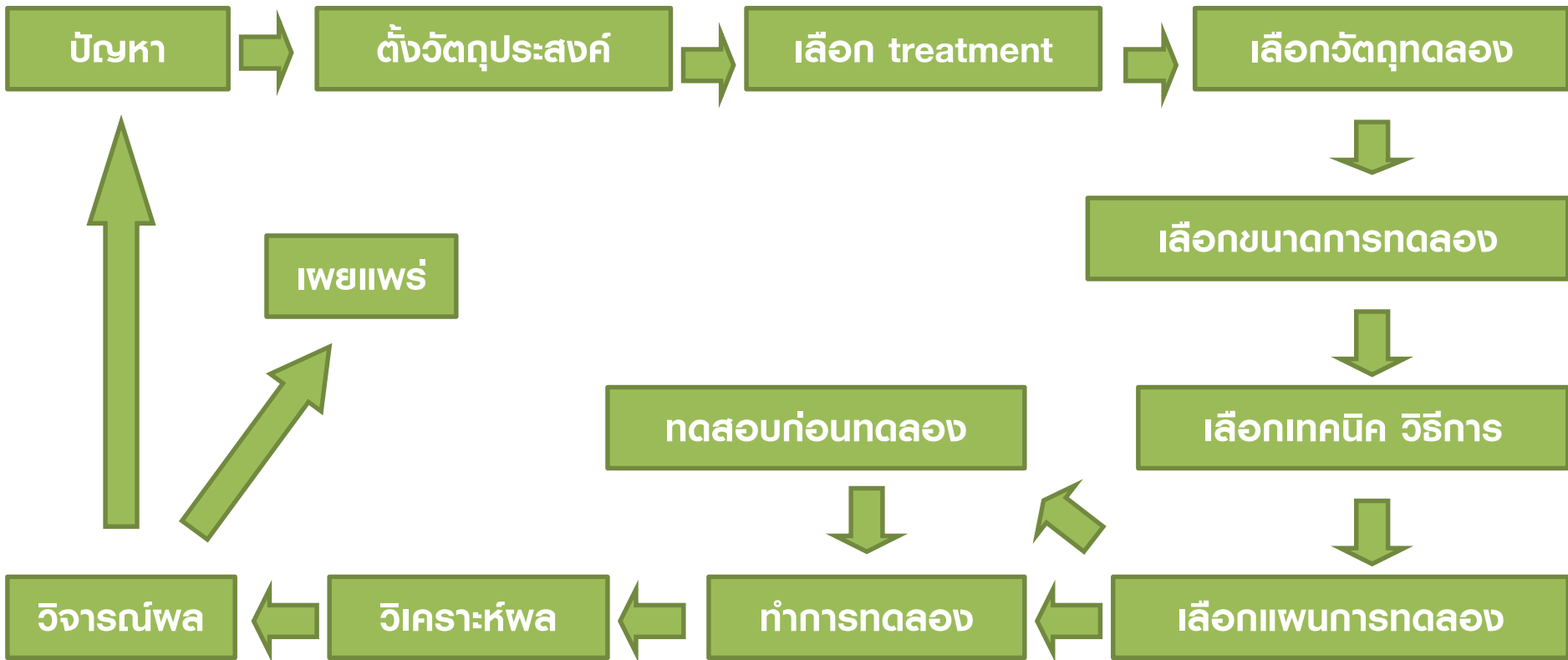


# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย

ผู้ช่วยศาสตราจารย์ ดร. นริศ สีนศิริ



# แบบแผนการใช้สถิติเพื่อการวิจัย



# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย

Single factor experiment

CRD

condition

Uniform experimental unit

SOV MSE F-test  
Tment xx  
A xx x.x\*  
B xx x.x\*  
AxB xx x.x\*  
Error xx  
Total

Two factor experiment

factorial experiment

SOV MSE F-test  
Tment xx  
A xx x.x\*  
B xx x.x\*  
AxB xx x.x\*  
Error xx  
Total

Split plot Design

SOV MSE F-test  
Mainplot A x.x\*  
Error a xx  
Sub plot B x.x\*  
AxB xx x.x\*  
Error b xx  
Total

Strip plot Design

SOV MSE F-test  
Rep xx x.x  
Verticalstrip x.x\*  
Error a xx  
Horitalstrip x.x\*  
Error b xx  
AxB xx x.x\*  
Error c xx  
Total

Three factor experiment

factorial experiment

SOV MSE F-test  
A xx x.x\*  
B xx x.x\*  
C xx x.x\*  
AxB xx x.x\*  
AxC xx x.x\*  
BxC xx x.x\*  
AxBxCxx x.x\*  
Error xx  
Total

Split- split plot Design

SOV MSE F-test  
Main plot x.x\*  
Error a xx  
Sub plot x.x\*  
AxB xx x.x\*  
Error b xx  
Sub-subpt. x.x\*  
AxC xx x.x\*  
BxC xx x.x\*  
AxBxC xx x.x\*  
Error c xx  
Total

Strip- split plot Design

SOV MSE F-test  
Rep xx x.x  
Vecal strip x.x\*  
Error a xx  
Hori-strip x.x\*  
Error b xx  
AxB xx x.x\*  
Error c xx  
Subplot C x.x\*  
AxC xx x.x\*  
BxC xx x.x\*  
AxBxC xx x.x\*  
Error d xx  
Total

Combine analysis of variance

SOV MSE F-test  
Location L x.x\*  
Repwithinsite x  
Nitrogen x.x\*  
Lx N xx x.x\*  
PoError a xx  
Variety V x.x\*  
LxV xx x.x\*  
NxV xx x.x\*  
LxNx xx x.x\*  
PoErrorb xx  
Total

RCBD

Uniform experimental unit with in block

SOV MSE F-test  
Rep xx x.x  
Tment xx  
A xx x.x\*  
B xx x.x\*  
AxB xx x.x\*  
Error xx  
Total

SOV MSE F-test  
Rep xx x.x  
Main plot x.x\*  
Error a xx  
Sub plot x.x\*  
AxB xx x.x\*  
Error b xx  
Total

SOV MSE F-test  
Rep xx x.x  
A xx x.x\*  
B xx x.x\*  
C xx x.x\*  
AxB xx x.x\*  
AxC xx x.x\*  
BxC xx x.x\*  
AxBxC xx x.x\*  
Error xx  
Total

SOV MSE F-test  
Rep xx x.x  
Main plot Ax.x\*  
Error a xx  
Sub plot B x.x\*  
AxB xx x.x\*  
Error b xx  
Sub-subpt x.x\*  
AxC xx x.x\*  
BxC xx x.x\*  
AxBxC xx x.x\*  
Error c xx  
Total

Latin square

Uniform experimental unit with in Row / column

SOV MSE F-test  
Row xx x.x  
Column xx x.x  
Tment xx  
A xx x.x\*  
B xx x.x\*  
AxB xx x.x\*  
Error xx  
Total

SOV MSE F-test  
Row xx x.x  
Column xx x.x  
Main plot x.x\*  
Error a xx  
Sub plot x.x\*  
AxB xx x.x\*  
Error b xx  
Total

SOV MSE F-test  
Row xx x.x  
Column xx x.x  
A xx x.x\*  
B xx x.x\*  
C xx x.x\*  
AxB xx x.x\*  
AxC xx x.x\*  
BxC xx x.x\*  
AxBxC xx x.x\*  
Error xx  
Total

SOV MSE F-test  
Row xx x.x  
Column xx x.x  
Main plot A x.x\*  
Error a xx  
Sub plot B x.x\*  
AxB xx x.x\*  
Error b xx  
Sub-subpt.Cx.x\*  
AxC xx x.x\*  
BxC xx x.x\*  
AxBxC xx x.x\*  
Error c xx  
Total

# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย

$$\text{Correction factor(CF)} = 58^2 / 9 = 3364 / 9 = 373.77$$

$$\text{total sum square} = (8^2 + 7^2 + \dots + 5^2) - \text{CF} = 380 - 373.77 = 6.23$$

$$\text{treatment SS.} = (21^2 + 19^2 + 18^2) / 3 - \text{CF} = 1126 / 3 - 373.77 = 1.563$$

Single factor experiment

CRD

condition

Uniform experimental unit

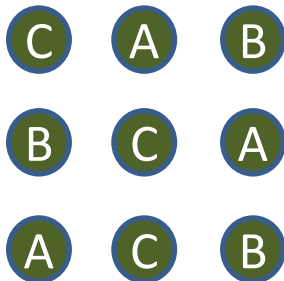
SOV MSE F-test  
Tment xx  $x \cdot x^*$   
Error xx  
Total

treatment	rep 1	rep 2	rep 3	total
A	8/64	7/49	6/36	21/441
B	7/49	6/36	6/36	19/361
C	7/49	6/36	5/25	18/324
				58/3364

Source of Variation	Degree of freedom	Sum of square	Mean square	F- test	Prob	
					.05	.01
treatment	t-1=2	1.56	0.78	$0.78 / 0.778 = 1.0025$	5.14	10.92
error	8 - 2 = 6	4.67	0.778			
total	txr-1= 8	6.23				

RCBD

randomization



Latin square

# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย

Single factor experiment

CRD

condition

Uniform experimental unit

SOV MSE F-test  
Tment xx x.x\*  
Error xx  
Total

treatment	rep 1	rep 2	rep 3	total
A	8/64	7/49	6/36	21/441
B	7/49	6/36	6/36	19/361
C	7/49	6/36	5/25	18/324
				58/3364

$$\text{Correction factor(CF)} = 58^2 / rxt = 3364/9 = 373.77$$

$$\text{total sum square} = (8^2+7^2+\dots+5^2)-CF = 380-373.77 = 6.23$$

$$\text{treatment SS.} = (21^2+19^2+18^2)/r-CF = 1126/3-373.77 = 1.563$$

Source of Variation	Degree of freedom	Sum of square	Mean square	F- test	Prob	
					.05	.01
treatment	t-1=2	1.56	0.78	0.78/0.778 = 1.0025	5.14	10.92
error	8-2=6	4.67	0.778			
total	txr-1= 8	6.23				

RCBD

Uniform experimental unit with in block

SOV MSE F-test  
Rep xx x.x  
Tment xx x.x\*  
Error xx  
Total

Treatment	rep 1	rep 2	rep 3	total
A	8/64	7/49	6/36	21/441
B	7/49	6/36	6/36	19/361
C	7/49	6/36	5/25	18/324
	22/484	19/361	17/289	58/3364

$$\text{Replication SS.} = (22^2+19^2+17^2)/t-CF = 1134/3 -CF = 378-373.77 = 4.23$$

Source of Variation	Degree of freedom	Sum of square	Mean square	F-test	prob	
					.05	.01
replication	r-1=2	4.23	2.115			
treatment	t-1=2	1.56	0.78	0.78/0.073 = 10.68	6.94	18.0
error	8-2-2=4	0.44	0.073			
total	txr-1= 8	6.23				

## randomization

Rep1	B	C	A
Rep2	A	C	B
Rep3	C	A	B

# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย

Correction factor(CF) =  $58^2 / rxt = 3364/9 = 373.77$

total sum square =  $(8^2+7^2+....+5^2)-CF = 380-373.77 = 6.23$

treatment SS. =  $(21^2+19^2+18^2)/r-CF = 1126/3=375.33-373.77 = 1.563$

Single factor experiment

treatment	rep 1	rep 2	rep 3	total
A	8/64	7/49	6/36	21/441
B	7/49	6/36	6/36	19/361
C	7/49	6/36	5/25	18/324
				58/3364

CRD

condition

Uniform experimental unit

SOV MSE F-test  
Tment xx **x.x\***  
Error xx  
Total

Treat-ment	rep 1	rep 2	rep 3	total
A	8/64	7/49	6/36	21/441
B	7/49	6/36	6/36	19/361
C	7/49	6/36	5/25	18/324
	22/484	19/361	17/289	58/3364

RCBD

Uniform experimental unit with in block

SOV MSE F-test  
Rep xx x.x  
Tment xx **x.x\***  
Error xx  
Total

row SS. =  $(19^2+20^2+19^2)/t-CF = 1122/3 - CF = 374-373.77 = 0.23$

column SS. =  $(22^2+19^2+17^2)/t-CF = 1134/3 - CF = 378-373.77 = 4.23$

Latin square

Uniform experimental unit with in Row / column

SOV MSE F-test  
Row xx x.x  
Column xx x.x  
Tment xx **x.x\***  
Error xx  
Total

	col 1	col 2	col 3	total
row	8/64 A	6/36 B	5/25 C	19/361
row	7/49 C	7/49 A	6/36 B	20/400
row	7/49 B	6/36 C	6/36 A	19/361
	22/484	19/361	17/289	58/3364

Source of Variation	Degree of freedom	Sum of square	Mean square	F- test	Prob	
					.05	.01
treatment	t-1=2	1.56	0.78	0.78/0.778 = <b>1.0025</b>	5.14	10.92
error	8 -2=6	4.67	0.778			
total	txr-1= 8	6.23				

Source of Variation	Degree of freedom	Sum of square	Mean square	F-test	prob	
					.05	.01
replication	r -1=2	4.23	2.115			
treatment	t -1=2	1.56	0.78	.78/.073 = <b>10.68</b>	6.94	18.0
error	8 -2-2=4	0.44	0.073			
total	txr-1= 8	6.23				

Source of Variation	Degree of freedom	Sum of square	Mean square	F- test	prob	
					.05	.01
row	t -1=2	0.23	0.115			
column	t -1=2	4.23	2.115			
treatment	t -1=2	1.56	0.78	0.78/0.105 = <b>7.428</b>	19.0	99.0
error	8 -2-2-2=2	0.21	0.105			
total	txr-1= 8	6.23				

# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย

Single factor experiment

Two factor experiment

CRD

factorial experiment

condition

Uniform experimental unit

SOV MSE F-test  
Tment xx  
A xx x.x\*  
B xx x.x\*  
Error xx  
Total

SOV MSE F-test  
Tment xx  
A xx x.x\*  
B xx x.x\*  
AxB xx x.x\*  
Error xx  
Total

## randomization

n0v1

n2v1

n0v3

n1v2

n1v1

n1v3

n2v1

n2v2

n0v2

n1v1

n0v3

n0v1

n1v2

n2v1

n2v2

n0v2

n1v3

n2v3

n2v2

n1v1

n0v2

n2v3

n0v3

n2v3

n1v3

n1v2

n0v1

$$CF = 110^2/abr = 12100/3 \times 3 \times 3 = 448.15$$

$$Total SS = (2^2 + 3^2 + 3^2 + \dots + 3^2) - CF = 484 - 448.15 = 35.85$$

$$Trtment SS = (7^2 + 10^2 + \dots + 10^2)/r - CF = 1436/3 - 448.15 = 30.52$$

$$Error SS = total SS - Trtment SS = 35.85 - 30.52 = 5.33$$

variety	Rep 1	Rep 2	Rep 3	total
		N 0		
MSU1	2/4	3/9	2/4	7/49
MSU2	3/9	3/9	4/16	10/100
MSU3	3/9	4/16	3/9	10/100
		N 10		
MSU1	4/16	5/25	5/25	14/196
MSU2	5/25	5/25	5/25	15/225
MSU3	4/16	3/9	4/16	11/121
		N 20		
MSU1	5/25	6/36	6/36	17/289
MSU2	5/25	5/25	6/36	16/256
MSU3	4/16	3/9	3/9	10/100
				110/

Variety (A)	Nitro gen 0	Nitro gen 10	Nitro gen 20
MSU1	n0v1	n1v1	n2v1
MSU2	n0v2	n1v2	n2v2
MSU3	n0v3	n1v3	n2v3

variety	Nitro gen 0	Nitro gen 10	Nitro gen 20	total
MSU1	7	14	17	38/1444
MSU2	10	15	16	41/1681
MSU3	10	11	10	31/961
total	27/729	40/1600	43/1849	110

$$A SS = (38^2 + 41^2 + 31^2)/br - CF = 4086/3 \times 3 - 448.15 = 5.85$$

$$B SS = (27^2 + 40^2 + 43^2)/ar - CF = 4178/3 \times 3 - 448.15 = 16.07$$

$$AxB SS = Trtment SS - A SS - B SS = 30.52 - 5.85 - 16.07 = 8.60$$

Source of Variation	Degree of freedom	Sum of square	Mean square	F-test
treatment	ab - 1 = 8	30.52	3.815	
A	a - 1 = 2	5.85	2.925	9.87
B	b - 1 = 2	16.07	8.035	27.1
AxB	(a - 1)(b - 1) = 4	8.60	2.15	7.26
error	26 - 8 = 18	5.33	0.296	
total	abr - 1 = 26	35.85		

# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย

Single factor experiment

Two factor experiment

factorial experiment

RCBD

Uniform experimental unit with in block

SOV MSE F-test  
 Rep xx x.x  
 Tment xx  
 A xx x.x\*  
 B xx x.x\*  
 AxB xx x.x\*  
 Error xx  
 Total

Variety (A)	Nitro gen 0	Nitro gen 10	Nitro gen 20
MSU1	n0v1	n1v1	n2v1
MSU2	n0v2	n1v2	n2v2
MSU3	n0v3	n1v3	n2v3

variet y	Nitro gen 0	Nitro gen 10	Nitro gen 20	total
MSU1	7	14	17	38/1444
MSU2	10	15	16	41/1681
MSU3	10	11	10	31/961
total	27/729	40/1600	43/1849	110

A SS =  $(38^2+41^2+31^2)/br-CF$   
 =  $4086/3 \times 3 - 448.15 = 5.85$

B SS =  $(27^2+40^2+43^2)/ar-CF$   
 =  $4178/3 \times 3 - 448.15 = 16.07$

AxB SS =  $Trtment SS - A SS - B SS$   
 =  $30.52 - 5.85 - 16.07 = 8.60$

variety	Rep 1	Rep 2	Rep 3	total
		N 0		
MSU1	2/4	3/9	2/4	7/49
MSU2	3/9	3/9	4/16	10/100
MSU3	3/9	4/16	3/9	10/100
		N 10		
MSU1	4/16	5/25	5/25	14/196
MSU2	5/25	5/25	5/25	15/225
MSU3	4/16	3/9	4/16	11/121
		N 20		
MSU1	5/25	6/36	6/36	17/289
MSU2	5/25	5/25	6/36	16/256
MSU3	4/16	3/9	3/9	10/100
	35	37	38	110/

Source of Variation	Degree of freedom	Sum of square	Mean square	F-test
Rep	r - 1 = 2	0.52	0.26	
treatment	ab - 1 = 8	30.52	3.815	
A	a - 1 = 2	5.85	2.925	9.72
B	b - 1 = 2	16.07	8.035	26.7
AxB	(a - 1)(b - 1) = 4	8.60	2.15	7.14
error	26 - 2 - 8 = 16	4.81	0.301	
total	abr - 1 = 26	35.85		

CF =  $110^2/abr = 12100/3 \times 3 \times 3 = 448.15$

Total SS =  $(2^2+3^2+3^2+...+3^2)-CF$   
 =  $484 - 448.15 = 35.85$

Trtment SS =  $(7^2+10^2+...+10^2)/r-CF$   
 =  $1436/3 = 478.67 - 448.15 = 30.52$

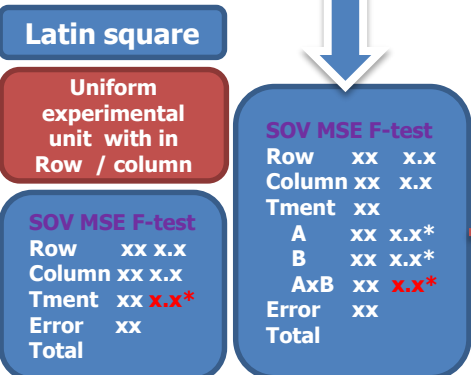
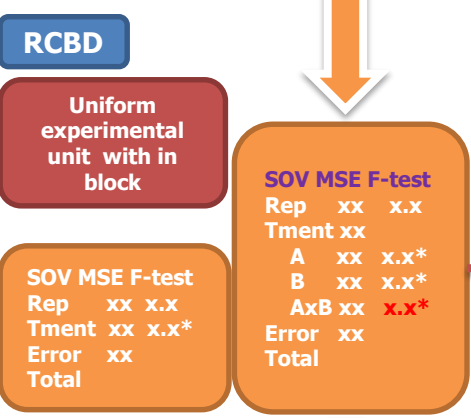
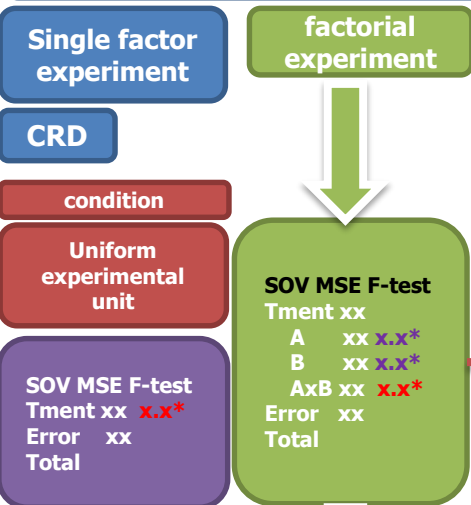
Error SS = total SS - Trtment SS  
 =  $35.85 - 30.52 = 5.33$

Rep SS =  $(35^2+37^2+...+38^2)/ab-CF$   
 =  $448.67 - 448.15 = 0.52$

Error SS = total SS - Rep SS - Trtment SS  
 =  $35.85 - 0.52 - 30.52 = 4.81$



# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย



Source of Variation	Degree of freedom	Sum of square	Mean square	F-test
Rep	$r - 1 = 2$	0.52	0.26	
treatment	$ab - 1 = 8$	30.52	3.815	
A	$a - 1 = 2$	5.85	2.925	9.72
B	$b - 1 = 2$	16.07	8.035	26.7
AxB	$(a - 1)(b - 1) = 4$	8.60	2.15	7.14
error	$26 - 2 - 8 = 16$	4.81	0.301	
total	$abr - 1 = 26$	35.85		

Source of Variation	Degree of freedom	Sum of square	Mean square	F-test
treatment	$ab - 1 = 8$	30.52	3.815	
A	$a - 1 = 2$	5.85	2.925	9.87
B	$b - 1 = 2$	16.07	8.035	27.1
AxB	$(a - 1)(b - 1) = 4$	8.60	2.15	7.26
error	$26 - 8 = 18$	5.33	0.296	
total	$abr - 1 = 26$	35.85		

Source of Variation	Degree of freedom	SS.	MS	F-test
row	$ab - 1 = 8$			
column	$ab - 1 = 8$			
treatment	$ab - 1 = 8$			
A	$a - 1 = 2$			
B	$b - 1 = 2$			
AxB	$(a - 1)(b - 1) = 4$			
error	$80 - 8 - 8 - 8 = 56$			
total	$t^2 - 1 = 80$			

# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย

Single factor experiment

Two factor experiment

CRD

Split plot Design

condition

Uniform experimental unit

**SOV MSE F-test**  
Mainplot A  $x \cdot x^*$   
Error a  $xx$   
Sub plot B  $x \cdot x^*$   
AxB  $xx$   $x \cdot x^*$   
Error b  $xx$   
Total

randomization

N 0

N 10

N 20

v1	v3	v2	v2	v3	v1	v3	v2	v1
v2	v1	v3	v2	v3	v1	v1	v3	v2
v3	v2	v1	v1	v2	v3	v3	v2	v1

nitrogen	Rep 1	Rep 2	Rep 3	Nitrogen total
N 0	8/64	10/100	9/81	27/729
N 10	13/169	13/169	14/196	40/1600
N 20	14/196	14/196	15/225	43/1849

$$CF = 110^2 / abr$$

$$= 12100 / 3 \times 3 \times 3$$

$$= 448.15$$

$$Total SS = (2^2 + 3^2 + 3^2 + \dots + 3^2) - CF$$

$$= 484 - 448.15 = 35.85$$

variety	N 0	N 10	N 20	total
MSU1	7	14	17	38/1444
MSU2	10	15	16	41/1681
MSU3	10	11	10	31/961
total	27/729	40/1600	43/1849	110

$$Main plot SS = (27^2 + 40^2 + 43^2) / rb - CF$$

$$= 4178 / 3 \times 3 = 464.22 - 448.1$$

$$= 16.122$$

$$Error a = (8^2 + 10^2 + \dots + 15^2) / b - CF$$

$$= 17.18 - 16.122$$

$$= 1.061$$

$$Subplot SS = (38^2 + 41^2 + 31^2) / ar - CF$$

$$= 4086 / 3 \times 3 - 448.15$$

$$= 5.85$$

$$AxB SS = (7^2 + 10^2 + \dots + 10^2) / r - CF - ASS - BSS$$

$$= 1436 / 3 = 478.67 - 448.15 = 30.52 - 16.122 - 5.85$$

$$= 8.548$$

$$Error b = 35.85 - 16.122 - 1.061 - 5.85 - 8.548$$

$$= 4.269$$

variety	Rep 1	Rep 2	Rep 3	total
Main plot N 0				
MSU1	2/4	3/9	2/4	7/49
MSU2	3/9	3/9	4/16	10/100
MSU3	3/9	4/16	3/9	10/100
Main plot N 10				
MSU1	4/16	5/25	5/25	14/196
MSU2	5/25	5/25	5/25	15/225
MSU3	4/16	3/9	4/16	11/121
Main plot N 20				
MSU1	5/25	6/36	6/36	17/289
MSU2	5/25	5/25	6/36	16/256
MSU3	4/16	3/9	3/9	10/100
				110/

Source of Variation	Degree of freedom	Sum of square	Mean square	F-test
Mainplot A	$a - 1 = 2$	16.122	8.061	45.8
Error a	$a(r-1) = 6$	1.061	0.176	
Sub plot B	$b - 1 = 2$	5.85	2.925	9.62
AxB	$(a - 1)(b - 1) = 4$	8.548	2.137	7.03
Error b	$a(r-1)(b-1) = 12$	4.269	0.304	
total	$abr - 1 = 26$	35.85		

# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย

RCBD

Uniform experimental unit with in block

Two factor experiment

Split plot Design

randomization

block 1

block 2

block 3

N 0	v1	v3	v2	v2	v3	v1	v3	v2	v1
N 10	v2	v1	v3	v2	v3	v1	v1	v3	v2
N 20	v3	v2	v1	v1	v2	v3	v3	v2	v1

SOV MSE F-test  
 Rep xx x.x  
 Main plot x.x\*  
 Error a xx  
 Sub plot x.x\*  
 AxB xx x.x\*  
 Error b xx  
 Total

nitrogen	Rep 1	Rep 2	Rep 3	Nitrogen total
N 0	8/64	10/100	9/81	27/729
N 10	13/169	13/169	14/196	40/1600
N 20	14/196	14/196	15/225	43/1849
Rep total	35	37	38	110/

variety	Nitro gen 0	Nitro gen 10	Nitro gen 20	total
MSU1	7	14	17	38/1444
MSU2	10	15	16	41/1681
MSU3	10	11	10	31/961
total	27/729	40/1600	43/1849	110

variety	Rep 1	Rep 2	Rep3	total
Main plot N 0				
MSU1	2/4	3/9	2/4	7/49
MSU2	3/9	3/9	4/16	10/100
MSU3	3/9	4/16	3/9	10/100
Main plot N 10				
MSU1	4/16	5/25	5/25	14/196
MSU2	5/25	5/25	5/25	15/225
MSU3	4/16	3/9	4/16	11/121
Main plot N 20				
MSU1	5/25	6/36	6/36	17/289
MSU2	5/25	5/25	6/36	16/256
MSU3	4/16	3/9	3/9	10/100
				110/

$CF = 1102/abr = 12100/3 \times 3 \times 3 = 448.15$   
 $Total SS = (22+32+32+...+32) - CF = 484 - 448.15 = 35.85$   
 $Rep SS = (35^2 + 37^2 + ... + 38^2) / ab - CF = 0.52$   
 $Main plot SS = (272+402+432) / rb - CF = 4178 / 3 \times 3 = 464.22 - 448.1 = 16.122$   
 $Error a = (82+102+...+152) / b - CF = 17.18 - 0.52 - 16.122 = 0.541$   
 $Subplot SS = (382+412+312) / ar - CF = 4086 / 3 \times 3 - 448.15 = 5.85$   
 $AxB SS = (72+102+...+102) / r - CF - A SS - B SS = 1436 / 3 = 478.67 - 448.15 = 30.52 - 16.122 - 5.85 = 8.548$   
 $Error b = 35.85 - 0.52 - 16.122 - 1.061 - 5.85 - 8.548 = 3.749$

Source of Variation	Degree of freedom	Sum of square	Mean square	F-test
Rep	r - 1 = 2	0.52	0.26	
Mainplot A	a - 1 = 2	16.122	8.061	59.7
Error a	(r-1)(a-1) = 4	0.541	0.135	
Sub plot B	b - 1 = 2	5.85	2.925	9.38
AxB	(a - 1)(b-1) = 4	8.548	2.137	6.84
Error b	a(r-1)(b-1) = 12	3.749	0.312	
total	abr-1 = 26	35.85		

# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย

Single factor experiment

Two factor experiment

CRD

Split plot Design

condition

Uniform experimental unit

SOV MSE F-test  
Mainplot A  $x,x^*$   
Error a  $xx$   
Sub plot B  $x,x^*$   
AxB  $xx$   $x,x^*$   
Error b  $xx$   
Total

SOV MSE F-test  
Tment  $xx$   $x,x^*$   
Error  $xx$   
Total

Source of Variation	Degree of freedom	Sum of square	Mean square	F-test
Mainplot A	$a - 1 = 2$	16.122	8.061	45.8
Error a	$a(r-1) = 6$	1.061	0.176	
Sub plot B	$b - 1 = 2$	5.85	2.925	9.62
AxB	$(a - 1)(b - 1) = 4$	8.548	2.137	7.03
Error b	$a(r-1)(b-1) = 12$	4.269	0.304	
total	$abr - 1 = 26$	35.85		

RCBD

Uniform experimental unit with in block

SOV MSE F-test  
Rep  $xx$   $x,x$   
Main plot  $x,x^*$   
Error a  $xx$   
Sub plot  $x,x^*$   
AxB  $xx$   $x,x^*$   
Error b  $xx$   
Total

SOV MSE F-test  
Rep  $xx$   $x,x$   
Tment  $xx$   $x,x^*$   
Error  $xx$   
Total

Source of Variation	Degree of freedom	Sum of square	Mean square	F-test
Replication	$r - 1 = 2$	0.52	0.26	
Mainplot A	$a - 1 = 2$	16.122	8.061	59.7
Error a	$(r-1)(a-1) = 4$	0.541	0.135	
Sub plot B	$b - 1 = 2$	5.85	2.925	9.38
AxB	$(a - 1)(b - 1) = 4$	8.548	2.137	6.84
Error b	$a(r-1)(b-1) = 12$	3.749	0.312	
total	$abr - 1 = 26$	35.85		

N 0

N 10

N 20

Latin square

Uniform experimental unit with in Row / column

SOV MSE F-test  
Row  $xx$   $x,x$   
Column  $xx$   $x,x$   
Main plot  $x,x^*$   
Error a  $xx$   
Sub plot  $x,x^*$   
AxB  $xx$   $x,x^*$   
Error b  $xx$   
Total

SOV MSE F-test  
Row  $xx$   $x,x$   
Column  $xx$   $x,x$   
Tment  $xx$   $x,x^*$   
Error  $xx$   
Total

	col 1	col 2	col 3
row 1	v1	v3	v2
row 2	v2	v1	v3
row 3	v3	v2	v1

randomization

Source of Variation	Degree of freedom
row	$a - 1 = 2$
column	$a - 1 = 2$
Mainplot A	$a - 1 = 2$
Error a	$(a - 1)(a - 2) = 2$
Sub plot B	$b - 1 = 2$
AxB	$(a - 1)(b - 1) = 4$
Error b	$a(a - 1)(b - 1) = 12$
total	$(a^2b) - 1 = 26$

# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย

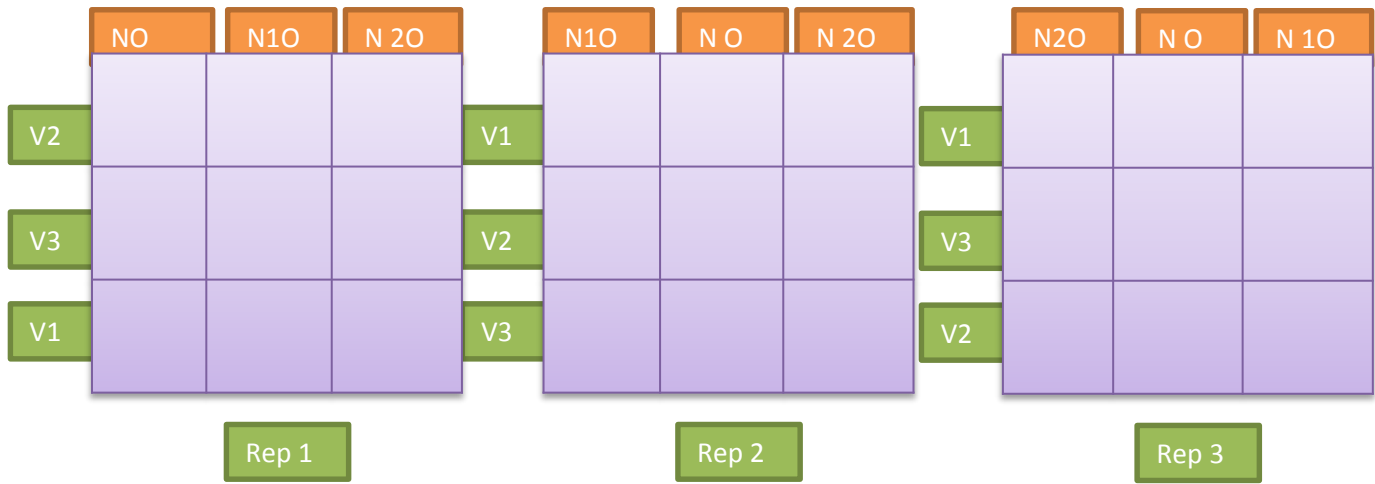
## randomization

Single factor experiment

Two factor experiment

CRD

Strip plot Design



condition

Uniform experimental unit

SOV MSE F-test  
Tment xx **x.x\***  
Error xx  
Total

RCBD

Uniform experimental unit with in block

SOV MSE F-test  
Rep xx x.x  
Verticalstrip x.x\*  
Error a xx  
Horitalstrip x.x\*  
Error b xx  
AxB xx **x.x\***  
Error c xx  
Total

SOV MSE F-test  
Rep xx x.x  
Tment xx x.x\*  
Error xx  
Total

Latin square

Uniform experimental unit with in Row / column

SOV MSE F-test  
Row xx x.x  
Column xx x.x  
Tment xx **x.x\***  
Error xx  
Total

Source of Variation	Degree of freedom	Sum of square	Mean square	F-test
Replication	$r - 1 = 2$			
Vertical strip A	$a - 1 = 2$			
Error a	$(r - 1)(a - 1) = 4$			
Horizontal strip B	$b - 1 = 2$			
Error b	$(r - 1)(b - 1) = 4$			
AxB	$(a - 1)(b - 1) = 4$			
Error c	$(r - 1)(a - 1)(b - 1) = 8$			
total	$abr - 1 = 26$			

# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย

Single factor experiment

Three factor experiment

CRD

factorial experiment

condition

SOV MSE F-test  
 A xxx x.xx\*  
 B xxx x.xx\*  
 C xxx x.xx\*  
 AxB xxx x.xx\*  
 AxC xxx x.xx\*  
 BxC xxx x.xx\*  
 AxBxCxxx x.xx\*  
 Error xxx  
 Total

Uniform experimental unit

N	P	K	Treatment combination
0	0	0	n0p0k0
0	0	10	n0p0k1
0	10	0	n0p1k0
0	10	10	n0p1k1
20	0	0	n1p0k0
20	0	10	n1p0k1
20	10	0	n1p1k0
20	10	10	n1p1k1
30	0	0	n2p0k0
30	0	10	n2p0k1
30	10	0	n2p1k0
30	10	10	n2p1k1

Source of Variation	Degree of freedom	Sum of square	Mean square	F- test
treatment	abc-1= 11			
A	a -1=2			xxx
B	b -1=1			xxx
C	c-1=1			xxx
AxB	(a -1)(b-1)=2			xxx
AxC	(a -1)(c-1)=2			xxx
BxC	(b -1)(c-1)=1			xxx
AxBxC	(a -1)(b-1)(c-1)=2			xxx*
error	35-11=24			
total	abcr-1= 35			

## randomization

	n0p1k1			
n0p1k0			n0p0k1	
	n0p0k0		n0p1k1	n0p0k1
n0p1k1		n0p0k1		
	n0p1k0			n0p0k0
n0p0k0			n0p1k0	

# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย

# randomization

Single factor experiment

Three factor experiment

factorial experiment

N	P	K	Treatment combination
0	0	0	n0p0k0
0	0	10	n0p0k1
0	10	0	n0p1k0
0	10	10	n0p1k1
20	0	0	n1p0k0
20	0	10	n1p0k1
20	10	0	n1p1k0
20	10	10	n1p1k1
30	0	0	n2p0k0
30	0	10	n2p0k1
30	10	0	n2p1k0
30	10	10	n2p1k1

n0p0k0	n0p1k1	n1p0k1	n2p1k0	n1p1k0	n2p1k1
n0p1k0	n1p0k0	n1p1k1	n0p0k1	n2p0k0	n2p0k1

Block 1

Block 2

Block 3

## RCBD

Uniform experimental unit with in block

SOV MSE F-test

Rep xx x.x  
 A xx x.x\*  
 B xx x.x\*  
 C xx x.x\*  
 AxB xx x.x\*  
 AxC xx x.x\*  
 BxC xx x.x\*  
 AxBxC xx x.x\*  
 Error xx  
 Total

SOV MSE F-test  
 Rep xxx x.xxx  
 Tment xxx x.xxx\*  
 Error xxx  
 Total

Source of Variation	Degree of freedom	Sum of square	Mean square	F- test
Rep	$r-1=2$			
treatment	$abc-1= 11$			
A	$a -1=2$			xxx
B	$b -1=1$			xxx
C	$c-1=1$			xxx
AxB	$(a -1)(b-1)=2$			xxx
AxC	$(a -1)(c-1)=2$			xxx
BxC	$(b -1)(c-1)=1$			xxx
AxBxC	$(a -1)(b-1)(c-1)=2$			xxx*
error	$35-2-11=22$			

# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย

Single factor experiment

CRD

condition

Uniform experimental unit

Three factor experiment

factorial experiment

N	P	K	Treatment combination
0	0	0	n0p0k0
0	0	10	n0p0k1
0	10	0	n0p1k0
0	10	10	n0p1k1
20	0	0	n1p0k0
20	0	10	n1p0k1
20	10	0	n1p1k0
20	10	10	n1p1k1
30	0	0	n2p0k0
30	0	10	n2p0k1
30	10	0	n2p1k0
30	10	10	n2p1k1

RCBD

Uniform experimental unit with in block

Latin square

Uniform experimental unit with in Row and column

SOV MSEF-test  
 Row xx x.x  
 Column xx x.x  
 A xx x.x\*  
 B xx x.x\*  
 C xx x.x\*  
 AxB xx x.x\*  
 AxC xx x.x\*  
 BxC xx x.x\*  
 AxBxC xx x.x\*  
 Error xx  
 Total

randomization

Col 1

Col 12

Source of Variation	Degree of freedom	SS	MS	F- test
row	$abc-1=11$			
column	$abc-1=11$			
treatment	$abc-1=11$			
A	$a-1=2$			xxx
B	$b-1=1$			xxx
C	$c-1=1$			xxx
AxB	$(a-1)(b-1)=2$			xxx
AxC	$(a-1)(c-1)=2$			xxx
BxC	$(b-1)(c-1)=1$			xxx
AxBxC	$(a-1)(b-1)(c-1)=2$			xxx*
error	$144-11-11-11=$			
total	$abc^2-1= 143$			



# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย

Single factor experiment

CRD

condition

Uniform experimental unit

SOV MSE F-test  
Tment xx  $x.x^*$   
Error xx  
Total

Three factor experiment

Split-split plot Design

SOV MSE F-test  
Main plot  $x.x^*$   
Error a  $xx$   
Sub plot  $x.x^*$   
AxB  $xx x.x^*$   
Error b  $xx$   
Sub-subpt.  $x.x^*$   
AxC  $xx x.x^*$   
BxC  $xx x.x^*$   
AxBxC  $xx x.x^*$   
Error c  $xx$   
Total

Main plot N 0

Main plot N 10

Main plot N 20

Sub plot P 0

Sub plot P 1

Sub-sub plot K 0

Sub-sub plot K 1

## randomization

P0 k1	P0 k0	P1 k0	p1 k1	P1 k0	P1 k1
P1 k0	P1 k1	P0 k1	P0 k0	P0 k1	P0 k0
P0 k1	P0 k0	P1 k0	p1 k1	P0 k1	P0 k0
P1 k0	P1 k1	P0 k1	P0 k0	P1 k0	P1 k1
P0 k1	P0 k0	P1 k0	p1 k1	P1 k0	P1 k1
P1 k0	P1 k1	P0 k1	P0 k0	P0 k1	P0 k0

Source of Variation	Degree of freedom	S S.	M S.	F-test
Main plot A	$a - 1 = 2$			xxx
Error a	$a(r-1) = 6$			
Sub plot B	$b - 1 = 1$			xxx
AxB	$(a - 1)(b-1) = 2$			xxx
Error b	$a(r-1)(b-1) = 6$			
Sub-sub plot C	$c - 1$			xxx
AxC	$(a-1)(c-1) = 2$			xxx
BxC	$(b-1)(c-1) = 1$			xxx
AxBxC	$(a-1)(b-1)(c-1) = 2$			xxx
Error c	$Ab(r-1)(c-1) =$			
total	$abc - 1 = 35$			

# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย

Single factor experiment

randomization

Rep 1

Main plot B N 10	Main plot A N 0	Main plot C N 20
---------------------	--------------------	---------------------

P0 k1	P0 k0	P1 k0	p1 k1	P1 k0	P1 k1
P1 k0	P1 k1	P0 k1	P0 k0	P0 k1	P0 k0

Rep 2

Main plot B N 10	Main plot C N 0	Main plot A N 20
---------------------	--------------------	---------------------

P0 k1	P0 k0	P1 k0	p1 k1	P0 k1	P0 k0
P1 k0	P1 k1	P0 k1	P0 k0	P1 k0	P1 k1

Rep 3

Main plot B N 10	Main plot A N 0	Main plot C N 20
---------------------	--------------------	---------------------

P0 k1	P0 k0	P1 k0	p1 k1	P1 k0	P1 k1
P1 k0	P1 k1	P0 k1	P0 k0	P0 k1	P0 k0

Main plot N 0

Sub plot P 0

Sub-sub plot K 0

Main plot N 10

Sub plot P 1

Sub-sub plot K 1

Main plot N 20

RCBD

Uniform experimental unit with in block

Three factor experiment

Split-split plot Design

SOV MSE F-test  
Rep xxx x.xx  
Main plot A x.xx\*  
Error a xxx  
Sub plot B x.xx\*  
AxB xxx x.xx\*  
Error b xxx  
Sub-sub pt.C x.xx\*  
AxC xxx x.xx\*  
BxC xxx x.xx\*  
AxBxC xxx x.xx\*  
Error c xxx  
Total

Source of Variation	Degree of freedom	SS	MS	F-test
Rep	$r-1=2$			
Main plot A	$a-1=2$			xxx
Error a	$(r-1)(a-1)=4$			
Sub plot B	$b-1=1$			xxx
AxB	$(a-1)(b-1)=2$			xxx
Error b	$a(r-1)(b-1)=6$			
Sub-sub plot C	$c-1$			xxx
AxC	$(a-1)(c-1)=2$			xxx
BxC	$(b-1)(c-1)=1$			xxx
AxBxC	$(a-1)(b-1)(c-1)=2$			xxx
Error c	$Ab(r-1)(c-1)=$			
total	$abc r-1=35$			

# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย

**Latin square**

Uniform experimental unit with in Row / column

**Split- split plot Design**

Three factor experiment

SOV MSE F-test  
 Row xx x.x  
 Column xx x.x  
 Main plot A x.x\*  
 Error a xx  
 Sub plot B x.x\*  
 AxB xx x.x\*  
 Error b xx  
 Sub-subpt.Cx.x\*  
 AxC xx x.x\*  
 BxC xx x.x\*  
 AxBxC xx x.x\*  
 Error c xx  
 Total

randomization

col 1

col 2

col3

row 1

row 2

row 3

	V1 K1	V3 K2	V2 K2	V2 K1	V3 K1	V1 K2	V3 K1	V2 K1	V1 K2
row 1	V1 K2	V3 K1	V2 K1	V2 K2	V3 K2	V1 K1	V3 K2	V2 K2	V1 K1
row 2	V2 K1	V1 K1	V3 K1	V2 K2	V3 K1	V1 K2	V1 K2	V3 K1	V2 K1
	V2 K2	V1 K2	V3 K2	V2 K1	V3 K2	V1 K1	V1 K1	V3 K2	V2 K2
row 3	V3 K2	V2 K1	V1 K2	V1 K1	V2 K1	V3 K1	V3 K1	V2 K1	V1 K2
	V3 K1	V2 K2	V1 K1	V1 K2	V2 K2	V3 K2	V3 K2	V2 K2	V1 K1

Main plot N 0	Sub plot V1	Sub-sub plot K 1
Main plot N 10	Sub plot V2	Sub-sub plot K 2
Main plot N 20	Sub plot V3	

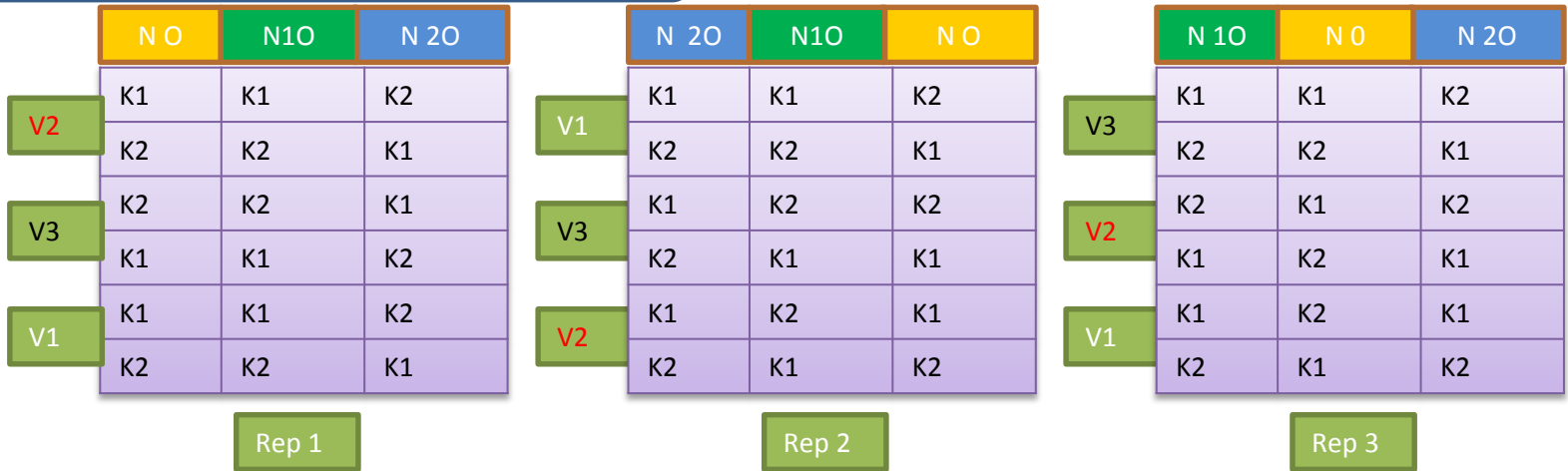
Source of Variation	Degree of freedom	SS	MS	F-test
Row	a-1=2			
column	a-1=2			
Main plot A	a-1=2			xxx
Error a	(a-1)(a-2)=2			
Sub plot B	b - 1=2			xxx
AxB	(a - 1)(b-1) =4			xxx
Error b	a(a-1)(b-1)=12			
Sub-sub plot C	c-1			xxx
AxC	(a-1)(c-1)=2			xxx
BxC	(b-1)(c-1)=1			xxx
AxBxC	(a-1)(b-1)(c-1)=2			xxx
Error c	ab(a-1)(c-1)=18			
total	abc-1= 54			

# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย

# randomization

Three factor experiment

Strip-split plot Design



SOV MSE F-test  
 Rep xx x.x  
 Vertical strip x.x\*  
 Error a xx  
 Hori-strip x.x\*  
 Error b xx  
 AxB xx x.x\*  
 Error c xx  
 Subplot C x.x\*  
 AxC xx x.x\*  
 BxC xx x.x\*  
 AxBxC xx x.x\*  
 Error d xx  
 Total

Vertical	N 0	Horizontal	V1	Sub-plot	K 1
Vertical	N 10	Horizontal	V2	Sub-plot	K 2
Vertical	N 20	Horizontal	V3		

Source of Variation	Degree of freedom
Replication	$r - 1 = 2$
Vertical strip A	$a - 1 = 2$
Error a	$(r - 1)(a - 1) = 4$
Horizontal strip B	$b - 1 = 2$
Error b	$(r - 1)(b - 1) = 4$
AxB	$(a - 1)(b - 1) = 4$
Error c	$(r - 1)(a - 1)(b - 1) = 8$
Sub plot C	$c - 1 =$
AxC	$(a - 1)(c - 1) = 2$
BxC	$(b - 1)(c - 1) = 1$
AxBxC	$(a - 1)(b - 1)(c - 1) = 2$
Error d	$ab(r - 1)(c - 1)$
Total	$rbc - 1$

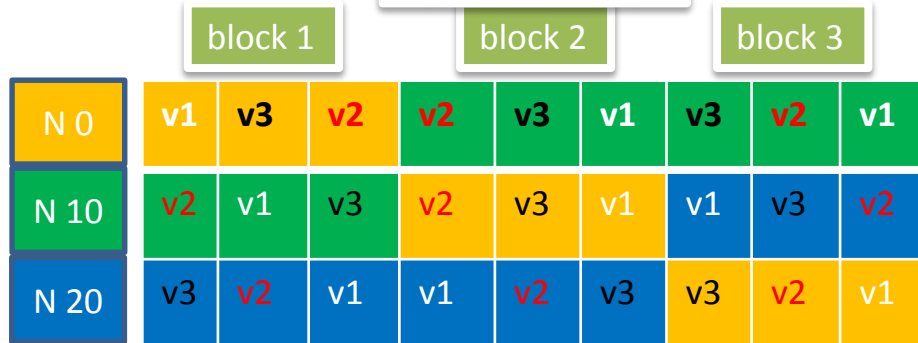
# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย

Combine analysis of variance

Split plot Design

3 location

randomization



RCBD

Uniform experimental unit with in block

SOV MSE F-test  
 Location L x.x\*  
 Repwithinsite x  
 Nitrogen x.x\*  
 Lx N xx x.x\*  
 PoError a xx  
 Variety V x.x\*  
 LxV xx x.x\*  
 NxV xx x.x\*  
 LxNx xx x.x\*  
 PoErrorb xx  
 Total

Source of Variation	Degree of freedom	Mean square	Compute F-test
Location L	m-1	LMS	LMS/RMS
Rep within site	m(r-1)	RMS	
Main-plot A	a-1	AMS	AMS/EaMS
LxA	(m-1)(a-1)	LxAMS	LxAMS/EaMS
Pooled Error a	m(r-1)(a-1)	EaMS	
Subplot B	b-1	BMS	BMS/EbMS
LxB	(m-1)(b-1)	LxBMS	LxBMS/EbMS
AxB	(a-1)(b-1)	AxBMS	AxBMS/EbMS
LxAxB	(m-1)(a-1)(b-1)	LxAxBMS	LxAxBMS/EbMS
Pooled Error b	ma(r-1)(b-1)	EbMS	
Total	mrab-1		

# ประมวลแบบแผนการใช้สถิติเพื่อการวิจัย

Single factor experiment

CRD

condition

Uniform experimental unit

SOV MSE F-test  
Tment xx  
A xx x.x\*  
B xx x.x\*  
AxB xx x.x\*  
Error xx  
Total

Two factor experiment

factorial experiment

Split plot Design

Strip plot Design

SOV MSE F-test  
Tment xx  
A xx x.x\*  
B xx x.x\*  
AxB xx x.x\*  
Error xx  
Total

SOV MSE F-test  
Mainplot A x.x\*  
Error a xx  
Sub plot B x.x\*  
AxB xx x.x\*  
Error b xx  
Total

factorial experiment

SOV MSE F-test  
A xx x.x\*  
B xx x.x\*  
C xx x.x\*  
AxB xx x.x\*  
AxC xx x.x\*  
BxC xx x.x\*  
AxBxCxx x.x\*  
Error xx  
Total

Split- split plot Design

SOV MSE F-test  
Main plot x.x\*  
Error a xx  
Sub plot x.x\*  
AxB xx x.x\*  
Error b xx  
Sub-subpt. x.x\*  
AxC xx x.x\*  
BxC xx x.x\*  
AxBxC xx x.x\*  
Error c xx  
Total

Strip- split plot Design

Combine analysis of variance

RCBD

Uniform experimental unit with in block

SOV MSE F-test  
Rep xx x.x  
Tment xx  
A xx x.x\*  
B xx x.x\*  
AxB xx x.x\*  
Error xx  
Total

SOV MSE F-test  
Rep xx x.x  
Main plot x.x\*  
Error a xx  
Sub plot x.x\*  
AxB xx x.x\*  
Error b xx  
Total

SOV MSE F-test  
Rep xx x.x  
Verticalstrip x.x\*  
Error a xx  
Horitalstrip x.x\*  
Error b xx  
AxB xx x.x\*  
Error c xx  
Total

SOV MSE F-test  
Rep xx x.x  
Main plot Ax.x\*  
Error a xx  
Sub plot B x.x\*  
AxB xx x.x\*  
Error b xx  
Sub-subpt x.x\*  
AxC xx x.x\*  
BxC xx x.x\*  
AxBxC xx x.x\*  
Error xx  
Total

SOV MSE F-test  
Rep xx x.x  
Vecal strip x.x\*  
Error a xx  
Hori-strip x.x\*  
Error b xx  
AxB xx x.x\*  
Error c xx  
Total

SOV MSE F-test  
Rep xx x.x  
Subplot C x.x\*  
AxC xx x.x\*  
BxC xx x.x\*  
AxBxC xx x.x\*  
Error c xx  
Total

SOV MSE F-test  
Location L x.x\*  
Repwithinsite x  
Nitrogen x.x\*  
Lx N xx x.x\*  
PoError a xx  
Variety V x.x\*  
LxV xx x.x\*  
NxV xx x.x\*  
LxNx xx x.x\*  
PoErrorb xx  
Total

SOV MSE F-test  
Row xx x.x  
Column xx x.x  
Main plot A x.x\*  
Error a xx  
Sub plot B x.x\*  
AxB xx x.x\*  
Error b xx  
Sub-subpt.Cx.x\*  
AxC xx x.x\*  
BxC xx x.x\*  
AxBxC xx x.x\*  
Error c xx  
Total

Latin square

Uniform experimental unit with in Row / column

SOV MSE F-test  
Row xx x.x  
Column xx x.x  
Tment xx  
A xx x.x\*  
B xx x.x\*  
AxB xx x.x\*  
Error xx  
Total

SOV MSE F-test  
Row xx x.x  
Column xx x.x  
Main plot x.x\*  
Error a xx  
Sub plot x.x\*  
AxB xx x.x\*  
Error b xx  
Total

SOV MSE F-test  
Row xx x.x  
Column xx x.x  
Main plot A x.x\*  
Error a xx  
Sub plot B x.x\*  
AxB xx x.x\*  
Error b xx  
Total

SOV MSE F-test  
Row xx x.x  
Column xx x.x  
A xx x.x\*  
B xx x.x\*  
C xx x.x\*  
AxB xx x.x\*  
AxC xx x.x\*  
BxC xx x.x\*  
AxBxC xx x.x\*  
Error xx  
Total

SOV MSE F-test  
Row xx x.x  
Column xx x.x  
Main plot A x.x\*  
Error a xx  
Sub plot B x.x\*  
AxB xx x.x\*  
Error b xx  
Sub-subpt.Cx.x\*  
AxC xx x.x\*  
BxC xx x.x\*  
AxBxC xx x.x\*  
Error c xx  
Total