

Contents

Preface

page 9

1	The design and analysis of experiments	
1.1	Introduction	11
1.2	Principles involved in experimentation	12
1.3	Statistical methods used in the analysis of experiments	13
1.4	Example of the interpretation of an experiment	14
1.5	Example of the use of the analysis of variance	16
1.6	Assumptions involved in the analysis of experiments	17
1.7	First steps in planning an experiment	19
1.8	Methods of improving the accuracy of an experiment	21
1.9	Choosing the design	24
1.10	Randomizing the design	25
1.11	Carrying out the analysis	29
2	Randomized blocks and Latin squares	
2.1	Randomized block design	31
2.2	Example of the analysis of a randomized block experiment	31
2.3	Testing specific comparisons	33
2.4	Testing a series of treatments	37
2.5	Latin square design	37
2.6	Example of the analysis of a Latin square experiment	39
2.7	Graeco-Latin square design	41
2.8	Efficiency of randomized blocks and Latin squares	41
2.9	Covariance analysis for the adjustment of treatment means	42
2.10	Standard errors of adjusted means	46
2.11	Significance tests in covariance analysis	47
2.12	Missing observations in a randomized block design	48
2.13	Missing observations in a Latin square design	54
3	Simple factorial and split-plot designs	
3.1	Purposes of factorial experiments	58
3.2	Example of a simple factorial experiment	59
3.3	The 2^3 factorial design	62
3.4	Example of the analysis of a 2^3 experiment	63
3.5	The 2^m factorial design	67
3.6	Designs involving factors at two levels	68
3.7	Halved-plot designs	71
3.8	Example of a halved-plot design	73
4	General factorial and split-plot designs	
4.1	Factorial designs with two sets of factors	75
4.2	Factorial designs with several sets of factors	78

4.3	Experiments with factors at many levels	78
4.4	Components of interaction	83
4.5	Interactions of quality and quantity	86
4.6	Dummy treatments	89
4.7	The general split-plot design	93
4.8	Standard errors in split-plot experiments	93
4.9	Example of a split-plot experiment	95
4.10	Covariance analysis in split-plot experiments	99
4.11	Missing split-plots	100
5	Factorial designs involving factors at two levels	
5.1	Confounding of a single comparison	102
5.2	Example of an experiment with confounding	104
5.3	Confounding of several comparisons	106
5.4	Determination of a confounded design	108
5.5	Estimation of error from high-order interactions	110
5.6	Analysis of a 2^m experiment with confounding	112
5.7	Partial confounding	112
5.8	Designs involving factors at four levels	115
6	Factorial designs involving factors at three levels	
6.1	The I and J components of interaction	117
6.2	Experiments with three factors at three levels	120
6.3	Example of a 3^3 experiment with confounding	123
6.4	Experiments with more than three factors at three levels	126
6.5	Confounding with factors at two and three levels	129
7	Fractional factorial experiments	
7.1	Fractional replication with factors at two levels	131
7.2	Confounding in fractional 2^m experiments	135
7.3	Example of a fractional factorial experiment	137
7.4	Fractional replication with factors at three levels	141
7.5	Other fractional factorial experiments	142
7.6	Sequences of fractional factorial experiments	143
8	Complex factorial designs	
8.1	Modifications to the factorial design	146
8.2	Quasi-Latin squares for 2^m experiments	146
8.3	Quasi-Latin squares for 3^m experiments	150
8.4	Split-plot confounding	152
8.5	A complex split-plot experiment	155
9	Response surface methods	
9.1	Introduction	162
9.2	First-order designs	162
9.3	Second-order designs	165
9.4	Blocking	168
9.5	Computer construction of response surface designs	169
9.6	Example of a response surface analysis	170
9.7	Examining the fitted surface	172
9.8	Experiments on mixtures	176
9.9	Mixture experiments when some components are inert or additive	179

10	Incomplete block designs for a single set of treatments	
10.1	Types of design	182
10.2	Balanced incomplete blocks	183
10.3	Example of a balanced incomplete block analysis	187
10.4	Youden squares	190
10.5	Resolvable designs	191
10.6	Other incomplete block designs	192
11	Long-term experiments	
11.1	Problems of long-term policy	196
11.2	Short-term designs involving time as a factor	196
11.3	Adjustment for residual or carry-over effects	198
11.4	Some designs for long-term experiments with stable conditions	199
11.5	Examples of the estimation of first residual effects in stable experiments	203
11.6	Complete balance for first residual effects	205
11.7	Some designs for serial experiments	208
11.8	Example of a serial experiment	211
11.9	Rotation experiments	214
12	Planning of groups of experiments	
12.1	General considerations	221
12.2	Size and number of experiments	221
12.3	Locating the experiments	223
12.4	Choosing the number of treatments	223
12.5	Choosing the designs	224
12.6	Degrees of freedom of the residual mean square	227
12.7	Sampling the experiments	228
12.8	Grouping of experimental results	229
13	Combination of experimental results	
13.1	General considerations	232
13.2	Methods of combination	232
13.3	Tests of homogeneity of variance and consistency of treatment effect	235
13.4	Combination of estimates of a single treatment effect	237
13.5	Series of similar experiments of comparable precision	239
13.6	Example of the analysis of a series of similar experiments	242
13.7	Series of experiments of differing precision	244
13.8	Combination of estimates obtained at different times and places	246
13.9	Combination of results in serial experiments	248
14	Scaling of observations	
14.1	Reasons for scaling observations	249
14.2	Scaling for additivity	250
14.3	Testing for additivity	252
14.4	The scaling of percentages—the probit transformation	254
14.5	Scaling to attain variance homogeneity	256
14.6	Scaling for non-normality	258
14.7	The half-normal plot	260
14.8	Rejection of outliers	262
14.9	Presentation of scaled observations	263
	Tables	265
	Bibliography	281
	Index	291