

APPENDIX 2: Statistics & ANOVA Tables

A2.1 Statistics

A2.1.1 Least Significant Differences

Multiple comparison tests were found to be inappropriate for the majority of the ANOVA tests. It was possible to carry out multiple comparison tests between species groups at individual light / stand levels but this was criticised as it would have involved breaking up the main experimental design (Tom Connolly, personal communication). There is much controversy surrounding the multiple comparison of group means as part of ANOVAs (Quinn & Keough, 2002). Two issues which are of particular importance include (i) the increased rate of Type 1 errors, an unavoidable consequence of multiple testing and (ii) independence of the contrasts necessary for the calculation of the family-wise Type I error. If multiple comparisons are not independent (i.e.: there are more than $p-1$ comparisons; common in unplanned pair-wise comparisons), the error rate is not easily calculated. This does not aid an appropriate adjustment of significance levels to correct for multiple testing. Of the many unplanned multiple comparison tests available, the Tukey's HSD test would be considered to be most appropriate. However it controls the family-wise Type I error rate to no more than the nominal level (0.05). As many multiple comparisons are inevitable, the error rate would be much larger than this. The alternative is to decrease the nominal level (0.05) but this has a knock on effect in reducing the power of individual comparisons that can make the unplanned tests difficult to interpret. In Chapter 3 and Chapter 5, least significant differences¹ (LSD) were appended to ANOVA plots of means to avoid rigid conclusions that can be drawn from letters above mean points.

A2.1.2 Genstat ANOVA models

Within Genstat, the BLOCKSTRUCTURE directive is used to specify the underlying (or blocking) structure of the design and the TREATMENT-STRUCTURE directive used to specify the treatment terms to be analysed by ANOVA (Payne, 2002). Treatment and block structure terms used in the main ANOVA models for Chapter 3 and Chapter 5 are outlined below.

¹ Least significant differences are the standard error of differences between means, multiplied by the t-statistic for the degrees of freedom of the standard error (Payne, 2002).

Chapter 3: Shade house trial

TREATMENT STRUCTURE TERMS: Species, Light, Species*Light

BLOCK STRUCTURE TERMS: (Rows*Column)/Rep/Pots

Chapter 5: Field trial

TREATMENT STRUCTURE TERMS: Species, Stand, Species*Stand

BLOCK STRUCTURE TERMS: Block/Strip/Rep/(Rows*Column)

The block structure model for the shade house trial (Chapter 3) specifies that the units or pots (1-15) are nested (/) within reps (1-3) which are nested within the rows (1-4) and columns (1-4) of the Latin square. The Latin Square is defined by rows crossed (*) with columns. The block structure model for the field trial (Chapter 5) specifies that each Latin square is nested (/) within reps (1-2), which are nested within stand treatment strips (1-3), which are nested within blocks (1-7).

The ANOVA tables clearly illustrate how the design structure has been incorporated into the analysis with sources of variation explained at each stratum level (below). Error terms are deduced from each stratum rather than following the philosophy of fixed and random effects (Payne, 2002). GenStat initially partitions the sums of squares according to the block model alone. This gives the total sum of squares for each of the strata. Then it partitions each stratum sum of squares into sums of squares for those treatment terms estimated in that stratum, and a residual which provides an estimate of variability against which these treatment sums of squares should be compared. The shade house trial ANOVA model has been used to illustrate how the degrees of freedom and the variance ratio has been calculated for each stratum level (Table A2.1).

Missing values in the orthogonal design were dealt with by substituting estimated values generated by Genstat's missing value estimation function (Payne, 2002). This function assumes that missing values are randomly distributed and estimates do not contribute to the sums of squares. Missing values are shown in brackets in the degree of freedom column within the ANOVA tables below.

Table A2.1 Degrees of freedom (d.f.) and variance (F) ratio calculations for the main ANOVA model in Chapter 3

Source of variation	d.f. calculation	d.f.	F ratio calculation
ROW stratum	4-1	3	row ms / residual ms 1
COLUMN stratum	4-1	3	column ms / residual ms 1
ROW.COLUMN stratum			
LIGHT	4-1	3	light ms / residual ms 1
Residual (1)	(16-1)-(3+3+3)	6	
Total	16-1	15	
ROW.COLUMN.REP stratum			row.column.rep ms / residual ms 2
Total	48-1	47	
ROW.COLUMN.REP.*Units*st			
SPECIES	15-1	14	species ms / residual ms 2
SPECIES.LIGHT	(15-1) x (4-1)	42	species.light ms / residual ms 2
Residual (2)	(720-1)- (47+14+42)	616	
TOTAL	720-1	719	

A2.2 Shade house Trial ANOVA tables (Chapter 3)

Table A2.2 Log_e plant mass

Source of variation	Degrees of Freedom (d.f.)	Sums of squares (s.s)	Mean sums of squares (m.s)	Variance Ratio (F)	Prob. value (P)
ROW stratum	3	0.847	0.282	0.61	
COLUMN stratum	3	3.881	1.290	2.81	
ROW.COLUMN stratum					
LIGHT	3	544.000	182.000	395.00	<.001
Residual	6	2.760	0.459	5.59	
ROW.COLUMN.REP stratum	32	2.630	0.082	1.26	
ROW.COLUMN.REP.*Units* st					
SPECIES	14	196.000	14.100	215.0	<.001
SPECIES.LIGHT	42	37.7	0.898	13.7	<.001
Residual	586(30)	38.3	0.065		
Total	689(30)	794.0			

Table A2.3 Log_e leaf mass

Source of variation	d.f.	s.s.	m.s.	F	P
ROW stratum	3	4.1333	1.3778	1.25	
COLUMN stratum	3	3.7021	1.2340	1.12	
ROW.COLUMN stratum					
LIGHT	3	676.4617	225.4872	204.40	<.001
Residual	6	6.6190	1.1032	3.76	
ROW.COLUMN.REP stratum	32	9.3898	0.2934	1.25	
ROW.COLUMN.REP.*Units* st					
SPECIES	14	153.7845	10.9846	46.63	<.001
SPECIES.LIGHT	42	64.9581	1.5466	6.57	<.001
Residual	586(30)	138.0373	0.2356		
Total	689(30)	1024.3723			

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Table A2.4 Log_e stem mass

Source of variation	d.f.	s.s.	m.s.	F	P
ROW stratum	3	0.69945	0.23315	0.54	
COLUMN stratum	3	3.78721	1.26240	2.93	
ROW.COLUMN stratum					
LIGHT	3	569.04677	189.68226	440.01	<.001
Residual	6	2.58649	0.43108	4.42	
ROW.COLUMN.REP stratum	32	3.12181	0.09756	1.49	
ROW.COLUMN.REP.*Units* st					
SPECIES	14	416.68577	29.76327	455.39	<.001
SPECIES.LIGHT	42	37.99696	0.90469	13.84	<.001
Residual	586(30)	38.29935	0.06536		
Total	689(30)	1025.22888			

Table A2.5 Log_e root mass

Source of variation	d.f.	s.s.	m.s.	F	P
ROW stratum	3	0.61368	0.20456	0.25	
COLUMN stratum	3	8.62997	2.87666	3.49	
ROW.COLUMN stratum					
LIGHT	3	521.89182	173.96394	211.18	<.001
Residual	6	4.94264	0.82377	6.42	
ROW.COLUMN.REP stratum	32	4.10503	0.12828	1.38	
ROW.COLUMN.REP.*Units* st					
SPECIES	14	257.45003	18.38929	197.86	<.001
SPECIES.LIGHT	42	44.03687	1.04850	11.28	<.001
Residual	586(30)	54.46361	0.09294		
Total	689(30)	865.98335			

Table A2.6 Relative growth rate per week (RGR)

Source of variation	d.f.	s.s.	m.s.	F	P
ROW stratum	3	0.0027987	0.0009329	0.61	
COLUMN stratum	3	0.0291430	0.0097143	6.39	
ROW.COLUMN stratum					
LIGHT	3	1.6855455	0.5618485	369.58	<.001
Residual	6	0.0091213	0.0015202	5.83	
ROW.COLUMN.REP stratum	32	0.0083505	0.0002610	1.08	
ROW.COLUMN.REP.*Units* st					
SPECIES	14	0.6070255	0.0433590	179.39	<.001
SPECIES.LIGHT	42	0.1171137	0.0027884	11.54	<.001
Residual	586(30)	0.1416359	0.0002417		
Total	689(30)	2.4886943			

Table A2.7 Leaf mass ratio (LMR)

Source of variation	d.f.	s.s.	m.s.	F	P
ROW stratum	3	0.018640	0.006213	0.40	
COLUMN stratum	3	0.109920	0.036640	2.36	
ROW.COLUMN stratum					
LIGHT	3	0.205894	0.068631	4.42	0.058
Residual	6	0.093238	0.015540	8.38	
ROW.COLUMN.REP stratum	32	0.059314	0.001854	0.81	
ROW.COLUMN.REP.*Units* st					
SPECIES	14	10.723561	0.765969	334.79	<.001
SPECIES.LIGHT	42	0.583205	0.013886	6.07	<.001
Residual	586(30)	1.340728	0.002288		
Total	689(30)	12.872304			

Table A2.8 Stem mass ratio (SMR)

Source of variation	d.f.	s.s.	m.s.	F	P
ROW stratum	3	0.008991	0.002997	1.49	
COLUMN stratum	3	0.034799	0.011600	5.77	
ROW.COLUMN stratum					
LIGHT	3	0.488466	0.162822	80.97	<.001
Residual	6	0.012066	0.002011	0.79	
ROW.COLUMN.REP stratum	32	0.081129	0.002535	1.47	
ROW.COLUMN.REP.*Units* st					
SPECIES	14	8.056672	0.575477	334.09	<.001
SPECIES.LIGHT	42	0.520291	0.012388	7.19	<.001
Residual	586(30)	1.009408	0.001723		
Total	689(30)	9.685232			

Table A2.9 Root mass ratio (RMR)

Source of variation	d.f.	s.s.	m.s.	F	P
ROW stratum	3	0.001946	0.000649	0.05	
COLUMN stratum	3	0.108118	0.036039	2.76	
ROW.COLUMN stratum					
LIGHT	3	1.241719	0.413906	31.72	<.001
Residual	6	0.078297	0.013050	4.24	
ROW.COLUMN.REP stratum	32	0.098547	0.003080	1.41	
ROW.COLUMN.REP.*Units* st					
SPECIES	14	2.772192	0.198014	90.79	<.001
SPECIES.LIGHT	42	0.897951	0.021380	9.80	<.001
Residual	586(30)	1.278114	0.002181		
Total	689(30)	6.318697			

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Table A2.10 Root:shoot ratio (R:S)

Source of variation	d.f.	s.s.	m.s.	F	P
ROW stratum	3	0.01647	0.00549	0.08	
COLUMN stratum	3	0.52772	0.17591	2.72	
ROW.COLUMN stratum					
LIGHT	3	6.10987	2.03662	31.52	<.001
Residual	6	0.38765	0.06461	3.61	
ROW.COLUMN.REP stratum	32	0.57259	0.01789	1.44	
ROW.COLUMN.REP.*Units* st					
SPECIES	14	12.56555	0.89754	72.16	<.001
SPECIES.LIGHT	42	4.73837	0.11282	9.07	<.001
Residual	586(30)	7.28886	0.01244		
Total	689(30)	31.53720			

Table A2.11 Leaf area ratio (LAR)

Source of variation	d.f.	s.s.	m.s.	F	P
ROW stratum	3	3.766E-05	1.255E-05	0.80	
COLUMN stratum	3	1.248E-04	4.158E-05	2.64	
ROW.COLUMN stratum					
LIGHT	3	2.624E-03	8.747E-04	55.46	<.001
Residual	6	9.464E-05	1.577E-05	3.17	
ROW.COLUMN.REF stratum	32	1.592E-04	4.974E-06	1.27	
ROW.COLUMN.REF.*Units* st					
SPECIES	13	2.151E-03	1.655E-04	42.41	<.001
SPECIES.LIGHT	39	1.766E-03	4.529E-05	11.61	<.001
Residual	542(30)	2.115E-03	3.901E-06		
Total	641(30)	8.908E-03			

Table A2.12 Log_e Specific leaf area (SLA)

Source of variation	d.f.	s.s.	m.s.	F	P
ROW stratum	3	0.28822	0.09607	2.15	
COLUMN stratum	3	0.31865	0.10622	2.37	
ROW.COLUMN stratum					
LIGHT	3	78.16584	26.05528	581.88	<.001
Residual	6	0.26866	0.04478	2.00	
ROW.COLUMN.REF stratum	32	0.71766	0.02243	0.97	
ROW.COLUMN.REF.*Units* st					
SPECIES	13	168.49377	12.96106	558.45	<.001
SPECIES.LIGHT	39	8.62444	0.22114	9.53	<.001
Residual	532(40)	12.34710	0.02321		
Total	631(40)	254.96912			

Table A2.13 Net assimilation ratio (NAR)

Source of variation	d.f.	s.s.	m.s.	F	P
ROW stratum	3	1116.6	372.2	0.15	
COLUMN stratum	3	32334.5	10778.2	4.32	
ROW.COLUMN stratum					
LIGHT	3	867286.9	289095.6	115.85	<.001
Residual	6	14972.9	2495.5	4.04	
ROW.COLUMN.REF stratum	32	19749.1	617.2	1.09	
ROW.COLUMN.REF.*Units* st					
SPECIES	13	277111.2	21316.2	37.76	<.001
SPECIES.LIGHT	39	129879.5	3330.2	5.90	<.001
Residual	541(31)	305408.3	564.5		
Total	640(31)	1602126.4			

Table A2.14 Relative height growth per week (RHG)

Source of variation	d.f.	s.s.	m.s.	F	P
ROW stratum	3	0.000238	0.000079	1.67	
COLUMN stratum	3	0.008452	0.002817	59.29	
ROW.COLUMN stratum					
LIGHT	3	0.091179	0.030393	639.60	<.001
Residual	6	0.000285	0.000048	0.67	
ROW.COLUMN.REP stratum	32	0.002259	0.000071	0.71	
ROW.COLUMN.REP.*Units* st					
SPECIES	14	0.057474	0.004105	41.28	<.001
SPECIES.LIGHT	42	0.026315	0.000627	6.30	<.001
Residual	585(31)	0.058175	0.000099		
Total	688(31)	0.232590			

Table A2.15 Relative diameter growth per week (RDG)

Source of variation	d.f.	s.s.	m.s.	F	P
ROW stratum	3	0.001053	0.000351	2.30	
COLUMN stratum	3	0.006295	0.002098	13.78	
ROW.COLUMN stratum					
LIGHT	3	0.252410	0.084135	552.60	<.001
Residual	6	0.000914	0.000152	1.88	
ROW.COLUMN.REP stratum	32	0.002592	0.000081	1.45	
ROW.COLUMN.REP.*Units* st					
SPECIES	14	0.039531	0.002824	50.49	<.001
SPECIES.LIGHT	42	0.033548	0.000799	14.28	<.001
Residual	585(31)	0.032719	0.000056		
Total	688(31)	0.353624			

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Table A2.16 Log_e Specific stem length

Source of variation	d.f.	s.s.	m.s.	F	P
ROW stratum	3	0.28540	0.09513	0.27	
COLUMN stratum	3	3.48295	1.16098	3.28	
ROW.COLUMN stratum					
LIGHT	3	361.09659	120.36553	340.55	<.001
Residual	6	2.12069	0.35345	4.43	
ROW.COLUMN.REP stratum	32	2.55484	0.07984	1.64	
ROW.COLUMN.REP.*Units* st					
SPECIES	14	114.74671	8.19619	168.33	<.001
SPECIES.LIGHT	42	18.85620	0.44896	9.22	<.001
Residual	584(32)	28.43612	0.04869		
Total	687(32)	506.15194			

Table A2.17 Log_e diameter/height ratio

Source of variation	d.f.	s.s.	m.s.	F	P
ROW stratum	3	0.02391	0.00797	0.12	
COLUMN stratum	3	0.57674	0.19225	2.95	
ROW.COLUMN stratum					
LIGHT	3	25.43957	8.47986	130.28	<.001
Residual	6	0.39054	0.06509	2.14	
ROW.COLUMN.REP stratum	32	0.97188	0.03037	0.89	
ROW.COLUMN.REP.*Units* st					
SPECIES	14	41.31812	2.95129	86.31	<.001
SPECIES.LIGHT	42	5.07536	0.12084	3.53	<.001
Residual	584(32)	19.96933	0.03419		
Total	687(32)	90.42886			

Table A2.18 Square root (number of leaves)

Source of variation	d.f.	s.s.	m.s.	F	P
ROW stratum	3	42.470	14.157	1.31	
COLUMN stratum	3	108.997	36.332	3.37	
ROW.COLUMN stratum					
LIGHT	3	3716.560	1238.853	114.82	<.001
Residual	6	64.735	10.789	1.89	
ROW.COLUMN.REP stratum	32	183.080	5.721	0.93	
ROW.COLUMN.REP.*Units* st					
SPECIES	12	7390.964	615.914	99.87	<.001
SPECIES.LIGHT	36	1018.818	28.301	4.59	<.001
Residual	500(28)	3083.637	6.167		
Total	595(28)	14266.175			

A2.3 Chapter 5: Field Trial ANOVA Tables (Chapter 5)

Table A2.19 Relative height growth per week 2001 (RHG)

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	0.002117	0.000353	0.61	
BLOCK.STRIP stratum					
STAND	2	0.011138	0.005569	9.64	0.003
Residual	12	0.006935	0.000578	3.75	
BLOCK.STRIP.REP stratum	21	0.003237	0.000154		
BLOCK.STRIP.REP.ROW st	126	0.011283	0.000089	0.86	
BLOCK.STRIP.REP.COLUMN st	126	0.010177	0.000081	0.78	
BLOCK.STRIP.REP.ROW.COLUMN st					
SPECIES	3	0.104102	0.034701	333.06	<.001
SPECIES.STAND	6	0.000602	0.000100	0.96	0.450
Residual	345(24)	0.035945	0.000104		
Total	647(24)	0.173409			

Table A2.20 Relative diameter growth per week 2001 (RDG)

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	0.004171	0.000695	4.98	
BLOCK.STRIP stratum					
STAND	2	0.011316	0.005658	40.54	<.001
Residual	12	0.001675	0.000139	2.11	
BLOCK.STRIP.REP stratum	21	0.001391	0.000066		
BLOCK.STRIP.REP.ROW stratum	126	0.008633	0.000069		0.92
BLOCK.STRIP.REP.COLUMN st	126	0.009859	0.000078		1.06
BLOCK.STRIP.REP.ROW.COLUMN st					
SPECIES	3	0.014193	0.004731	63.82	<.001
SPECIES.STAND	6	0.001976	0.000329	4.44	<.001
Residual	344(25)	0.025499	0.000074		
Total	646(25)	0.075551			

Table A2.21 Log_e diameter:height 2001

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	1.21915	0.20319	0.95	
BLOCK.STRIP stratum					
STAND	2	11.59916	5.79958	26.99	<.001
Residual	12	2.57883	0.21490	5.22	
BLOCK.STRIP.REP stratum	21	0.86480	0.04118		
BLOCK.STRIP.REP.ROW stratum	126	3.41202	0.02708	0.80	
BLOCK.STRIP.REP.COLUMN stratum	126	4.20160	0.03335	0.98	
BLOCK.STRIP.REP.ROW.COLUMN stratum					
SPECIES	3	40.62253	13.54084	399.33	<.001
SPECIES.STAND	6	0.36408	0.06068	1.79	0.100
Residual	344(25)	11.66478	0.03391		
Total	646(25)	73.67978			

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Table A2.22 Leaf chlorophyll 2001

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	683.57	113.93	1.52	
BLOCK.STRIP stratum					
STAND	2	1516.20	758.10	10.09	0.003
Residual	12	902.04	75.17	1.17	
BLOCK.STRIP.REP stratum	21	1353.03	64.43		
BLOCK.STRIP.REP.ROW stratum	126	5729.81	45.47	0.98	
BLOCK.STRIP.REP.COLUMN stratum	126	5674.19	45.03	0.97	
BLOCK.STRIP.REP.ROW.COLUMN st					
SPECIES	3	31982.67	10660.89	228.81	<.001
SPECIES.STAND	6	2712.96	452.16	9.70	<.001
Residual	319(50)	14862.95	46.59		
Total	621(50)	61180.53			

Table A2.23 Relative height growth per week 2002 (RHG)

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	0.001816	0.000303	1.64	
BLOCK.STRIP stratum					
STAND	2	0.000024	0.000121	0.07	0.937
Residual	12	0.002214	0.000185	2.32	
BLOCK.STRIP.REP stratum	21	0.001669	0.000079		
BLOCK.STRIP.REP.ROW st	126	0.007910	0.000063	1.43	
BLOCK.STRIP.REP.COLUMN st	126	0.009000	0.000071	1.62	
BLOCK.STRIP.REP.ROW.COLUMN					
SPECIES	3	0.017627	0.005876	133.4	<.001
SPECIES.STAND	6	0.002958	0.000493	11.19	<.001
Residual	258(111)	0.011363	0.000044		
Total	560(111)	0.044987			

Table A2.24 Relative diameter growth 2002 (RDG)

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	0.000566	0.000094	0.66	
BLOCK.STRIP stratum					
STAND	2	0.000042	0.000021	0.15	0.866
Residual	12	0.001713	0.000143	2.31	
BLOCK.STRIP.REP stratum	21	0.001300	0.000062		
BLOCK.STRIP.REP.ROW stratum	126	0.008051	0.000064	1.97	
BLOCK.STRIP.REP.COLUMN st	126	0.007037	0.000056	1.72	
BLOCK.STRIP.REP.ROW.COLUMN st					
SPECIES	3	0.012556	0.004185	128.8	<.001
SPECIES.STAND	6	0.003032	0.000505	15.55	<.001
Residual	258(111)	0.008384	0.000032		
Total	560(111)	0.035236			

Table A2.25 Log_e diameter:height ratio 2002

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	2.50979	0.41830	1.52	
BLOCK.STRIP stratum					
STAND	2	12.44533	6.22267	22.66	<.001
Residual	12	3.29550	0.27462	6.08	
BLOCK.STRIP.REP stratum	21	0.94834	0.04516		
BLOCK.STRIP.REP.ROW stratum	126	5.31280	0.04217	1.19	
BLOCK.STRIP.REP.COLUMN strat	126	6.52526	0.05179	1.47	
BLOCK.STRIP.REP.ROW.COLUMN st					
SPECIES	3	53.78818	17.92939	507.91	<.001
SPECIES.STAND	6	0.91699	0.15283	4.33	<.001
Residual	260(109)	9.17808	0.03530		
Total	562(109)	80.79882			

Table A2.26 Log_e Leader:lateral ratio

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	23.802	3.967	1.80	
BLOCK.STRIP stratum					
STAND	2	12.113	6.056	2.75	0.104
Residual	12	26.404	2.200	2.21	
BLOCK.STRIP.REP stratum	21	20.879	0.994		
BLOCK.STRIP.REP.ROW stratum	126	168.552	1.338	1.05	
BLOCK.STRIP.REP.COLUMN stratum	126	185.540	1.473	1.15	
BLOCK.STRIP.REP.ROW.COLUMNst					
SPECIES	3	234.003	78.001	61.16	<.001
SPECIES.STAND	6	38.055	6.342	4.97	<.001
Residual	235(134)	299.696	1.275		
Total	537(134)	796.638			

Table A2.27 Number of leaves (square-rooted)

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	119.988	19.998	2.59	
BLOCK.STRIP stratum					
STAND	2	0.465	0.233	0.03	0.970
Residual	12	92.558	7.713	1.27	
BLOCK.STRIP.REP stratum	21	127.526	6.073		
BLOCK.STRIP.REP.ROW stratum	126	667.156	5.295	1.37	
BLOCK.STRIP.REP.COLUMN stratum	126	783.032	6.215	1.61	
BLOCK.STRIP.REP.ROW.COLUMN st					
SPECIES	3	1567.146	522.382	135.41	<.001
SPECIES.STAND	6	191.574	31.929	8.28	<.001
Residual	247(122)	952.870	3.858		
Total	549(122)	3452.323			

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Table A2.28 Number of branches (square-rooted)

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	7.2288	1.2048	2.37	
BLOCK.STRIP stratum					
STAND	2	1.0516	0.5258	1.03	0.385
Residual	12	6.0990	0.5082	1.61	
BLOCK.STRIP.REP stratum	21	6.6472	0.3165		
BLOCK.STRIP.REP.ROW stratum	126	44.7542	0.3552	1.37	
BLOCK.STRIP.REP.COLUMN stratum	126	56.2351	0.4463	1.72	
BLOCK.STRIP.REP.ROW.COLUMN st					
SPECIES	3	171.9281	57.3094	221.07	<.001
SPECIES.STAND	6	3.2752	0.5459	2.11	0.053
Residual	239(130)	61.9567	0.2592		
Total	541(130)	280.0179			

Table A2.29 Log_e Leaf area

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	0.004983	0.000831	2.11	
BLOCK.STRIP stratum					
STAND	2	0.001983	0.000992	2.52	0.122
Residual	12	0.004717	0.000393		
BLOCK.STRIP.ROW stratum	63	0.016395	0.000260	1.29	
BLOCK.STRIP.COLUMN stratum	63	0.012723	0.000202	1.00	
BLOCK.STRIP.ROW.COLUMN st					
SPECIES	3	0.047064	0.015688	77.48	<.001
SPECIES.STAND	6	0.001647	0.000275	1.36	0.238
Residual	117(63)	0.023691	0.000203		
Total	272(63)	0.096835			

Table A2.30 Log_e leaf mass

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	14.7923	2.4654	0.91	
BLOCK.STRIP stratum					
STAND	2	11.2692	5.6346	2.07	0.169
Residual	12	32.6220	2.7185	3.40	
BLOCK.STRIP.REP stratum	21	16.7825	0.7992		
BLOCK.STRIP.REP.ROW stratum	126	147.6021	1.1714	1.63	
BLOCK.STRIP.REP.COLUMN stratum	126	127.4235	1.0113	1.41	
BLOCK.STRIP.REP.ROW.COLUMN st					
SPECIES	3	631.6185	210.5395	293.50	<.001
SPECIES.STAND	6	23.0571	3.8429	5.36	<.001
Residual	254(115)	182.2062	0.7173		
Total	556(115)	969.2283			

Table A2.31 Log_e stem mass

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	0.9550	0.1592	0.19	
BLOCK.STRIP stratum					
STAND	2	5.0447	2.5223	3.01	0.087
Residual	12	10.0401	0.8367	3.32	
BLOCK.STRIP.REP stratum	21	5.2973	0.2523		
BLOCK.STRIP.REP.ROW stratum	126	39.4254	0.3129	1.41	
BLOCK.STRIP.REP.COLUMN stratum	126	34.5738	0.2744	1.23	
BLOCK.STRIP.REP.ROW.COLUMN st					
SPECIES	3	36.9196	12.3065	55.37	<.001
SPECIES.STAND	6	10.2909	1.7151	7.72	<.001
Residual	254(115)	56.4550	0.2223		
Total	556(115)	163.2701			

Table A2.32 Log_e root mass

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	3.5128	0.5855	0.73	
BLOCK.STRIP stratum					
STAND	2	28.7868	14.3934	17.92	<.001
Residual	12	9.6386	0.8032	2.66	
BLOCK.STRIP.REP stratum	21	6.3372	0.3018		
BLOCK.STRIP.REP.ROW stratum	126	36.8568	0.2925	1.35	
BLOCK.STRIP.REP.COLUMN stratum	126	35.1450	0.2789	1.29	
BLOCK.STRIP.REP.ROW.COLUMN st					
SPECIES	3	65.6767	21.8922	100.95	<.001
SPECIES.STAND	6	14.1881	2.3647	10.90	<.001
Residual	250(119)	54.2138	0.2169		
Total	552(119)	213.1334			

Table A2.33 Log_e total plant mass

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	2.2965	0.3828	0.48	
BLOCK.STRIP stratum					
STAND	2	9.7667	4.8834	6.18	0.014
Residual	12	9.4750	0.7896	3.62	
BLOCK.STRIP.REP stratum	21	4.5777	0.2180		
BLOCK.STRIP.REP.ROW stratum	126	34.8657	0.2767	1.40	
BLOCK.STRIP.REP.COLUMN stratum	126	32.4250	0.2573	1.30	
BLOCK.STRIP.REP.ROW.COLUMN st					
SPECIES	3	78.5199	26.1733	132.08	<.001
SPECIES.STAND	6	13.6115	2.2686	11.45	<.001
Residual	251(118)	49.7381	0.1982		
Total	553(118)	194.1851			

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Table A2.34 Relative growth rate per week

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	0.002165	0.00036	0.61	
BLOCK.STRIP stratum					
STAND	2	0.007150	0.00357	6.03	0.015
Residual	12	0.007119	0.00059	0.62	
BLOCK.STRIP.REP stratum	21	0.020037	0.00095	2.78	
BLOCK.STRIP.REP.*Units* stratum					
SPECIES	2	0.063696	0.03185	92.84	<.001
SPECIES.STAND	4	0.007366	0.00184	5.37	<.001
Residual	358(98)	0.122803	0.00034		
Total	405(98)	0.208570			

Table A2.35 Log_e leaf area ratio (LAR)

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	3.4461	0.5744	1.17	
BLOCK.STRIP stratum					
STAND	2	15.8572	7.9286	16.13	<.001
Residual	12	5.8967	0.4914		
BLOCK.STRIP.ROW stratum	63	20.9801	0.3330	1.37	
BLOCK.STRIP.COLUMN stratum	63	36.3891	0.5776	2.37	
BLOCK.STRIP.ROW.COLUMN st					
SPECIES	3	40.1216	13.3739	54.82	<.001
SPECIES.STAND	6	5.4367	0.9061	3.71	0.002
Residual	113(67)	27.5653	0.2439		
Total	268(67)	112.7886			

Table A2.36 Log_e specific leaf area (SLA)

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	1.69441	0.28240	4.36	
BLOCK.STRIP stratum					
STAND	2	6.54970	3.27485	50.59	<.001
Residual	12	0.77676	0.06473		
BLOCK.STRIP.ROW stratum	63	4.54796	0.07219	1.58	
BLOCK.STRIP.COLUMN stratum	63	3.33182	0.05289	1.16	
BLOCK.STRIP.ROW.COLUMN st					
SPECIES	3	104.8047	34.93491	763.56	<.001
SPECIES.STAND	6	0.64855	0.10809	2.36	0.035
Residual	114(66)	5.21579	0.04575		
Total	269(66)	102.8646			

Table A2.37 Log_e net assimilation rate (NAR)

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	5.2198	0.8700	2.25	
BLOCK.STRIP stratum					
SPECIES	2	4.9559	2.4780	6.41	0.013
Residual	12	4.6412	0.3868	1.45	
BLOCK.STRIP.*Units* stratum					
STAND	2	10.8033	5.4017	20.26	<.001
SPECIES.STAND	4	4.9571	1.2393	4.65	0.001
Residual	168(57)	44.7880	0.2666		
Total	194(57)	70.2853			

Table A2.38 Leaf mass ratio (LMR)

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	0.091793	0.015299	1.03	
BLOCK.STRIP stratum					
STAND	2	0.258004	0.129002	8.72	0.005
Residual	12	0.177625	0.014802	4.08	
BLOCK.STRIP.REP stratum	21	0.076206	0.003629		
BLOCK.STRIP.REP.ROW stratum	126	0.720240	0.005716	1.60	
BLOCK.STRIP.REP.COLUMN stratum	126	0.755275	0.005994	1.68	
BLOCK.STRIP.REP.ROW.COLUMN st					
SPECIES	3	6.900149	2.300050	645.35	<.001
SPECIES.STAND	6	0.226230	0.037705	10.58	<.001
Residual	251(118)	0.894567	0.003564		
Total	553(118)	8.052055			

Table A2.39 Stem mass ratio (SMR)

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	0.154036	0.025673	1.56	
BLOCK.STRIP stratum					
STAND	2	0.282668	0.141334	8.57	0.005
Residual	12	0.197979	0.016498	3.26	
BLOCK.STRIP.REP stratum	21	0.106136	0.005054		
BLOCK.STRIP.REP.ROW stratum	126	0.647374	0.005138	1.49	
BLOCK.STRIP.REP.COLUMN stratum	126	0.664967	0.005278	1.53	
BLOCK.STRIP.REP.ROW.COLUMN st					
SPECIES	3	5.237559	1.745853	504.61	<.001
SPECIES.STAND	6	0.165593	0.027599	7.98	<.001
Residual	250(119)	0.864958	0.003460		
Total	552(119)	6.807085			

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Table A2.40 Root mass ratio (RMR)

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	0.166381	0.027730	0.79	
BLOCK.STRIP stratum					
STAND	2	0.750253	0.375126	10.66	0.002
Residual	12	0.422447	0.035204	5.56	
BLOCK.STRIP.REP stratum	21	0.133011	0.006334		
BLOCK.STRIP.REP.ROW stratum	126	0.871268	0.006915	1.78	
BLOCK.STRIP.REP.COLUMN stratum	126	0.752798	0.005975	1.54	
BLOCK.STRIP.REP.ROW.COLUMN st					
SPECIES	3	0.593334	0.197778	50.94	<.001
SPECIES.STAND	6	0.049871	0.008312	2.14	0.049
Residual	250(119)	0.970642	0.003883		
Total	552(119)	3.593667			

Table A2.41 Log_e ingrowth of foreign roots

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	29.4163	4.9027	1.38	
BLOCK.STRIP stratum					
STAND	2	20.8986	10.4493	2.94	0.091
Residual	12	42.6575	3.5548		
BLOCK.STRIP.ROW stratum	63	58.8871	0.9347	1.74	
BLOCK.STRIP.COLUMN stratum	63	89.6671	1.4233	2.64	
BLOCK.STRIP.ROW.COLUMN st					
SPECIES	3	2.6592	0.8864	1.65	0.183
SPECIES.STAND	6	7.2700	1.2117	2.25	0.043
Residual	117(63)	63.0316	0.5387		
Total	272(63)	241.8788			

Table A2.42 Frequency of over-topping vegetation (proportion arcsine square-rooted)

Source of variation	d.f.	s.s.	m.s.	F	P
BLOCK stratum	6	4.41139	0.73523	2.25	
BLOCK.STRIP stratum					
STAND	2	11.66302	5.83151	17.83	<.001
Residual	12	3.92442	0.32703	2.06	
BLOCK.STRIP.REP stratum	21	3.33388	0.15876		
BLOCK.STRIP.REP.ROW stratum	126	11.26087	0.08937	2.03	
BLOCK.STRIP.REP.COLUMN stratum	126	12.09621	0.09600	2.18	
BLOCK.STRIP.REP.ROW.COLUMN st					
SPECIES	3	4.39512	1.46504	33.25	<.001
SPECIES.STAND	6	0.96511	0.16085	3.65	0.002
Residual	285(84)	12.55833	0.04406		
Total	587(84)	53.03510			

Table A2.43 pH

Source of variation	d.f.	s.s.	m.s.	F	P
Block stratum	6	1.29393	0.21566	2.27	
Block.Strip stratum					
Stand	2	0.30007	0.15003	1.58	0.247
Residual	12	1.14227	0.09519	5.89	
Block.Strip.Orientation stratum					
	63	1.01780	0.01616		
Total	83	3.75407			

Table A2.44 Wilson mean site values

Source of variation	d.f.	s.s.	m.s.	F	P
Block stratum	6	0.136990	0.022832	3.26	
Block.Strip stratum					
Stand	2	0.199267	0.099633	14.22	<.001
Residual	12	0.084067	0.007006		
Total	20	0.420324			

Table A2.45 Volumetric soil moisture content for August 2001 (calibrated readings)

Source of variation	d.f.	s.s.	m.s.	F	P
Block stratum	6	0.266926	0.044488	0.59	
Block.Strip stratum					
Stand	2	0.812043	0.406021	5.36	0.022
Residual	12	0.909797	0.075816	5.19	
Block.Strip.Rep stratum	21	0.307055	0.014622	2.43	
Block.Strip.Rep.Pit stratum					
	41(1)	0.246209	0.006005		
Total	82(1)	2.510326			

Table A2.46 Volumetric soil moisture content for August 2002 (calibrated readings)

Source of variation	d.f.	s.s.	m.s.	F	P
Block stratum	6	0.248297	0.041383	0.74	
Block.Strip stratum					
Stand	2	0.248254	0.124127	2.23	0.150
Residual	12	0.666812	0.055568	5.24	
Block.Strip.Rep stratum	21	0.222608	0.010600	1.36	
Block.Strip.Rep.Pit stratum					
	42	0.326571	0.007776		
Total	83	1.712541			

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Table A2.47 Anaerobic depth

Source of variation	d.f.	s.s.	m.s.	F	P
Block stratum	6	126894.	21149.	1.00	
Block.Strip stratum					
Stand	2	139728.	69864.	3.30	0.076
Residual	11(1)	233198.	21200.		
Total	19(1)	451534.			

Table A2.48 Arcsine square-root of *Calluna vulgaris* proportion

Source of variation	d.f.	s.s.	m.s.	F	P
Block stratum	6	0.29732	0.04955	2.41	
Block.Strip stratum					
Stand	2	1.64244	0.82122	39.92	<.001
Residual	12	0.24684	0.02057		
Total	20	2.18660			

A2.4 *Sorbus aucuparia* Field Trial (Chapter 6)

A2.4.1 Main study

Table A2.49 Arcsine square-root of light proportion

Source of variation	d.f.	s.s.	m.s.	F	P
Block stratum	5	0.48187	0.09637	2.77	
Block.*Units* stratum					
Treatment	1	7.95469	7.95469	228.57	<.001
Residual	113	3.93258	0.03480		
Total	119	12.36913			

Table A2.50 Arcsine square-root of *Calluna vulgaris* proportion

Source of variation	d.f.	s.s.	m.s.	F	P
Block stratum	5	6.4265	1.2853	8.48	
Block.*Units* stratum					
Treatment	1	0.3310	0.3310	2.18	0.142
Residual	113	17.1302	0.1516		
Total	119	23.8877			

Table A2.51 Log_e stem height

Source of variation	d.f.	s.s.	m.s.	F	P
Block stratum	5	5.36322	1.07264	10.97	
Block.*Units* stratum					
Treatment	1	0.66718	0.66718	6.82	0.010
Residual	110(3)	10.75719	0.09779		
Total	116(3)	16.56189			

Table A2.52 Log_e basal diameter

Source of variation	d.f.	s.s.	m.s.	F	P
Block stratum	5	4.2540	0.8508	7.93	
Block.*Units* stratum					
Treatment	1	0.0053	0.0053	0.05	0.825
Residual	111(2)	11.9051	0.1073		
Total	117(2)	16.1607			

Table A2.53 Log_e basal diameter:height ratio

Source of variation	d.f.	s.s.	m.s.	F	P
Block stratum	5	0.31326	0.06265	1.07	
Block.*Units* stratum					
Treatment	1	0.59703	0.59703	10.21	0.002
Residual	108(5)	6.31712	0.05849		
Total	114(5)	7.17082			

Table A2.54 Log_e stem height increment 2001

Source of variation	d.f.	s.s.	m.s.	F	P
Block stratum	5	5.9878	1.1976	1.88	
Block.*Units* stratum					
Treatment	1	4.3534	4.3534	6.84	0.010
Residual	110(3)	69.9869	0.6362		
Total	116(3)	80.0997			

A2.4.2 Wilkin's study

Table A2.55 Arcsine square-root *C.vulgaris* proportion

Source of variation	d.f.	s.s.	m.s.	F	P
Block stratum	5	1.4365	0.2873	2.08	
Block.*Units* stratum					
Stand	1	1.4251	1.4251	10.34	0.002
Residual	113	15.5739	0.1378		
Total	119	18.4355			

Table A2.56 Log_e Stem height

Source of variation	d.f.	s.s.	m.s.	F	P
Block stratum	5	5.6811	1.1362	5.95	
Block.*Units* stratum					
Stand	1	3.3145	3.3145	17.34	<.001
Residual	113	21.5957	0.1911		
Total	119	30.5913			

Appendix 2

Table A2.57 Square-root of seedling number (abundance)

Source of variation	d.f.	s.s.	m.s.	F	P
Block stratum	5	7.4223	1.4845	3.15	
Block.*Units* stratum					
Stand	1	10.0270	10.0270	21.29	<.001
Residual	113	53.2163	0.4709		
Total	119	70.6656			

Table A2.58 Two way ANOVA: Seedling number (Square rooted)

Source of variation	d.f.	s.s.	m.s.	F	P
Light	1	4.4871	4.4871	7.55	0.008
Calluna	1	1.6996	1.6996	2.86	0.096
Light.Calluna	1	0.0072	0.0072	0.01	0.913
Residual	60	35.6485	0.5941		
Total	63	41.8424			

Table A2.59 Two way ANOVA: Log_e seedling height

Source of variation	d.f.	s.s.	m.s.	F	P
Stand	1	2.0340	2.0340	10.13	0.002
Calluna	1	0.2001	0.2001	1.00	0.322
Stand.Calluna	1	0.0179	0.0179	0.09	0.767
Residual	60	12.0515	0.2009		
Total	63	14.3034			