The Analysis of Variance of the Stem Analysis

Kinashi, Kenkichi
Kyushu University

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Kenkichi KINASHI

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The stem analysis, so-called, is usually the record of growth which shows by each section and each year. Growth may be represented by wood volume, but sometimes it must be replaced with some material characteristics.

Investigating wood quality, it must be necessary to examine the relation between the quality and the part of bole or stem. The part or location of stem material may be represented by section and age ring, like some multiple circular coordinate. So if the location is the factor, there must be three definite factors, height (section), age (tree age ring) and direction (N, E, S, W).

Nell Ditchburne showed the analysis of variance in triangular form in her article "A Method of Analysis for a Double Classification arranged in Triangular Tables", in Biometrics Vol. 11, No. 4, (1955).

It may be applicable to the stem analysis, as I have tried to show (1965). But the stem analysis is not exact triangular form. Some additional comparisons should be added. Moreover, if there is interaction effect between main factors, the basic assumption that interactions do not exist will be denied. And the data must be set to make interaction term. Here one case shows one example of *Eucalyptus regnans* after Higgs.

	DF	Ring (Ht. elim.)	Ht. (R.elim.)	MS	F
Tree	3	1.6047	1.6047	0.5349	22.57
Rings	6	**1.8760**	1.7988	0.3129	13.19
Heights	7	0.2916	**0.3688**	0.0526	2.22
RxH	28	1.1564	1.1564	0.0413	1.74
Error	128	2.9235	2.9235	0.0237	
Total	167	7.8522	7.8522		

Data are 4 trees. 8 sections (BH, 10%, 20%, 30%, 40%, 50%, 70%, 90%) and annual ring width (cm) (2, 6, 10, 14, 18, 22, 26 years). RxH is significant at 5% level but not significant at 1% level.

On this and past experience, a significant interaction between height and ring ages generally exists.

Stem Analysis of Annual Ring Width (cm) *E. regnans* (after Higgs)

		Ring No. from Bark							Total for Ring				
Ht. Level	Tree No	2	6	10	14	18	22	26	2 to 26	2 to 22	2 to 18	2 to 10	2 to 6
BH	2	0.55	0.75	0.55	0.90	0.90	0.65	0.70					
	3	0.50	0.65	0.55	0.80	0.65	0.75	0.60					
	5	1.00	0.45	0.55	0.45	0.70	0.75	1.15					
	9	0.50	0.75	0.45	0.65	0.55	0.50	0.80					
	Σ	2.55	2.60	2.10	2.80	2.80	2.65	3.25	18.75	15.50	12.85	7.25	5.15

10%	2	0.55	0.80	0.80	0.75	0.55	0.75	0.75					
	3	0.60	1.05	0.60	0.60	1.00	0.90	0.85					
	5	0.75	0.40	0.55	0.45	0.45	1.15	1.00					
	9	0.55	0.55	0.40	0.40	0.45	0.50	0.65					
	Σ	2.45	2.80	2.35	2.20	2.45	3.30	3.25	18.80	15.55	12.25	7.60	5.25
20%	2	0.55	0.55	0.70	0.70	0.75	0.95	0.75					
	3	0.40	0.50	0.55	0.75	1.00	1.00	1.00					
	5	0.70	0.40	0.60	0.35	0.45	1.15	0.90					
	9	0.40	0.40	0.30	0.25	0.40	0.75	0.80					
	Σ	2.05	1.85	2.15	2.05	2.65	3.85	3.45	18.05	14.60	10.75	6.05	3.90
30%	2	0.35	0.65	0.75	0.65	0.70	1.30						
	3	0.40	0.40	0.60	0.90	0.75	0.95						
	5	0.45	0.35	0.40	0.60	0.55	0.90						
	9	0.35	0.45	0.40	0.35	0.40	0.50						
	Σ	1.55	1.85	2.15	2.50	2.40	3.65			14.10	10.45	5.55	3.40
40%	2	0.40	0.55	0.65	0.65	0.85							
	3	0.75	0.65	0.75	0.95	1.15							
	5	0.40	0.45	0.75	0.40	0.75							
	9	0.40	0.35	0.30	0.25	0.35							
	Σ	1.95	2.00	2.45	2.25	3.05					11.70	6.40	3.95
50%	2	0.40	0.60	0.80	0.60	0.90							
	3	0.40	0.65	0.75	1.00	0.55							
	5	0.35	0.45	0.50	0.65	0.70							
	9	0.35	0.40	0.40	0.45	0.45							
	Σ	1.50	2.10	2.45	2.70	2.60					11.35	6.05	3.60
70%	2	0.70	0.70	0.95									
	3	0.40	0.75	1.10									
	5	0.40	0.50	0.90									
	9	0.40	0.50	0.70									
	Σ	1.90	2.45	3.65								8.00	4.35
90%	2	0.45	0.80										
	3	0.60	0.90										
	5	0.60	0.80										
	9	0.50	0.75										
	Σ	2.15	3.25										5.40
												Total	106.15

Total for ht.								Total for all		
BH to 90	16.10	18.90							No. 2	29.30
BH to 70	13.95	15.65	17.30						No. 3	30.65
BH to 50	12.05	13.20	13.65	14.50	15.95				No. 5	26.20
BH to 30	8.60	9.10	8.75	9.55	10.30	13.45		Total	No. 9	20.00
BH to 20	7.05	7.25	6.60	7.05	7.90	9.80	9.95	106.15	Σ	106.15

Sum of Squares:

Trees. $(29.30^2+30.65^2+26.20^2+20.00^2)/42-(106.15)^2/168=68.6750-67.0703=1.6047$

Rings (a) unadiusted for height effeet

$(16.10^2/32+18.90^2/32+17.30^2/28+14.50^2/24+15.95^2/24+13.45^2/16+9.95^2/12)-67.0703$
$=(8.1003+11.1628+10.6889+8.7604+10.6001+11.3064+8.2502)-67.0703=1.7988$

(b) with height effect eliminated

$(18.90-16.10)^2/(2\times32)=7.84/64=0.1225$
$(2\times17.30-15.65-13.95)^2/(6\times28)=25/168=0.1488$
$(3\times15.95+3\times14.50-2\times13.65-2\times13.20-2\times12.05)^2/(30\times24)=183.6025/720=0.2550$
$(5\times13.45-10.30-9.55-8.75-9.10-8.60)^2/(30\times16)=438.9025/480=0.9143$
$(6\times9.95-9.80-7.90-7.05-6.60-7.25-7.05)^2/(42\times12)=197.4025/504=0.3916$
* $(15.95-14.50)^2/2\times24=2.1025/48=0.0438$ $\sum=1.8760$

Height (a) unadjusted for ring effect

$(18.75^2/28+18.80^2/28+18.05^2/28+14.10^2/24+11.70^2/20+11.35^2/20+8.00^2/12$
$+5.40^2/8)-67.0703=(12.5558+12.6228+11.6358+8.2837+6.8445+6.4411+5.3333$
$+3.6450)-67.0703=67.3620-67.0703=0.2917$

(b) with ring effect eliminated

* $(18.80-18.75)^2/(2\times28)=0.0025/56=0.0000$
$(2\times18.05-18.80-18.75)^2/(6\times28)=2.1025/168=0.0125$
$(3\times14.10-14.60-15.55-15.50)^2/(12\times24)=11.2225/288=0.0389$
* $(11.35-11.70)^2/(2\times20)=0.1225/40=0.0030$
$\{2\times(11.35+11.70)-10.45-10.75-12.25-12.85\}^2/(12\times20)=0.0400/240=0.0001$
$(6\times8.00-6.05-6.40-5.55-6.05-7.60-7.25)^2/(42\times12)=82.81/504=0.1643$
$(7\times5.40-4.35-3.60-3.95-3.40-3.90-5.25-5.15)^2/(56\times8)=67.24/448=0.1500$
$\sum=0.3688$

ck: $1.7988+0.3688=2.1676$ $1.8760+0.2917=2.1677$

Interaction of Ring and Height

$(2.55^2+2.60^2+2.10^2+\cdots+3.25^2)/4-67.0703-1.8760-0.2916$
or $-1.7988-0.3688=1.1564$

Total

$(0.55^2+0.75^2+\cdots\cdots+0.75^2)-67.0703=(13.3725+13.8400+13.1900+9.6400+8.0075+7.1125$
$+5.9350+3.8250)-67.0703=74.9225-67.0703=7.8522$

Figgs: Doctoral thesis, Australia National University, 1969.