NOTE

A NOTE ON THE EFFECT OF OUTLIERS ON THE VARIABILITY IN *ACACIA AURICULIFORMIS* TRIALS

P. Venkateswarlu & Kamis Awang*

F/FRED - Winrock International, P.O. Box 1038, Kasetsart University, Bangkok, Thailand

Outliers in experiments arise for various reasons, *e.g.*, rare fertility patches, incorrect assignment of treatments, *etc.* The classical analysis of variance method of fitting constants will tend to provide biased and inefficient estimates of treatment effects if there are some outlying observations amidst the data values. The question is how does one test whether a suspected datum is an outlier or not?

The purpose of this note is to illustrate Tiku's robust procedure for the detection of outliers (Tiku *et al.* 1986) with experimental data from *Acacia auriculiformis* provenance trials, and to compare the estimates of error variances where outliers have been included and excluded.

Tree height data from collaborative *A. auriculiformis* provenance trials sponsored by the Multipurpose Tree Species (MPTS) Research Network were used to determine the effect of outliers on experimental variability. The trials, each of six replications with 25 provenances of *A. auriculiformis*, were carried out at eight locations in Southeast Asia. Although all eight data sets were examined for the presence of outliers, we have selected one from location 7 for illustration here.

Outliers were determined by plotting least square residuals (Table 1) against the cumulative probability values in a Q-Q plot (Figure 1). Residuals corresponding to Provenance 18 in the 1st and 5th replications, and Provenance 23 in the 1st replication (marked a,b,c) were located away from other data points lying on a nearly straight line.

Thus, the observations of these three points were suspected outliers. The test for data anomaly and detection of outliers was performed and analysis of variance (Table 2) was computed using the 'FIT' directive of GENSTAT (1983) at the ICRISAT Center in India.

The following procedure tests whether removal of outliers results in a significant reduction in residual mean squares. To test whether suspected points were in fact outliers, the difference in the residual sums of squares (CSS) and difference in degrees of freedom (CDF) were calculated using the following formulae:

$$CSS = RSS1 - RSS2$$
$$CDF = DF_{RSS1} - DF_{RSS2}$$
$$F_{cal} = (CSS \div CDF) \div RMS2$$

* *Present address: Faculty of Forestry, Universiti Pertanian Malaysia, 43400 Serdang, Selangor Darul Ehsan, Malaysia*

where

RSS1	=	Residual sums of squares for compete data set
RSS2	=	Residual sums of squares without outliers
DF_{RSS1}	=	Residual df for complete data set
DF_{RSS2}	=	Residual df without outliers
F_{cal}	=	Calculated F-value
RMS2	=	Residual mean sums of squares without outlier

Fitting appropriate values in the formulae, we get the following results:

CSS = 207.612 - 118.221 = 89.391

CDF = 120 - 117 = 3

Fcal = (89.391 ÷ 3) ÷ 1.010 = 29.50

Table 1. Least square residuals of a data set from location 7

Prove-nanace	Least square residuals					
	Rep1	Rep2	Rep3	Rep4	Rep5	Rep6
1	- 2.84	0.10	1.76	0.36	0.25	0.37
2	- 1.88	0.76	- 0.67	0.83	0.71	0.24
3	- 0.98	1.16	-1.87	1.03	- 0.29	0.94
4	0.74	0.08	0.45	- 0.65	- 0.67	0.06
5	- 2.03	- 0.69	- 0.22	1.18	0.16	1.59
6	- 1.23	1.01	0.38	- 0.12	- 0.44	0.39
7	- 1.88	1.06	- 0.17	0.63	0.11	0.24
8	2.24	- 0.42	- 0.55	0.25	-1.17	- 0.34
9	- 0.94	- 0.10	1.06	- 0.24	- 0.25	0.47
10	- 0.43	- 1.09	0.48	0.28	- 0.04	0.79
11	0.04	- 1.32	0.65	- 0.05	0.53	0.16
12	1.82	0.46	, 0.03	- 0.87	0.01	-1.46
13	2.66	- 1.50	-1.64	0.36	0.05	0.07
14	- 0.68	0.36	0.53	0.53	- 0.29	- 0.46
15	- 0.66	0.88	- 0.75	0.85	- 0.37	0.06
16	1.81	0.05	0.31	- 1.29	- 0.50	- 0.03
17	- 0.04	- 0.60	0.36	0.36	- 0.05	- 0.03
18	- 2.86[c]	- 1.12	- 0.85	- 1.25	7.73[a]	-1.64
19	- 1.16	0.68	0.25	- 0.15	- 0.07	0.46
20	2.17	0.51	-1.12	- 0.02	- 1.74	0.19
21	0.67	0.21	0.38	- 0.72	- 0.44	- 0.11
22	- 0.14	0.60	- 0.54	0.06	0.25	- 0.23
23	3.72[b]	- 0.49	- 0.72	- 0.62	- 0.84	- 0.61
24	- 0.46	- 0.72	2.75	- 0.55	- 0.87	- 0.14
25	2.74	0.08	- 0.25	- 0.15	- 1.77	- 0.64

a, b, c are suspected outliers.

The change in residual mean squares was compared with the residual mean squares of the ANOVA calculated without outliers (1.010 with 117 degrees of freedom), which is an estimate of the error variance per plot. F_{cal} is greater than the tabulated F-value for 3 and 117 degrees of freedom (2.84). Therefore, at least one of the suspected points (a, b or c) is an outlier.

Table 2. Analysis of variance

Source of variation	Complete data set df	SS	MS	Without outliers a & b df	SS	MS
Replication	5	150.37		5	130.93	
Provenances	24	97.53	1.73	24	90.19	1.01
Residual	120	207.61		117	118.22	
Total	140	455.51		147	339.34	

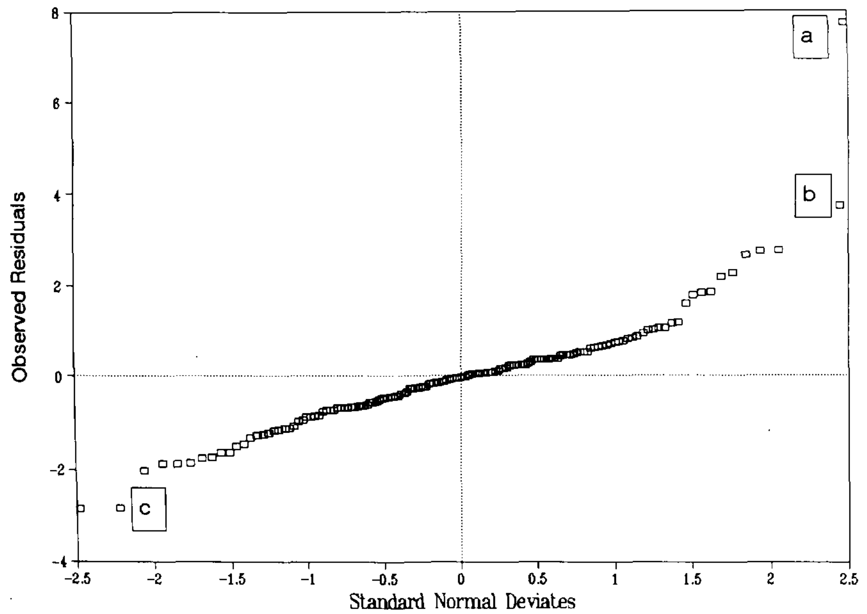

Figure 1. Q-Q plot (least square residuals versus cumulative probability values showing three outliers (a, b, c) in the data set

The next step is to perform analysis of variance ignoring outliers in sequence. The resulting F-values were 66.8 ($p<0.001$) for Provenance 18 in rep 5, 6.33 ($p<0.05$) for Provenance 23 in rep 1, and 0.60 (not significant) for Provenance 18 in rep 1. Plotting the new least square residual values against the cumulative probability values with the significant outliers deleted resulted in a nearly straight line (Figure 2).

Following the method of Tiku *et al.*, (1986), each of the eight trials was analysed and appeared to have an outlier. The coefficients of variation for the complete data sets ranged from 10 to 33%. After the outliers were removed, the variation was much reduced, with CVs ranging from 9 to 23%. The mean squares reduction resulting from the removal of outlying data varied from 10 to 52% (Table 3).

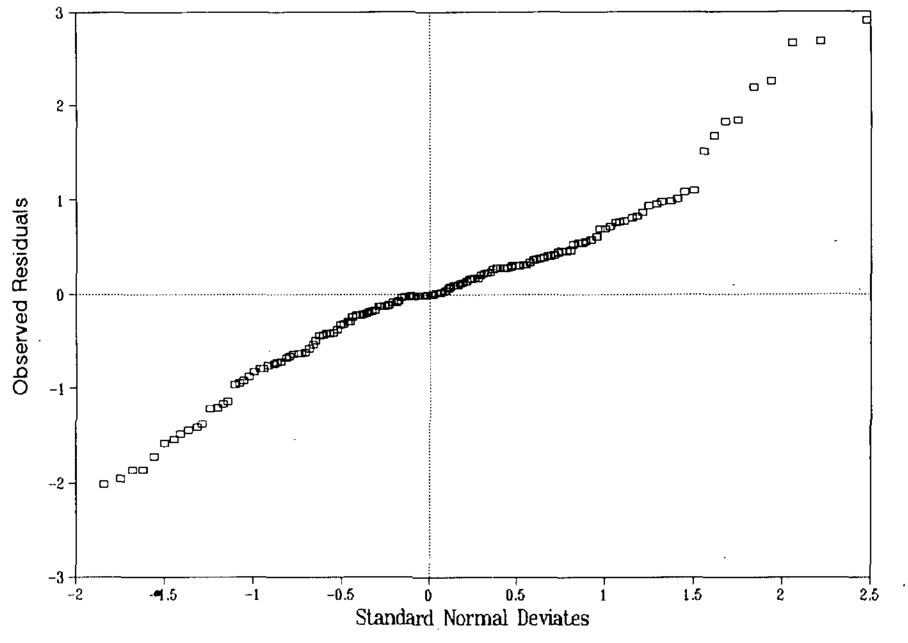

Figure 2. Q-Q plot after deleting outliers

Table 3. Estimates of error variances, coefficient of variation and percentage reduction in error variances

Location number	With outliers		Without outliers		Per cent reduction in RMS	No. of outliers detected
	Residual MSS	CV %	Residual MSS	CV %		
1	0.3828	10	0.3442	9	10	1
2	0.3472	15	0.1678	10	52	3
3	0.6552	13	0.5803	11	11	1
4	0.3414	21	0.2937	19	14	2
5	0.5701	33	0.5113	23	10	1
6	0.5014	10	0.4345	9	13	1
7	1.7300	18	1.0080	13	42	2
8	0.6124	1	0.5438	12	11	1

Data from field experiments should be subjected to rigorous and statistically sound exploration for outliers, as they have remarkable effect on the inferences on provenance comparisons. Once an outlier is detected it is worthwhile analysing the data after removing it, since this provides a more precise estimate of error variance and hence provenance contrasts.

Acknowledgements

The authors thank the cooperators of the Multipurpose Tree Species Research Network, S. Bhumibhamon, Nor Aini Abd. Shukor, G. Adjers, F. J. Pan, D. Gwaze, B. Kietvuttinon, K. Pitpreecha and S. Simsiri, who conducted the trials. The authors also thank G. Swaminathan of the statistics unit at the ICRISAT Center for helping us with a computer programme.

References

GENSTAT. 1983. *A General Statistical Program*. The Numerical Algorithms Groups Ltd., Oxford, U.K.

TIKU, M.L., TAN, W.Y. & BALAKRISHNAN, N. 1986. *Robust Inference*. Marcel Dekker Inc, New York: 178.

A NOTE ON THE EFFECTS OF PRESSURE ON THE BONDING QUALITY OF MERANTI BUKIT (*SHOREA PLATYCLADOS*)

Kamarulzaman Nordin, Y.E. Tan & Johari Othman

Forest Research Institute Malaysia (FRIM), Kepong, 52109 Kuala Lumpur, Malaysia

Various factors are known to affect the gluing properties of timbers. Among them are moisture content of wood at the time of gluing, open and close assembly time, type of adhesives used, surface quality of the gluing surfaces and clamping pressure (Chugg 1964, Anonymous 1982). The use of proper clamping pressures ensures intimate contact between gluing surfaces, produces glue film of sufficient thickness and minimises the risk of stress concentration particulary when substrates of uniform thickness are already in use. Too low a pressure causes insufficient contact between mating surfaces whereas over-pressing results in excessive squeeze-out of glue, giving rise to poor bonding results.

Meranti bukit (*Shorea platyclados*), a dark red meranti (DRM), was used in this experiment. The timber is one of the most popular timber species in this country and for export, due mainly to its easy working properties and other amenable characteristics. The objective of this study was to determine the effects of clamping pressure on the glue bond integrity of glued-laminated members. Two different types of adhesives were employed, *i.e.*, phenol resorcinol formaldehyde (PRF) and polyvinyl acetate (PVAc). PRF is a weather-boil-proof (WBP) adhesive suitable for structural use while PVAc is commonly used in the furniture industry.

Timbers of approximate dimensions of 25 × 55 × 700 *mm* were conditioned at about 20°C and 65% relative humidity (RH) until a moisture content equilibrium of 12-16% was achieved. The final dimensions of the timbers used for the gluing process were 19 × 55 × 700 *mm*. Gluing was carried out shortly after final planing to minimize possible contamination of the bonding surfaces. A glue spread of 300 $g\,m^{-2}$ was applied manually using a hand roller by double spreading. Clamping was carried out using a hydraulic cold press immediately after glue application, allowing practically no open assembly time. Five levels of pressure of 0.64, 1.00, 1.36, 1.75 and 2.14*MPa* (90, 140, 190, 245 and 300 *psi*) were used to press the laminates. This was maintained for a duration of 24 *h* at ambient conditions of 25° - 30°*C* and 60 - 80% RH. For each pressure level, ten laminations were prepared. A conditioning period of one week was allowed to the assemblies to facilitate proper curing of adhesive. Block shear test and vacuum-pressure cyclic delamination test as stipulated in the current Malaysian Standard, MS 758:1981 (Anonymous 1981), were used to assess the bonding quality of the laminates. The block shear test was meant to evaluate the shear strength of the bonded specimens in dry or interior conditions. The delamination test, on the other hand, assesses the gluing performance of the bonded specimens under simulated service environments. The dimensions, test conditions and assessment procedures for both tests were as described in Appendices B, C, and D of the Malaysian Standard, MS 758:1981 (Anonymous 1981).

The results of the block shear test which were expressed as failing stress and percentage of wood failure are summarized in Tables 1 and 2. The results show generally that PVAc glued specimens produced superior bonding shear strength and higher percentage of wood failure as compared to the PRF glued specimens. The bonding shear strength was also not much affected by the different pressure levels applied. The full factorial analysis of variance (ANOVA) revealed that there was signigicant interaction between adhesives and pressures ($p \leq 0.05$; $F = 2.75$). This led to a different approach in analysis. One-way ANOVA of individual adhesives carried out subsequently to determine the effect of different pressure levels indicated that pressure did significantly affect the bonding shear strength of PRF ($p \leq 0.05$; $F = 2.78$) glued specimens. Further analysis using Duncan's Multiple Range test to verify the difference for PRF glued specimens (Table 3) indicated that the 1.36*MPa* pressure was significantly superior to any other pressure levels in terms of bonding shear strength exhibited. However, its effect was not significantly different from those of the highest (2.14 *MPa*) and lowest (0.64 *MPa*) pressures employed or other pressure levels, with the exception of the 1.75 *MPa* pressure.

Table 1. Mean and minimum values of bonding shear strength of PRF and PVAc laminated specimens

Adhesive type	Pressure level (*MPa*)				
	0.64	1.00	1.36	1.75	2.14
PRF	10.87 (9.15) ((1.16))	11.06 (8.44) ((1.01))	11.49 (8.41) ((1.38))	10.35 (8.01) ((1.51))	11.18 (9.63) ((0.86))
PVAc	11.82 (10.76) ((0.97))	11.15 (8.37) ((1.52))	11.35 (9.54) ((1.25))	11.63 (10.10) ((0.89))	11.68 (9.95) ((1.12))

[1] All bonding shear strength values were corrected to 19% moisture content. The sample size for each assembly pressure level was 20;
( ) - values denote the minimum values;
(( )) - values denote standard deviation.

Table 2. Mean percentage of wood failure of PRF and PVAC laminated specimens

Adhesive type	Pressure level (*MP*a)				
	0.64	1.00	1.36	1.75	2.14
PRF	73	91	75	81	88
PVAc	100	100	97	99	98

Table 3. Significance of the differences in the bonding shear strength of PRF glued specimens resulting from different pressure levels applied

Pressure level (*MPa*)	Bonding shear stress (*MPa*)	Significance*
1.36	11.49	a
2.14	11.18	a
1.00	11.06	ab
0.64	10.87	ab
1.75	10.35	b

*Pressure levels with the same letters are not significantly different ($p \leq 0.05$).

For PVAc glued specimens, the bonding shear strength was found not significantly affected by the different pressure levels employed. The bonding shear strength was the highest at clamping pressure of 0.64 *MPa*, which was the lowest pressure level employed in this experiment. Nevertheless, all pressure levels applied produced high bonding shear strength values, with the mean and minimum values exceeding the minimum requirement of 9.47 *MPa* and 5.24 *MPa* respectively, as calculated based on the stipulation in the Malaysian Standard, MS 758:1981 (Anonymous).

The vacuum-pressure cyclic delamination test produced zero delamination for all pressures applied using either PRF or PVAc adhesives. Such a result, in addition to the excellent block shear test results, will then qualify meranti bukit for structural glue-lamination when PRF is used. For meranti bukit bonded with PVAc adhesive, although the bonded blocks met the requirement of bonding integrity test for structural glue-lamination, the flow characteristics of the adhesive during continuous loading render the product unsuitable for structural purposes. Nevertheless, PVAc bonded products qualify for non-structural use.

Acknowledgement

The authors wish to thank Mr. Tan Ah Peng for assisting in data collection.

References

ANONYMOUS. 1981. *Specification for Glued-laminated Timber Structural Members*. Malaysian Standard MS 758:1981. Standards and Industrial Research Institute of Malaysia, Shah Alam, Selangor, Malaysia.

ANONYMOUS. 1982. *Wood Handbook: Wood as an Engineering Material.* Forest Products Laboratory, U.S. Department of Agriculture, Madison, Wisconsin.

CHUGG, W.A. 1964. *Glulam. The Theory and Practice of the Manufacture of Glued-laminated Timber Structures.* Ernest Benn Limited, London.

ERRATA

In JTFS 6(2),

(1) page 105, Table 4 should read:

Table 4. The grade index assessment for meranti tembaga (*Shorea leprosula*) of 0.75 × 0.75 × 24 in size at upper ground after exposure for 60 months

(2) page 109, Figure 10 should read:

Figure 10. The amount of dry salt retention in CCB and CCA treated kempas at two different test sites for sample size of 1.5 × 0.25 × 24 *in*

(3) page 110, Figure 12 should read:

Figure 12. The amount of dry salt retention in CCB and CCA treated meranti tembaga at two different test sites for sample size of 1.5 × 0.25 × 24 *in*

(4) page 112, Table 5 should read:

Table 5. The percentage of individual compounds in treated kempas stakes at 0, 6 and 12 months exposed in the test plots

ANNOUNCEMENTS

JTFS 7(1) : SPECIAL ISSUE ON PROCEEDINGS OF THE WORKSHOP ON THE REHABILITATION OF DEGRADED FOREST LANDS HELD IN BRISBANE, QUEENSLAND, AUSTRALIA IN NOVEMBER, 1991.

The next issue of the JTFS, *i.e.*, JTFS 7(1), will be entirely devoted to the proceedings of the above workshop. This special issue has been considered for publication for the principal reason that the papers presented, which have been reviewed, focus on an area that has great relevance to tropical forest science, strongly linked to the current emphasis of not only conserving tropical forests but also increasing forest cover through, for example, reforestation of degraded or underutilised lands.

The issue will comprise a total of 14 papers that deal with a series of case histories and discussions of lessons emerging from them and from particular problem areas, centring on :

* how to grow high value rainforest trees;
* how to cheaply rehabilitate large areas of degraded land;
* how to rehabilitate sites with infertile soils and little residual forest;
* how to integrate ecosystem rehabilitation and rural development;
* how to measure rehabilitation success.

The papers are written by scientists participating at the Workshop from Australia, China, India, Indonesia, Malaysia, Philippines, Thailand and Vietnam. Subscribers to the JTFS will receive the Proceedings as a regular issue. Others may place an order at RM 20.00 (Malaysia) or US$ 20.00 (overseas) per copy. Please write to :

The Business Manager
Journal of Tropical Forest Science
Forest Research Institute Malaysia
Kepong, 52109 Kuala Lumpur
Malaysia

Tel : 03 - 6342633; Fax : 603 - 6367753

IUFRO INTERNATIONAL WORKSHOP ON SUSTAINABLE FOREST MANAGEMENTS

DATE : OCTOBER 17-21, 1994
VENUE : HIGHLAND FURANO, FURANO, HOKKAIDO, JAPAN

This workshop which will be concerned with Divisions 3 and 4 of IUFRO will fall under the following headings:

* Harvesting and silviculture for sustainable forestry
* The theory and practice of sustainable forest management

The topics to be discussed are :

* Soil and vehicle interactions
* Effects of harvesting operations on tree growth
* Site preparation
* Environmentally conscious harvesting techniques
* Cost analysis on harvesting from sensitive sites
* Sustainable forest management
* Multiple use forest management
* Forest planning systems
* Forest growth modelling
* Forest inventory

For further information, contact :

Dr. Hidejiro Nagumo
Office of Organizing Committee, Research Division,
The University Forests, The University of Tokyo
1-1-1 Yayoi, Bunkyo-ku, Tokyo 113, Japan

Tel : +81-3-3812-2111 ext. 5490 , Fax : +81-3-3812-4745

ENVIRONMENT MALAYSIA '94 : INTERNATIONAL CONFERENCE & EXHIBITION ON ENVIRONMENT & DEVELOPMENT

DATE : OCTOBER 19-21, 1994
VENUE : SHANGRI-LA HOTEL, KUALA LUMPUR, MALAYSIA

The Conference will focus on the following topics :

* Water pollution; water quality management
* Air and noise; air quality management
* Solid waste management
* Environment management; education and training
* Land use
* Business and the environment

The Exhibition will feature major consultants, contractors, supplies of current and advanced waste treatment and pollution control technologies and equipment for water, wastewater, air, solid waste, hazardous waste and noise. The latest technology from Europe, North America, Asia and the Pacific will be highlighted and displayed.

For further information contact :

The Conference Secretariat
ENVIRONMENT MALAYSIA '94
c/o ENSEARCH, 38A Jalan SS 21/58
Damansara Utama, 47400 Petaling Jaya
Malaysia

Tel : 03-7177588/7173819; Fax : 03-7177596

SEMINAR ON COMMUNITY DEVELOPMENT AND CONSERVATION OF FOREST BIODIVERSITY THROUGH COMMUNITY FORESTRY

DATE : OCTOBER 26-28, 1994
VENUE : REGIONAL COMMUNITY FORESTRY TRAINING CENTER, KASETSART UNIVERSITY, BANGKOK, THAILAND

The Seminar will highlight the development of new strategies for integrating forest conservation with community development, and will comprise the following sessions :

* Issues in community development and conservation
* Regional experiences : opportunities and constraints
* Joint efforts : regional overview
* Panel discussion : how to integrate development and conservation activities
* Working groups
* Presentation of working groups

For further information, contact :

Dr. Somsak Sukwong
Director, Regional Community Forestry Training Center
P.O. Box 1111, Kasetsart University
Bangkok 10903, Thailand

Tel : (662) 5790108/5614881 ; Fax : (662) 5614880

INTERNATIONAL MYCOLOGICAL INSTITUTE : TRAINING COURSES

The International Mycological Institute, an institute of CAB International, is offering the following courses :

* International Course on the Identification of Fungi of Agricultural Importance. August 8 - September 16, 1994.
  (A six-week course for plant pathologists training in the classification and identification of economocally important groups of microfungi)

* Modern Techniques in the Identification of Bacteria and Filamentous Fungi. October 31 - November 11, 1994.
  (A two-week course designed to give microbiologists/plant pathologists training in modern techniques currently of use in microbial taxonomy)

For further information, contact :

Miss J. Pryse (Training Officer)
International Mycological Institute
Bakeham Lane, Egham
Surrey TW20 9TY, United Kingdom

Tel : 0784 470111; Fax : 0784 470909
Telex : 9312102252 MI G; Email : cabi-imi@cgnet.com