestability due to crude protein.

5. What conclusions do you reach?
   Are the treatment differences similar in both replicates?
   Give the treatment means.

1) Linear Model

$Y_{ij}(t) = M + R_i + C_j + \gamma(t) + e_{ij}(t)$ → For single replicate

$Y_{ijk}(t) = M + R_i + C_j + S_k + \gamma(t) + e_{ijk}(t)$ → for combined replicate

M = overall mean
C_j = column effect
$\gamma(t)$ = treatment "
R_i = Row effect
S_k = square "
$e_{ijk}(t)$ = Error

2) $H_0: M_{11} = M_{9.5} = M_8 = M_{6.5}$

3) Replicate I

	Source	df	SS	MS	F	
	Total	15	90.56			
(%C.P)	Treat.	3	70.61	23.53	23.49	*
(Low)	Row	3	3.975	1.325	1.32	
(time)	Column	3	9.965	3.32	3.3	
	Error	6	6.01	1.002		

$SS\,T = \Sigma Y_{ij}^2 - C = 33360.3 - \frac{(729)^2}{16} = 90.56$

$SS(Tr.) = \Sigma \frac{Y(t)^2}{r} - C = 33340.4 - 33269.8 = 70.61$

$SS(Row) = \Sigma \frac{Y_{i.}^2}{r} - C = 33273.7 - 33269.8 = 3.975$

$SS(Column) = \Sigma \frac{Y_{.j}^2}{r} - C = 33279.7 - 33269.8 = 9.965$

$SS(E) = SS(T) - SS(Tr) - SS(R) - SS(C) = 6.01$

F table → $F_{.05;3,6} = 4.76$

Significant difference among treatments.

Replicate II

Source	df	SS	MS	F
Total	15	157.7		
Treat	3	134.91	44.97	15.94 *
Row	3	1.095	.365	.129
Column	3	4.775	1.59	.56
Error	6	16.925	2.82	

$SS(Tot) = 33354.5 - 33196.84 = 157.7$
$SS(TR) = 33331.7 - 33196.84 = 134.91$
$SS(R) = 33197.9 - 33196.84 = 1.095$
$SS(C) = 33201.6 - 33196.84 = 4.775$
$SS(E) = 16.925$

$F_{table} \rightarrow F_{.05,3,6} = 4.76$

Significant difference among treatment means.

Combined replicates

Source	df	SS	MS	F
Total	31	248.28	8.00	
Treat	3	205.52	68.5	53.52 *
Square	1	.02	.02	.016
Row	6 (3+3)	5.02	.84	.656
Column	3	10.85	3.62	2.83
Error	18	23.02	1.28	

? →

$\sqrt{SS(Tot)} = 66714.86 - 66466.58 = 248.28$
$\sqrt{SS(TR)} = 66672.1 - 66466.58 = 205.52$
$\sqrt{SS(R)} = 66470.6 - 66466.58 = 5.02$
$SS(C) = 66477.43 - 66466.58 = 10.85$

$$SS(square) = \frac{(\Sigma Y_{ij})^{2}_{(I)} + (\Sigma Y_{ij})^{2}_{(II)}}{n} - C = 66466.6 - 66466.58 = .02$$

$F_{table} \rightarrow F_{.05,3,18} = 3.16$

Significant difference among treatment means.

4) Replicate I

	df	A	B	C	D	$\Sigma c_i^2/n_i = (SS(Q))$
Linear	1	(-3) 190.7 + (-1) 188.7 + (1) 180.9 + (3) 169.3				$(-72)^2/80 = 64.8$
Quad.	1	(1) 190.7 + (-1) 188.7 + (-1) 180.9 + (1) 169.3				$-9.6^2/16 = 5.76$
Cubic	1	(-1) 190.7 + (3) 188.7 + (-3) 180.9 + (1) 169.3				$2^2/80 = .05$

EMS = 1.002

MS	F	F
64.8	64.8/1.002	64.7
5.76	5.76/1.002	5.75
.05	.05/1.002	.05

Replicate II

	df	A	B	C	D	$\Sigma c_i^2/n_i$
Linear	1	(-3) 196.2 + (-1) 186.2 + (1) 182.3 + (3) 164.1				$-100.5^2/80 = 126.3$
Quad	1	(1) 196.2 + (-1) 186.2 + (-1) 182.3 + (1) 164.1				$-8.2^2/16 = 4.2$
Cubic	1	(-1) 196.2 + (3) 186.2 + (-3) 182.3 + (1) 164.1				$-20.5^2/80 = 5.25$

EMS = 2.82

MS	F
126.3	
4.2	
5.25	

F Table → $F_{.05,1,6} = 5.99$

Significant linear and ~~quadratic~~ effects in Rep. I., whereas only linear significance in Rep. II.

5) There is a significant effect of % C.P. levels on % D.M. digestibility in both replicates & when combined, there is a significant effect of treatments but not row and column effects.
There effects were linear and quadratic in replicate I whereas there was a linear effect in Replicate II.

Means Treat.	Rep. I	Rep. II	Combined
A	47.7	49.05	48.38
B	47.2	46.6	46.9
C	45.2	45.6	45.4
D	42.3	41	41.65

LSD Rep. I: 42.3 | 45.2 | 47.2 | 47.7 — LSR = .75

Rep. II: 41 | 45.6 | 46.6 | 49.05 — LSR = 1.27

Treat. means are similar but LSD indicates that A & B not different in Rep. I, and B & C in Rep. II.