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Assessment and Analysis of two Pinus kesiya Provenance Trials in Indonesia

Trial No. 7 (T 72) Aek Nauli, Trial No. 8 (T 70) Habinsaran

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Assessment and analysis of two *Pinus kesiya* provenance trials in Indonesia

Trial No. 7 (T 72) Aek Nauli
Trial No. 8 (T 70) Habinsaran

by

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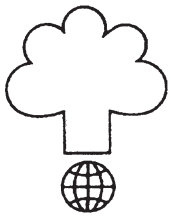

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Poor branching characteristics; whorls of heavy persistent branches and long internodes have militated against the acceptance of *P. kesiya* as a plantation species. Here Habinsaran trial site, Indonesia. Photo: Christian Pilegaard Hansen

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Danida Forest Seed Centre (DFSC) is a Danish non-profit institute which has been working with development and transfer of know-how in management of tree genetic resources since 1969. The development objective of DFSC is to contribute to improve the benefits of growing trees for the well-being of people in developing countries. DFSC's programme is financed by the Danish International Development Assistance (Danida).

Preface

This report presents the results of a joint assessment of two *Pinus kesiya* provenance trials in Indonesia. The trials were established by RGMI Forestry, Research and Development Division in 1992 as part of an international series of provenance trials of the species.

The joint RGMI/DFSC field assessment took place in September 1999 with participation of Thomas Saragih, Wagiman, Nabil, Parlindungan Panjaitan and Gibson Manurung of RGMI Forestry, R&D. From DFSC participated Anders Ræbild and Christian Pilegaard Hansen.

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Contents

Preface i
Contents iii
Acronyms and abbreviations iv

1 Background 1

2 *P. kesiya* provenance trials established by RGMI Forestry, Indonesia 2

3 Field assessment and data management 4

4 Statistical analysis 5
4.1 Plot of raw data 6
4.2 Statistical model 6
4.3 Co-variates 6
4.4 Check of model assumptions 7
4.5 What to do when model assumptions are not fulfilled 8
4.6 Fixed or random effects 9
4.7 Test of differences between species and provenances 9
4.8 Lsmeans (estimates from the fixed model) 10
4.9 Best Linear Unbiased Predictors (BLUPs - estimates from the random model) 10

5 Results of statistical analysis of individual traits 11
5.1 Survival 12
5.2 Height growth 14
5.3 Diameter growth 16
5.4 Mean volume of tree 18
5.5 Total volume per hectare 20
5.6 Stemform 22
5.7 Wood density (Pilodyn) 24
5.8 Branching (branch diameter) 26
5.9 Foxtailing 28
5.10 Flowering 30

6 Conclusions 32
6.1 Growth 32
6.2 Adaptation 32
6.3 Quality 32
6.4 Overall conclusion 32

7 References 34

Annexes

Annex 1 Maps
Annex 2 Trial descriptions
Annex 3 Site descriptions
Annex 4 Plot data set

Acronyms

CAMCORE	Central America and Mexico Coniferous Resources Co-operative, USA
CIEF	Centro de Investigaciones y Experiencias Forestales, Argentina
CSIRO	Commonwealth Scientific and Industrial Research Organisation, Australia
Danida	Danish International Development Assistance
DFSC	Danida Forest Seed Centre, Humlebæk, Denmark
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária, Petrolona, Pernambuca, Brazil
FAO	Food and Agriculture Organization of the United Nations, Rome, Italy
ICFRE	Indian Council of Forestry Research and Education, Dehra Dun, India
IF	Instituto Florestal, São Paulo, Brazil
IPEF	Instituto de Pesquiasa e Estudos Florestais, Piracicaba, Brazil
OFI	Oxford Forestry Institute, United Kingdom
RCFTI	Research Centre for Forest Tree Improvement, Forest Science Institute, Vietnam
RFD	Royal Forest Department, Thailand

1. Background

The Aek Nauli and Habinsaran trials form part of an international series of provenance trials of *P. kesiya*.

The objective of the international series is to explore and analyse the genetic variation in growth, quality and adaptive traits among provenances of *P. kesiya* throughout the range of the species. The results will facilitate an informed choice of seed source in planting programmes. Furthermore, the results will be useful when planning conservation activities of the species.

Below the background of the international series is briefly described.

Initial research on inter-population differences in *P. kesiya* was undertaken in Zambia in the 1950s. The test material included provenances from the Philippines, Vietnam and Assam. A comprehensive review of these studies is given in Armitage and Burley (1980).

During 1969, FAO and the Forest Research Institute of Australia sponsored seed collections of 19 seed sources of *P. kesiya* from the Philippines (17 provenance collections and 2 commercial seedlots). The material was complemented by two Zambian land races (of Philippine and Vietnamese origin, respectively). These collections were used for provenance trials in a large number of countries for which the Commonwealth Forestry Institute supplied advice and assisted in data processing and interpretation (Burley and Wood 1976). Results from individual trials were reviewed by Gibson and Barnes (1984). They concluded that neither provenance representation, nor test site representation warranted an international evaluation. It was recommended that a more comprehensive exploration and analysis of the genetic variation of *P. kesiya* should be undertaken. Recommendations in this regard was also put forward by the Sixth Session of the FAO Panel of Experts on Forest Gene Resources (FAO 1988).

Exploration of provenance variation and collection of seed for field trials took place in the late 1980s in collaboration between national institutions in Brazil, Myanmar, China, Madagascar, Philippines, Thailand, Vietnam, Zambia, Zimbabwe, Oxford Forestry Institute (OFI) and Danida Forest Seed Centre (DFSC). In 1988, seed collections were complete and distribution to collaborating countries could begin (Barnes et al. 1989). Distribution of seed was co-ordinated by OFI and handled by DFSC. During 1989-93, seed of 42 provenances and land races from the above 9 countries were distributed to 20 institutions in 19 countries. Some of the seedlots were separated by mother trees to allow testing of individual families.

A status of seed distribution and established field trials is found in DFSC (1996) and DFSC (1997). Some 30 trials have been established in 17 countries. Trials in Argentina, Brazil, Colombia, Indonesia, South Africa, Swaziland, Vietnam and Zimbabwe are reported with high survival and are in general in good conditions. Status of trials in Burundi, India, Rwanda and Sri Lanka is unknown, as no information has been received from these countries. Trials established in Fiji, Kenya, Nepal, the Philippines and Thailand have been abandoned because of fire damage, drought and browsing.

In a circular letter sent out by OFI and DFSC in 1996, host institutes were asked about their interest in undertaking a joint evaluation and were at the same time asked about the status of the trials (DFSC 1996). Positive responses in regard to the proposal of undertaking a joint assessment and analysis of trials have been received from all countries where existence of trials has been confirmed. The number, distribution and representation of provenances in these trials were considered sufficient to justify an assessment and analysis of the international series. Of special interest is the possibility of an in-depth analysis of provenance x site interactions, thanks to the representation of the same set of provenances at many trial sites.

A manual was elaborated during 1997-98 with a proposal for a set of characters to be assessed in all trials (DFSC 1998). Field assessment of trials commenced in April 1998 (Vietnam).

2. *P. kesiya* provenance trials in Indonesia

RGMI Forestry, Indonesia, has established two provenance trials of *P. kesiya* in 1992 in North Sumatra, Indonesia. The trials are located at the Aek Nauli and Habinsaran forestry sectors and have trial identification numbers T72 and T70, respectively.

The provenances represented in the trials are shown in the below table.

Remarks about the table:

1. Seedlots 712, 713, 714, 715, 716, 183, 118, 366, i.e. the not *P. kesiya*/*P. yunnanensis* sources, are local controls, and do not form part of the international seed exchange under the international programme.
2. The field assessment revealed that the Doi Inthanon provenance of *P. kesiya* in fact was *P. tecunumanii*. As the seed lot could not be further identified, it has been omitted from the analysis.
3. The Guanaja provenance of *P. caribaea* var. *hondurensis* and the Coto Mines provenance of *P. kesiya* are only in the Aek Nauli trial, not in the Habinsaran one.
4. *Eucalyptus grandis* has been included as a local control in both trials. The Eucalyptus plots in the Aek Nauli trial have been cut down, and hence Eucalyptus is only in the Habinsaran trial. The plots have been assessed, but not included in the statistical analysis.
5. The Simao provenance of *P. kesiya* is only present in the Habinsaran trial, and only in one of the four replicates. This plot has been assessed, but the provenance has not been included in the statistical analysis.

Details of the trial establishment and management are presented in Annex 2 and descriptions of the sites are in Annex 3.

The Aek Nauli trial has a low survival rate. Many trees have reportedly been cut down during weeding operations, probably because weedings have been delayed. It is further reported that trees in the trial have suffered from herbicide application. As a result, many plots in the Aek Nauli trial have few trees left, and other plots have been entirely lost (no trees left). This is weakening the statistical analysis of the trial.

The Habinsaran trial, on the other hand, has a much higher and more uniform survival. The growth at the Habinsaran trial also compares favourable to the Aek Nauli trial.

As mentioned above, both trials suffer from misplaced seedling/rows/plots. The problem with seedlot 723 (the Doi Inthanon source of *P. kesiya)* in both trials has been mentioned above, but also in other plots, there are rows, parts of rows or single trees of other origin, i.e. misplaced seedlings. These trees have in all cases been omitted from the assessment.

Local ID	DFSC Acc. No.	Species	Provenance	Country
712	-	*P. oocarpa*	Mal Paso	Guatemala
713	-	*P. tecunumanii*	Mt. Pine Ridge	Belize
714	-	*P. oocarpa*	El Paraiso	Honduras
715	-	*P. tecunumanii*	San Raphael	Nicaragua
716	-	*P. caribaea*	Guanaja	Honduras
718	1572/85	*P. kesiya*	Coto Mines	Philippines
719	1525/85	*P. kesiya*	Nam Now	Thailand
720	1521/85	*P. kesiya*	Nong Krating	Thailand
721	1519/85	*P. kesiya*	Lang Hanh	Vietnam
722	1522/85	*P. kesiya*	Doi Suthep	Thailand
723	1523/85	*P. kesiya*	Doi Inthanon	Thailand
724	1639/86	*P. kesiya*	Simao	China
725	1783/88	*P. kesiya*	Bodana A8	Madagascar
726	1773/88	*P. kesiya*	Aungban	Myanmar
727	1633/86	*P. yunnanensis*	Shangsi	China
183	-	*P. merkusii*	Indonesia	Indonesia
118	-	*P. patula*	Zimbabwe landrace	Zimbabwe
366	-	*E. grandis*	Coff's Harbour	Australia

3. Field assessment and data management

The assessment followed the methodology described in DFSC (1998) and included the characters:

1. Survival;
2. Health;
3. Social status (Kraft);
4. Height;
5. Diameter (DBH);
6. Straightness;
7. No. of whorls;
8. No. of branches in whorl;
9. Branch diameter;
10. No. of forks;
11. Position of first fork;
12. Foxtail;
13. Flowering and fruiting;
14. Wood density (Pilodyn);

For a detailed description of the assessment methodology, please refer to DFSC (1998).

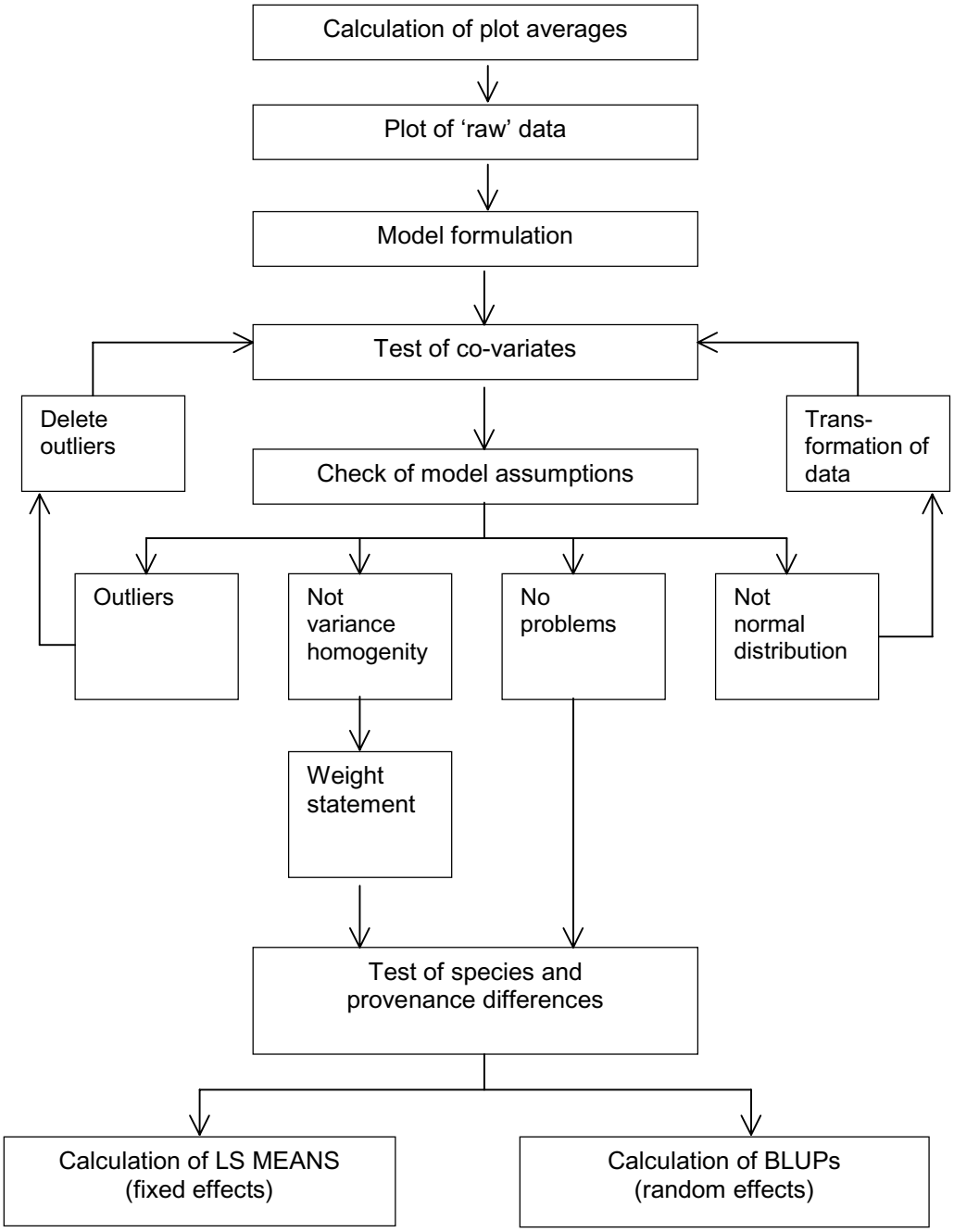
The assessment was a full assessment, i.e. all trees within each plot were included. For the local controls, i.e. seedlots not *P. kesiya*, the assessment was limited to survival, height, diameter, stemform and pilodyn.

Relative wood density was measured with a Pilodyn wood tester with pin diameter 2.0 mm.

Assessment data was recorded in the field on assessment sheets, see example in DFSC (1998). The data was immediately after the assessment entered to a lap-top computer in spreadsheet format. From the spreadsheet, data was later transferred to a SAS-dataset for further analysis.

4. Statistical analysis

Overview of steps involved in the statistical analysis



The objectives of the statistical analysis are:

- to examine statistically significant differences between seedlots (provenances) in adaptability, growth and quality traits. A list of analysed traits is provided in Chapter 5;
- to conclude and recommend on the practical application of the results (species and provenance recommendations);
- to investigate patterns of genetic variation;
- to provide data for an overall analysis of the international series of provenance trials of *Pinus kesiya*, i.e. analysis across sites. This step will await completion of the analysis of individual trials.

Statistical analysis is done on plot values, e.g. plot averages or plot sums. Calculation of plot values is described in Annex 4.

The SAS analytical package has been used for the analysis (SAS, 1990).

The statistical analysis of each trait follows a sequence of steps. They are:

1. Plot of raw data;
2. Formulation of statistical model;
3. Test of co-variates;
4. Check of model assumptions;
5. When model assumptions are not fulfilled: (a) transformation of data; (b) deletion of outliers; (c) weight statement;
6. Test of differences between species and provenances;
7. Calculation of lsmeans (estimated from a model with fixed effects);
8. Calculation of BLUPs (estimated from a model with random effects).

The statistical analysis is illustrated in the above figure and the steps are further described in the below text.

Generally speaking, two different approaches are applied in the statistical analysis: a fixed effect approach and a random effect approach. The fixed effects approach is concerned with the genetic entries (seedlots) actually in the trial, whereas the random effects approach concerns what would happen if the experiment was to be repeated. Following the fixed effect approach, the estimates are calculated as least square means (lsmeans), whereas the random effect approach gives the best linear unbiased predictors (BLUPs). See further explanation below.

4.1 Plot of raw data

The main purpose of the plots is to indicate the scale of the variable along with a first impression of the variation within the trial. Often the visual inspection of the data reveals clear differences between the provenances, or gives hints regarding proper transformations of the data. Obvious outliers (extreme values) may also be identified already at this stage.

The most useful single plot is probably a plot of the variable against the provenances, marking the values with values identifying the blocks. However, other plots may also be relevant, e.g. plotting the values by block or by the distance along the axis of the trial.

4.2 Statistical model

The test of differences between seedlots (provenances) is based on the model:

$$X_{jk} = \mu + provenance_j + block_k + \varepsilon_{jk}$$

where X_{jk} is the value of the trait in question (e.g. height) in plot *jk*,
μ is the grand mean,
$provenance_j$ is the effect of seedlot number *j* and is assumed to be either a fixed or a random effect, according to which approach is used (see later),
$block_k$ is the effect of block *k* in the trial, assumed to be a random effect, and
ε_{jk} is the residual of plot *jk* and is assumed to follow a normal distribution $N(0, \sigma_e^2)$.

Please note that the controls (seedlots not *Pinus kesiya*/*P.yunnanensis*) are considered (analysed) together with these sources not considering that they actually are sources of different species.

4.3 Co-variates

In order to reduce the residual variation in trials with heterogeneous trial conditions (e.g. variation in soil, elevation, slope and exposure within trial), a number of co-variates are included in the model. As a standard routine the following four co-variates are tested:

plotx: Horizontal position of plot within trial (see map of trial);
ploty: Vertical position of plot within trial (see map of trial);

To catch non-linear patterns of site variation vertically and horizontally, plotx2 and ploty2 are applied:

plotx2: $plotx2=(plotx - mean(plotx))^2$
ploty2: $ploty2=(ploty - mean(ploty))^2$

In addition to the above four co-variates, additional co-variates are considered in some of the trials:

level: Level of plot in relation to a reference plot within the trial (0);
plotxy

$$Plotxy = plotx \times ploty$$

In testing the effect of co-variates, we start with a model with all co-variates included. Co-variates that are not significant are removed successively by removing the least significant co-variate and running the model again until all remaining co-variates in the model are significant ($P<0.10$).

4.4 Check of model assumptions

The statistical model rests on a number of standard assumptions. Key assumptions are (see e.g. Box *et al.* 1978):

(i) that the residuals are independent;
(ii) that the residuals follow a normal distribution;
(iii) that there is variance homogeneity in effects included in the model.

The model assumptions are checked graphically by producing a number of plots:

1. Student's residuals versus predicted values;
2. Cooks distance versus predicted values;
3. Student's residuals versus provenance;
4. Frequency chart of residuals;
5. Student's residuals versus block;
6. Student's residuals versus plotx;
7. Student's residuals versus ploty;
8. Student's residuals versus level (if level is among the considered co-variates).

The residuals represent variation that can not be accounted for by the model. For each observation, the model calculates a predicted value, taking into account the effects of the model (provenance, block and co-variates). The residual variation is then the difference between the observed value and the predicted value.

Student's residuals (also called 'standardised residuals') are calculated as the residual divided by its standard error. If the assumption of normal distributed residuals is valid, the Student's residuals have the property of a normal distribution with mean 0 and variance 1, meaning that 95% of the values should lie within ± 1.96. In cases of trials with imbalance, the Student's residuals correct for imprecision due to low sample numbers, and in models with co-variates they compensate for large deviations at extreme values.

The Student's residual e_t for observation *ij* is given by

$$e_t = \frac{e_{ij}}{s_{ij}} = \frac{X_{ij} - P_{i\bullet} - B_{\bullet j}}{s_{ij}}$$

where e_{ij} is the residual, X_{ij} is the value for observation *ij*, $P_{i\bullet}$ is the effect of provenance *i*, $B_{\bullet j}$ is the effect of block *j*, and s_{ij} is the standard deviation (standard error) of observation *ij*.

Cooks distance gives a measure of the influence of a single observation (plot) on the model, and gives an indication of possible 'outliers' (see below) (Afifi & Clark 1996). A high value indicates an observation with a large influence on the outcome of the model.

In the following, a description of the check of the model assumptions is given.

Independence

The assumption of independence means that the residual of one observation is not dependent on the residual of another. This assumption is typically violated when using pseudo-replicates, e.g. when doing more observations on the same experimental unit and treating them as different experimental units. Another example is when two or more plots of the same provenance within the same block are treated as independent observations. In such cases, an average of the values should be used as the block value for the provenance in question.

The graphical check of the residuals does not reveal possible problems with observations dependent upon each other, and there is no easy method to ensure that the condition of independence is fulfilled. Proper design and planning of the experiment result and application of a correct statistical model is the best insurance to obtain independent observations.

The assumption of independence may also be violated if there is a time- or site-dependency in the data. To check for such dependency, residuals are plotted against the horizontal and vertical axis of the trial (plotx and ploty) and where applicable, also the level of plot, to investigate any systematic environmental variation. Usually there is none, as the co-variates (plotx and ploty) account for this.

Normality

The assumption of normality may be checked in various ways, graphically as well as by statistical tests. In this analysis, we use the frequency chart of residuals as a graphical check. In the frequency chart, the frequencies should be more or less bell-shaped with no large tails at the ends. A formal statistical test, the Shapiro-Wilk statistic, is given in the SAS-procedure UNIVARIATE with the option NORMAL (SAS 1988a). This procedure also offers different kinds of plots of the residuals. However, since the test is usually considered to be conservative, rejecting only severe deviations from normality, the test results should be considered with caution (Brockhoff, pers. comm.).

When the number of observations is low, it becomes increasingly difficult to check the assumption of normality. Even though the frequency chart may show a rather odd and irregular distribution, this need not be a sign of non-normality. At small sample sizes it is not unlikely that odd distributions may result from random variation, and unless the test for normality demonstrates that the assumption is violated, there is no need to reject the model. On the other hand, when the number of samples is very large, the test for normality may become rejected even though the frequency chart of residuals appears to be normal. This is because the power of the test increases with the number of observations, and even small deviations from normality may result in rejection of the hypothesis of normal distributed residuals. In such cases it

should be considered whether the frequency chart indicate that the assumption is fulfilled, or the deviations are so large that transformation of data (see later) is required.

Deviations from the assumption of normality may also be interpreted as a distribution with a large number of outliers (see later).

Variance inhomogeneity

Variance inhomogeneity occurs when different experimental units (blocks and provenances) have different variance. A typical example is when the residuals of some provenances appear very clustered in the diagram of Student's residuals versus provenances, whereas the residuals of other provenances are spread out, often with values of Student's residuals exceeding ±2. This may result from a simple scale effect (larger provenances have larger variance), in which case the plots of Student's residuals and Cook's distance versus predicted values appear funnel-shaped. It may also be related to the provenance itself (some provenances are more variable than others). In this case, the variance inhomogeneity will be displayed in the plot of student's residuals versus provenance.

Outliers

Outliers are extreme observations that do not follow the trends of the remaining data. Such observations may have a large influence on the estimates and statistical tests of the model and should therefore be considered carefully.

Outliers are detected by inspection of the plots of Student's residuals and of Cook's distance. Observations that have values of Student's residuals exceeding ±2.5 (rule of thumb), and observations with large values of Cook's distance, are possible outliers and should be investigated further. Outliers may be due to errors in the recording or typing of data, or due to mislabelling of the seedlots in the nursery or in the field. Poor survival in the plot, leaving only a few trees to use in the calculation of plot means is another source of outliers. However, it also happens that the outliers are due to some unexplained variation, perhaps in soil conditions or other environmental variation. Finally it should be mentioned that a large number of outliers might indicate that the distribution of residuals is not normal, and hence that a transformation of data is required (see later).

When outliers occur as a result of errors, the dataset should of course be corrected, which will solve the problem. It is less obvious what to do in the cases where there are no easy explanations. Outliers should only be excluded if it can be justified, i.e. an explanation can be given. In a few cases, however, explanations were not found, and observations were excluded alone on basis of the extreme nature of the value. Great care is required in the decision to exclude plot values, as it will have great importance for the result of the analysis, especially with few blocks (replications). Running the analysis again without the outlier(s) gives an indication of the sensitivity of the analysis in regard to the outliers, and assist in deciding whether to keep or delete the extreme observation(s).

In the interpretation of the statistical analysis in this report, it is always mentioned if one or more extreme values have been considered as outliers and omitted from the analysis, and on what grounds.

4.5 What to do when model assumptions are not fulfilled

In many cases one or more of the model assumptions are not fulfilled. In the below, procedures for correction are described.

Independence

Apart from making sure that the statistical design and the model is correct there is not much to do about dependence between observations. If some clear variation can be observed in the residuals, other co-variates than the ones mentioned above could be considered.

Deviations from normality

Usually deviations from normality are handled by transformation of data. Snedecor & Cochran (1980) and Afifi & Clark (1996) provide guidance on data transformations:

1. Counts (of rare events) often follow a Poisson distribution and are transformed with the square root.
2. Variables having a binomial character (e.g. dead or alive) summarised in a proportion (e.g. living trees in a plot) may be transformed with the arc sine transformation.
3. If the standard deviation varies directly with the mean, a logarithmic transformation may stabilise the variance.

There are theoretical reasons for choosing the above transformations (Snedecor & Cochran 1980), but it follows from Afifi & Clark (1996) that the range of transformations may be seen as a continuum and that various other transformations are available.

None of the variables included in the present assessment have the character of a Poisson distribution, but the square root transformation has nevertheless in some cases been applied.

In many cases the analysis of survival data results in skewed distributions of the residuals, with tails at either the lower or upper end (many trees dead or many trees alive). In such cases an arc sine transformation of data will often prove useful. The arc sine transformation is given by

$$\arcsin(proportion) = \sin^{-1}\sqrt{proportion}$$

where proportion is a figure between zero and one

(e.g. the surviving fraction of trees). An important property of the transformation is that the variance near zero or one is stretched out, thus facilitating the analysis of variance (Snedecor & Cochran 1980).

For many growth variables, the variance increases directly with tree size, and the proper transformation is thus the logarithm. In most cases, the natural logarithm (ln) has been applied to achieve a normal distribution of residuals.

Variance inhomogeneity

In the cases where the variance varies with the size of the variable, a transformation of data is the proper way to solve the problem (see above). However, in some cases the provenances simply have different variances irrespective of size, and it is necessary to weight the observations with weights proportional to the reciprocals of the error variances to ensure variance homogeneity (SAS 1988b, cf. Afifi & Clark 1996). There may also be cases where different blocks have different variances, but this has not been observed in the present trial(s).

Weighting occurs in the following sequence: An ordinary analysis of variance of the variable is performed. The residuals from this analysis are grouped according to provenance, and the variance of the residuals for each provenance is calculated. The inverse of these variances is then used as weights in an analysis of variance. When calculating the sums of squares in the model, the weights are multiplied with the squared value of the deviance of each observation from the predicted value (SAS 1988b). This has the effect that provenances with small variances have a larger influence on the model than provenances with larger variances. In other words, the more stable the provenance, the more it counts in the analysis. Provenances with large uncertainty on the other hand have less influence.

4.6 Fixed or random effects

A special problem relates to the choice between considering the effects in the statistical model as fixed or random. Statistically speaking, fixed effects are considered as *parameters* (unknown constants). Random effects are considered *stochastic variables* with an expected value of zero and a variance (Skovgård 1994). Fixed effects are used when the individual groups (seedlots) are of interest. Models with random effects are used when interest is in the size of the variation between the groups (described by the variance), including groups that are not represented in the trial. In analysis of random effects it is important that the groups are representative of a larger population of groups, and they should preferably be chosen by randomisation (Skovgård 1994). In the words of Stonecypher (1992), 'fixed models address estimating and testing to infer the existence of true differences among means, whereas the random models address estimating and testing to infer the existence of components of variance'.

To choose between a fixed or a random effects model is a choice with no simple answer. Stonecypher (1992) has formulated the following two questions to facilitate a choice:

1. 'Are the conclusion confined to the things actually studied; to the immediate sources of these things; or extended to apply to more general population?'

2. 'In complete repetitions of the experiment would the same things be studied again; would new samples be drawn from the same sources; or would new samples be drawn from the general population?'

When the objective is to estimate components of variance, the effects should be considered as random. If the objective is to estimate differences among means, the effects should be considered as fixed. In some cases fixed and random effects may be combined in the model (mixed models). This is the case when special designs are applied, such as split-plot or nested designs.

In our model with only provenances and blocks, it is necessary to choose between considering the provenance effect as random or as fixed. If the aim is to compare the specific provenances and the actual production on the site, it is natural to consider the provenance effect as fixed. If, on the other hand, (i) the provenances are assumed to be representatives of a population of provenances; (ii) the aim is to expand the conclusions to this population; (iii) to estimate the production and (iv) should the experiment be repeated, then the provenance effect should be considered as random.

The results of the statistical tests are irrespective of whether the provenance effect is considered a fixed or a random effect. However, there are major differences in the estimates resulting from the two approaches (see below). Since it may be argued that both the fixed and the random approaches are relevant in this analysis, both sets of estimates have been calculated.

4.7 Test of differences between species and provenances

In our statistical model, differences between provenances for a given trait are tested by an F-test comparing the mean square of provenances with the residual mean square. The hypothesis tested is that there is no difference between the provenances. If the F-test is significant, we reject the hypothesis and conclude that there are significant differences between the provenances.

The testing is done using the GLM procedure in SAS (SAS 1990). Since the testing of random variables may involve combinations of different mean squares (Skovgård 1994), an approximation called Satterthwaites approximation is used in the calculation of degrees of freedom (SAS 1988).

4.8 Lsmeans (estimates from the fixed model)

In the fixed model approach, the estimates for the provenances are calculated as the least square means (lsmeans). The main difference between raw means and lsmeans is that lsmeans account for missing values and imbalanced designs. Thus, in completely balanced designs there are no differences between lsmeans and the raw means. It follows that the lsmeans are the best estimates for the given provenance in the trial.

The confidence intervals and limits are calculated from the formula (Skovgård 1994).

$$X \pm t_{1-\alpha/2,(a-1)(b-1)} \sqrt{s^2 / b}$$

where X is the least square mean, α is the confidence level (in this case 0.05, giving a 95% confidence interval), a is the number of provenances and b is the number of replicates (blocks) of each provenance. s^2 is the mean square of the error (MS_e). The confidence limits are calculated directly by SAS in the LSMEANS statement with the CL option.

Since the estimates are calculated individually, different provenances may have different lengths of the confidence intervals (due to different variances). In the cases where the data have been weighted, the confidence intervals are adjusted according to the variance of each provenance and thus are of different lengths.

Special problems arise when the data has been transformed. If the least square means and the confidence limits are calculated on basis of the transformed values, the back-transformed estimates will be geometric means rather than arithmetic means. This implies that the estimates become biased towards lower values, and compared to the real values actually are under-estimates. If on the other hand the estimates are calculated using raw data, the lsmeans will be arithmetic means (comparable to the real mean values), but the confidence limits are based on a faulty distribution and will be wrong. In this analysis we have calculated estimates on the transformed values in order to get a fair representation of the differences between provenances. Usually the figures are presented together with a raw mean to circumvent the problem with under-estimation.

4.9 Best Linear Unbiased Predictors (BLUPs - estimates from the random model)

In the random approach, the provenance effects are seen as coming from a normal distribution with an expected value and a variance. This is in opposition to the fixed effect approach, where the provenance effects are seen as constants. Estimating provenance effects in random models is more complicated than in fixed models, because the observed variation between provenances is contemplated as a mixture between true provenance effects and random error variation (*cf.* White & Hodge 1989). The variation between the provenances is therefore always larger than the true 'genetic' variation, except in cases where the error variation is negligible.

In order to predict the effect of a given provenance, it is necessary to correct the estimates for the part of the variance that is due to random error variation. This is done by calculating the best linear unbiased predictors (BLUPs, White & Hodge 1989). The calculation of BLUPs is cumbersome and only feasible with a suitable software package. In this case, the SAS procedure MIXED has been used. It follows from the above that the predicted values for the provenances fall within a smaller range than the least square means. Often the results are presented as deviations from the mean value to allow for easier comparison between different experiments. The deviations are expressed either in real values (m, cm^2 etc.) or in % deviation from the mean value. Here deviations are presented as % deviations from the mean values.

The problems with transformed values are the same as described for the least square means above. A further complication arises when calculating the deviations from the mean value in percent. If the mean value is calculated on the base of transformed values, and the deviations are calculated on the basis of this back-transformed mean, the deviations from the mean will not sum to zero. In this analysis, we have therefore chosen to base the deviations from the mean value on values calculated after transformation.

The BLUPs are presented with *t*-type confidence intervals. However, these should be interpreted with caution since it is probably wrong to assume that the underlying distribution of the estimates is normal because of the limited sample size (Littell *et al.* 1996). Confidence intervals are presented to give an impression of the variation between the provenances and should not be interpreted with respect to differences between provenances.

5. Results of statistical analysis of individual traits

The below table displays the traits selected for analysis, grouped into growth traits, adaptive traits and quality traits. For a full description of the traits and their calculation, please refer to Annex 4.

Group	**Trait description**	**Analysed trait**
Growth	Height growth	Height of tree with diameter corresponding to mean basal area (H_G)
	Diameter growth	Diameter of tree corresponding to mean basal area (D_G)
	Mean volume of tree	Average of volumes above bark of trees in plot
	Standing volume per hectare	Volume per hectare
Adaptation	Survival	Survival rate
	Flowering and fruiting	Average score of male flowers
	Foxtailing	Foxtailing percentage
Quality	Stemform	Stemform score (1-9)
	Relative wood density (Pilodyn)	Diameter adjusted pilodyn readings
	Branching	Average branch diameter
	Branching	Average branch/DBH ratio

5.1 Survival

OVERVIEW OF ANALYSIS		
	Aek Nauli	**Habinsaran**
Co-variates	None	PLOTY2
Data transformation required	Yes. Arc sin transformation	Yes. Arc sin transformation
Weight statement	Yes	Yes
Outliers	None	None
F-test	6.27 (***)	3.32 (***)

Analysis of survival data at year 7 reflects not only differences in 'true' survival rates but is also affected by within-plot competition. For the Aek Nauli trial, irregularities in weeding have resulted in loss of many seedlings, and great care is therefore required in the interpretation of results of this trial.

The Habinsaran trial has a much higher survival rate than the Aek Nauli trial. Many of the seed sources have a survival rate above or close to 90 per cent, e.g. *P. oocarpa* (Mal Paso), Lang Hanh (Vietnam), *P. tecunumanii* (Mt. Pine Ridge), and Bodana (Madagascar). There are not statistical significant differences among the top provenances, but it is possible to distinguish between a high and a low survival group. In the latter one we find *P. patula*, Doi Suthep (Thailand) and Aungban (Myanmar).

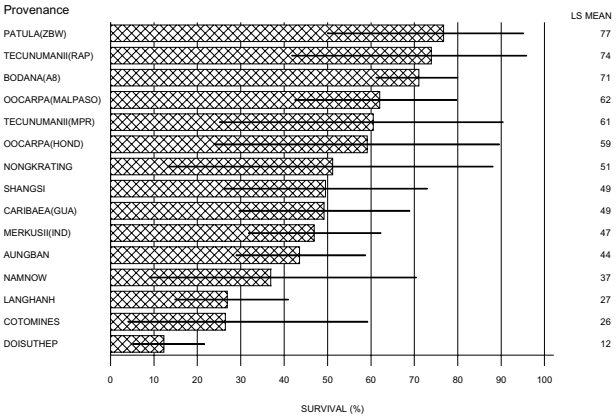
The ranking in regard to survival is quite different in the Aek Nauli trial, but as mentioned above, these results have to be interpreted with great care, as also indicated by the very wide confidence intervals. The Lang Hanh (Vietnam), Coto Mines (Philippines) and Doi Suthep (Thailand) have very low survival rates. Especially the low survival rate of Lang Hanh is surprising as it is among the highest ranking provenances in the Habinsaran trial. *P. patula*, *P. tecunumanii* (San Raphael) and Bodana (Madagascar) are high ranked at Aek Nauli, whereas only Bodana is among the best at Habinsaran. *P. patula* and *P. tecunumanii* (San Raphael) have below average survival rates.

Pinus kesiya provenance trial, Aek Nauli, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 7

Established November 1992. Assessed September 1999

Survival (%)

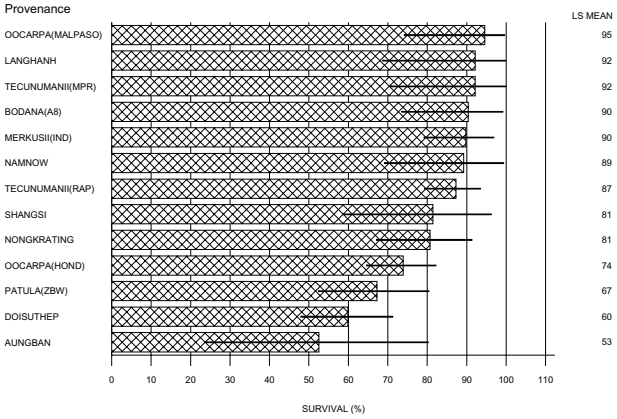


Pinus kesiya provenance trial, Habinsaran, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 8

Established October 1992. Assessed September 1999

Survival (%)

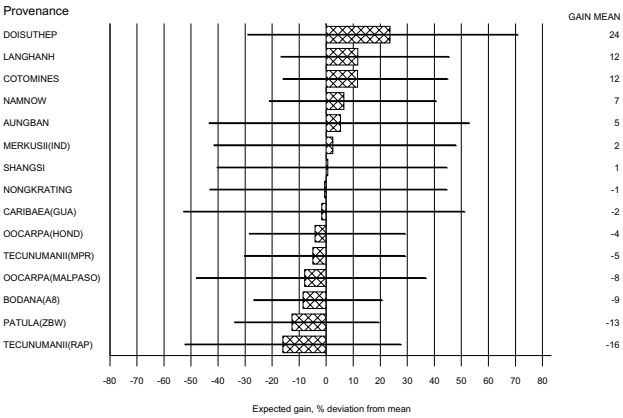


Pinus kesiya provenance trial, Aek Nauli, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 7

Established November 1992. Assessed September 1999

Survival. Best linear un-biased predictors (BLUPs)

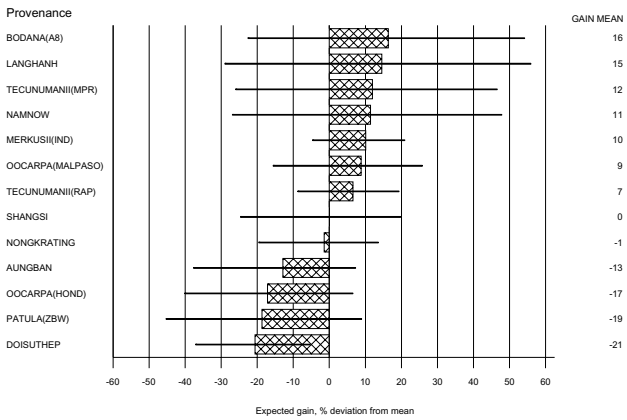


Pinus kesiya provenance trial, Habinsaran, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 8

Established October 1992. Assessed September 1999

Survival. Best linear un-biased predictors (BLUPs)



5.2Height growth

OVERVIEW OF ANALYSIS		
	Aek Nauli	**Habinsaran**
Co-variates	None	PLOTX and PLOTY2
Data transformation required	No	No
Weight statement	No	Yes
Outliers	Lang Hanh (Block 1)	None
F-test	12.96 (***)	96.18 (***)

The analysis of height growth shows highly significant differences among provenances in both trials. The ranking of provenances is very similar in the two trials. The two *P. tecunumanii* sources are at the top in both trials, although the exact ranking of the two sources are different from the one trial to the other.

The *P. tecunumanii* sources are followed by the two sources of *P. oocarpa*. The best source of *P. kesiya* in the Aek Nauli trial is the Coto Mines provenance (Philippines), which is unfortunately not in the Habinsaran trial. Coto Mines is followed by the provenances Doi Suthep (Thailand), Bodana (Madagascar) and Lang Hanh (Vietnam). There are however no statistically significant differences among these sources. At the bottom end we find Nam Now (Thailand), Nong Krating (Thailand) and Aungban (Myanmar). At the very bottom is the Shangsi provenance of *P. yunnanensis*.

In the Habinsaran trial, again the Lang Hanh, Bodana and Doi Suthep are the most promising *P. kesiya* sources. Nam Now, Nong Krating, Aungban and Shangsi sources are at the bottom.

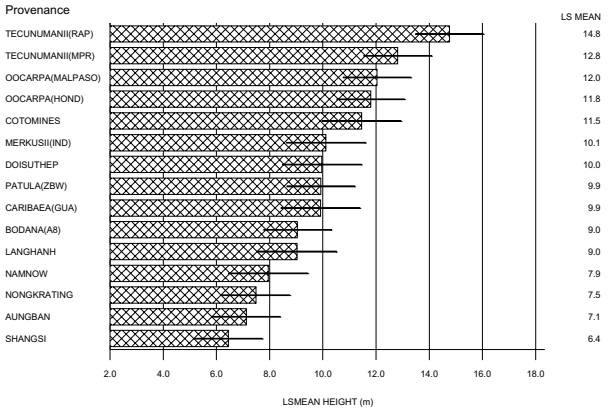
The local *P.merkusii* source is in both trials ranking below the *P. tecunumanii*/*P. oocarpa* sources but higher than the *P. kesiya* sources. The *P. patula* source (of Zimbabwe origin) does not show much promise. It is intermediately placed in the Aek Nauli trial, but at the very bottom at Habinsaran. The *P. caribaea* source is only in the Aek Nauli trial, where it is showing a (surprisingly) poor growth.

Pinus kesiya provenance trial, Aek Nauli, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 7

Established November 1992. Assessed September 1999

Vertical height (m)

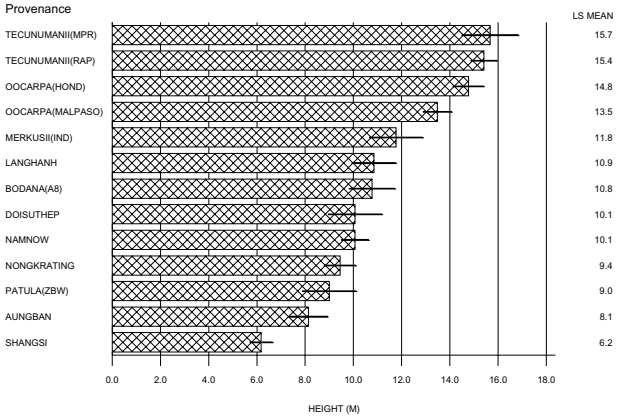


Pinus kesiya provenance trial, Habinsaran, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 8

Established October 1992. Assessed September 1999

Height (m)

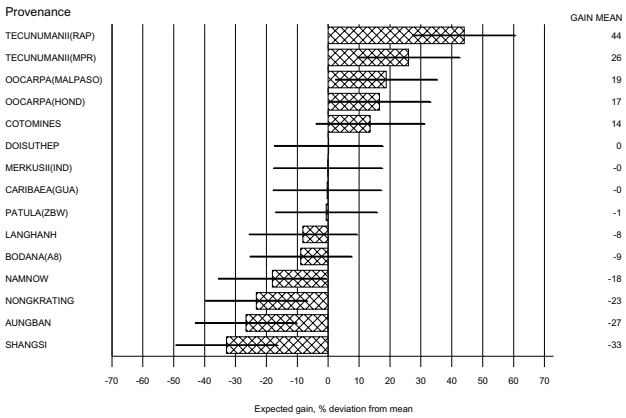


Pinus kesiya provenance trial, Aek Nauli, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 7

Established November 1992. Assessed September 1999

Height gain. Best linear un-biased predictors (BLUPs)

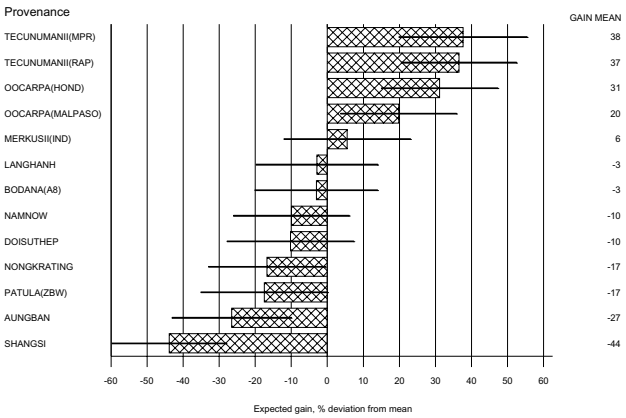


Pinus kesiya provenance trial, Habinsaran, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 8

Established October 1992. Assessed September 1999

Height gain. Best linear un-biased predictors (BLUPs)



5.3 Diameter growth

OVERVIEW OF ANALYSIS		
	Aek Nauli	**Habinsaran**
Co-variates	None	PLOTX, PLOTY and PLOTY2
Data transformation required	No	No
Weight statement	No	Yes
Outliers	Lang Hanh (Block 1)	None
F-test	6.29 (***)	28.31 (***)

There are highly significant differences in regard to diameter growth in both trials.

The results of the Aek Nauli trial- again - have to be interpreted with care as differences in survival between plots may have influenced diameter growth. This is reflected in the considerably larger confidence intervals in the Aek Nauli trial compared to the Habinsaran trial.

If we look at the results of the Habinsaran trial first, the ranking of provenances is not very different from what we have seen for height growth. We have the *P. tecunumanii* sources at the top, followed by *P. oocarpa*. Lang Hanh (Vietnam) and Bodana (Madagascar) are again best among the *P. kesiya* sources, although there are only small and statistically insignificant differences among the best *P. kesiya* sources. The *P. yunnanensis* source (Shangsi-China), *P. patula* and Aungban (Myanmar) are at the bottom end and they can be distinguished also statistically from the above mentioned sources.

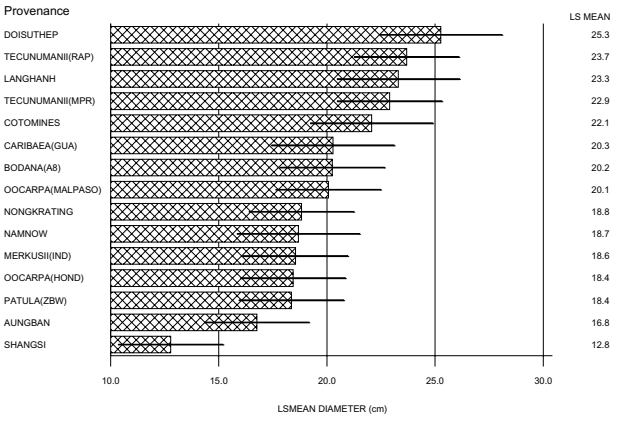
In the Aek Nauli trial the ranking is quite different, which is believed to a large extent due to the differences in survival. Doi Suthep (Thailand) and Lang Hanh (Vietnam) placed in the top together with the two *P. tecunumanii* sources. The two *P. oocarpa* sources are ranked relatively low. In the lower end, the picture is identical to the Habinsaran trial with Shangsi (China), Aungban (Myanmar) and *P. patula* having the poorest diameter growth.

Pinus kesiya provenance trial, Aek Nauli, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 7

Established November 1992. Assessed September 1999

Diameter (cm)

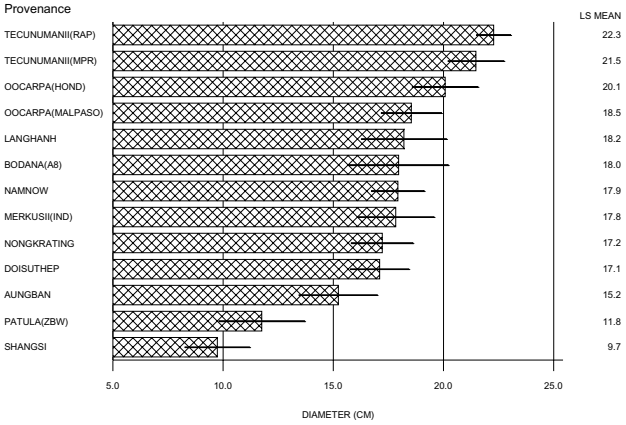


Pinus kesiya provenance trial, Habinsaran, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 8

Established October 1992. Assessed September 1999

Diameter (cm)

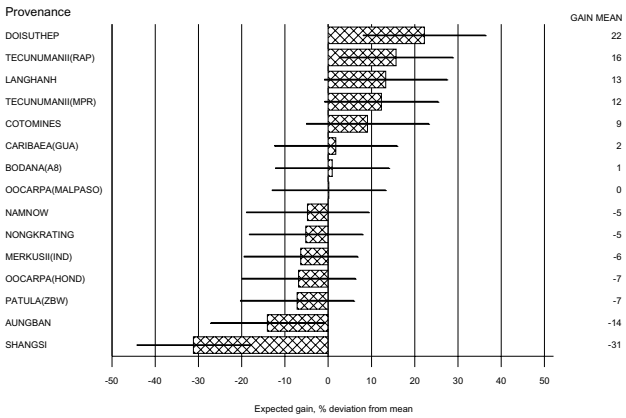


Pinus kesiya provenance trial, Aek Nauli, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 7

Established November 1992. Assessed September 1999

Diameter gain. Best linear un-biased predictors (BLUPs)

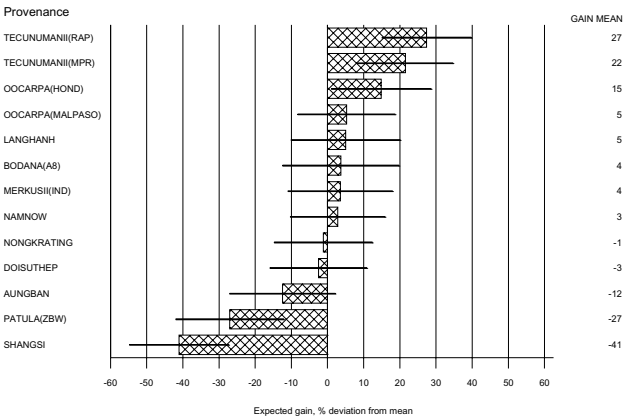


Pinus kesiya provenance trial, Habinsaran, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 8

Established October 1992. Assessed September 1999

Diameter gain. Best linear un-biased predictors (BLUPs)



5.4 Mean volume of tree

OVERVIEW OF ANALYSIS		
	Aek Nauli	**Habinsaran**
Co-variates	None	PLOTX and PLOTY
Data transformation required	No	No
Weight statement	No	Yes
Outliers	None	None
F-test	6.63 (***)	52.14 (***)

Mean volume of tree is calculated as the average of the volumes of individual trees. As both height and diameter are included in the volume formula, the trait thus illustrates a combined effect of height and diameter.

Again, the Aek Nauli results have to be interpreted with care because of the different survival rates and consequently diameter growth.

In the Habinsaran trial, the two *P. tecunumanii* seed sources are at the top, followed by the *P. oocarpa* sources. They again are followed by the local *P. merkusii* and only then we find the best *P. kesiya* sources. They are Lang Hanh (Vietnam) and Bodana (Madagascar). *P. patula* and *P. yunnanensis* are at the bottom.

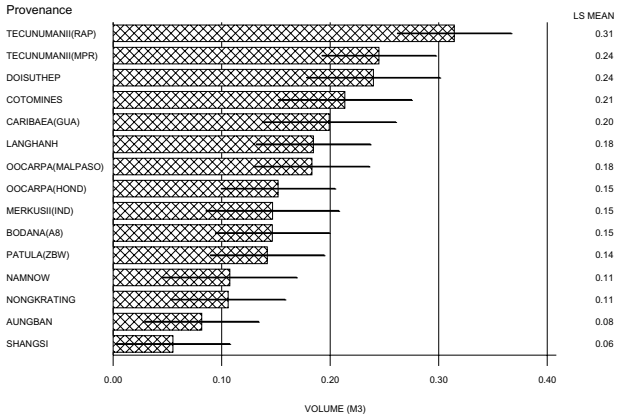
In the Aek Nauli trial, we also have the two *P. tecunumanii* sources at the top, but they are followed closely by Doi Suthep (Thailand) and Coto Mines (Philippines). At the bottom we find, as in the Habinsaran trial, Aungban (Myanmar) and Shangsi (China).

Pinus kesiya provenance trial, Aek Nauli, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 7

Established November 1992. Assessed September 1999

Volume of mean tree (m3)

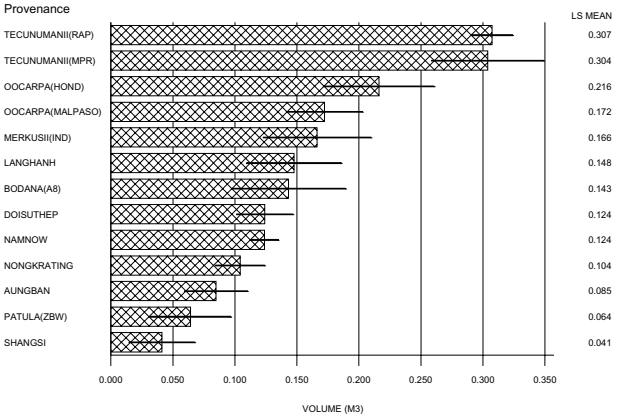


Pinus kesiya provenance trial, Habinsaran, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 8

Established October 1992. Assessed September 1999

Volume of mean tree (m3)

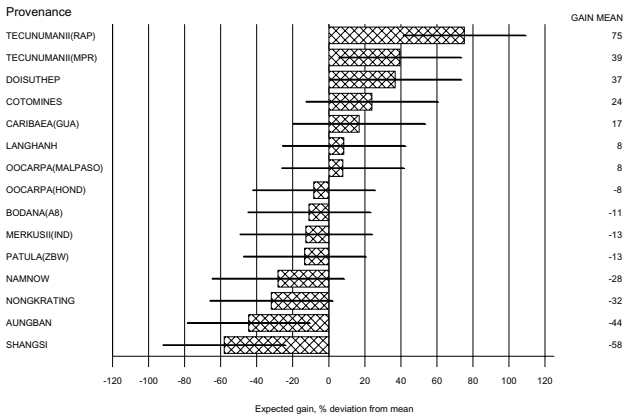


Pinus kesiya provenance trial, Aek Nauli, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 7

Established November 1992. Assessed September 1999

Volume of mean tree. Best linear un-biased predictors (BLUPs)

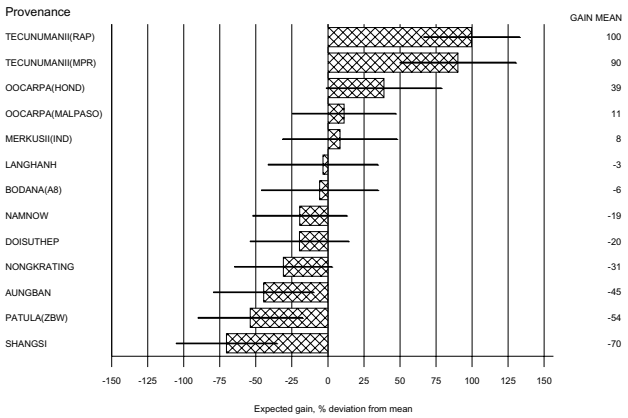


Pinus kesiya provenance trial, Habinsaran, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 8

Established October 1992. Assessed September 1999

Volume of mean tree. Best linear un-biased predictors (BLUPs)



5.5 Total volume per hectare

OVERVIEW OF ANALYSIS		
	Aek Nauli	**Habinsaran**
Co-variates	PLOTXY	PLOTX and PLOTY2
Data transformation required	No	No
Weight statement	Yes	Yes
Outliers	None	None
F-test	6.01 (***)	33.88 (***)

The analysis of total volume production can be seen as an analysis summarising survival, height growth and diameter growth in one analysis as all three traits are included in the calculation.

The Habinsaran trial shows a ranking of provenances almost identical to what we have seen for mean volume of tree. The two *P. tecunumanii* sources are by far the most productive, with the San Raphael source slightly better than the Mt. Pine Ridge although the difference is not statistically significant. Following the *P. tecunumanii* sources, but with significantly lower production, we have the two *P. oocarpa* provenances followed by *P. merkusii*. The best sources of *P. kesiya* are again Bodana (Madagascar) and Lang Hanh (Vietnam).

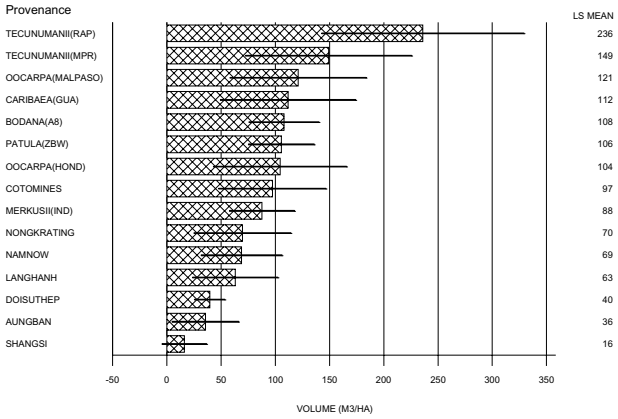
In the Aek Nauli trial, we also have the *P. tecunumanii* sources at top, but the ranking underneath is somewhat different to the Habinsaran trial. The Bodana landrace from Madagascar is the best *P. kesiya* source like in the Habinsaran trial, whereas

Pinus kesiya provenance trial, Aek Nauli, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 7

Established November 1992. Assessed September 1999

Volume per ha (m3/ha)

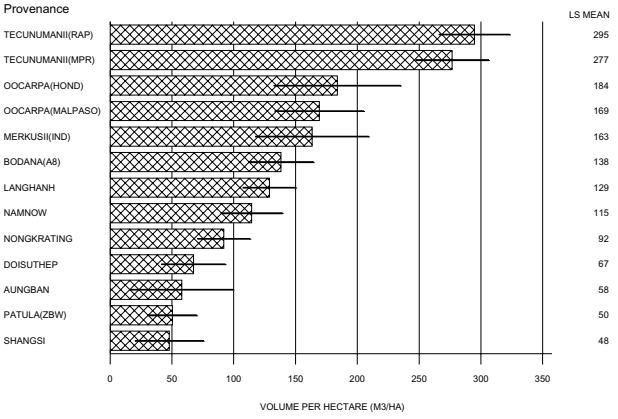


Pinus kesiya provenance trial, Habinsaran, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 8

Established October 1992. Assessed September 1999

Volume per hectare (m3/ha)

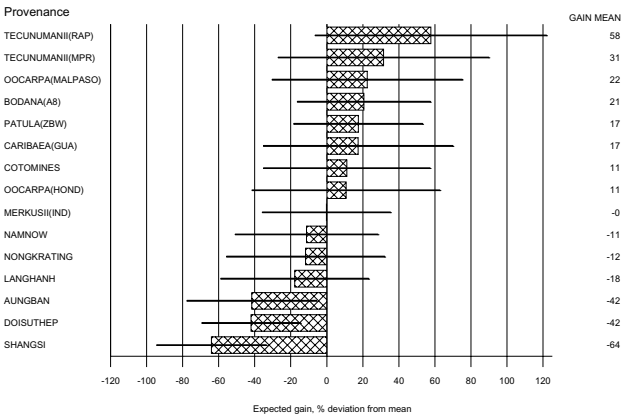


Pinus kesiya provenance trial, Aek Nauli, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 7

Established November 1992. Assessed September 1999

Volume per hectare. Best linear un-biased predictors (BLUPs)

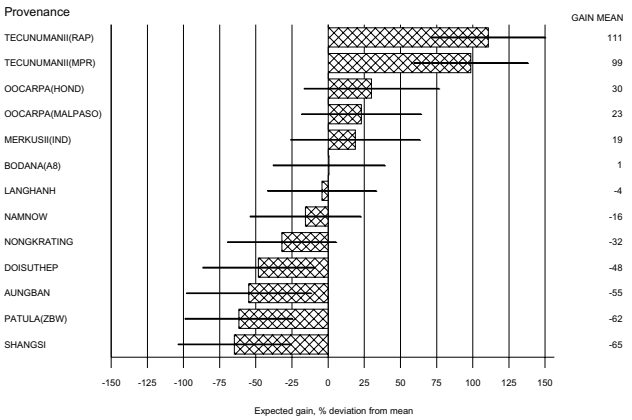


Pinus kesiya provenance trial, Habinsaran, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 8

Established October 1992. Assessed September 1999

Volume gain. Best linear un-biased predictors (BLUPs)



5.6 Stemform

OVERVIEW OF ANALYSIS		
	Aek Nauli	**Habinsaran**
Co-variates	PLOTY2	None
Data transformation required	Yes. Ln transformation	No
Weight statement	Yes	Yes
Outliers	Nong Krating (Block 2)	None
F-test	8.05 (***)	11.60 (***)

The statistical analysis reveals significant differences among provenances in regard to stemform in both trials.

The *P. merkusii* and the *P. caribaea* source (the latter is only in the Aek Nauli trial) have a considerably poorer stemform than the other sources.

The ranking of provenances is different in the two trials. In the Habinsaran trial, *P. patula* is at the top followed by *P. oocarpa* (Honduras) and the two *P. tecunumanii* sources. The best *P. kesiya* sources are Nong Krating (Thailand), Nam Now (Thailand) and Bodana (Madagascar). Aungban (Myanmar), Lang Hanh (Vietnam), Shangsi (China) and Doi Suthep (Thailand) have the poorest stemform among the *P. kesiya* sources.

At Aek Nauli, Nam Now (Thailand) and Doi Suthep (Thailand) are at the top. This in contrast to the Habinsaran trial where Nam Now is intermediate, and Doi Suthep is in the lower half. Next at Aek Nauli we have the sources of *P. oocarpa*, *P. tecunumanii*, *P. patula* and Bodana (Madagascar) which were at the very top at Habinsaran.

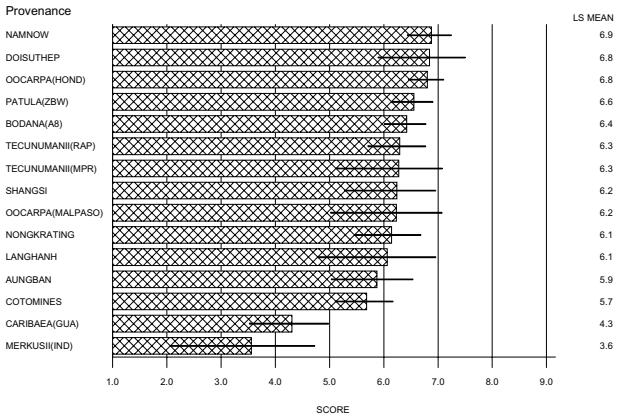
For both trials, there are only small – and not statistically significant – differences among the top ranking seed sources.

Pinus kesiya provenance trial, Aek Nauli, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 7

Established November 1992. Assessed September 1999

Stemform (1-9 score)

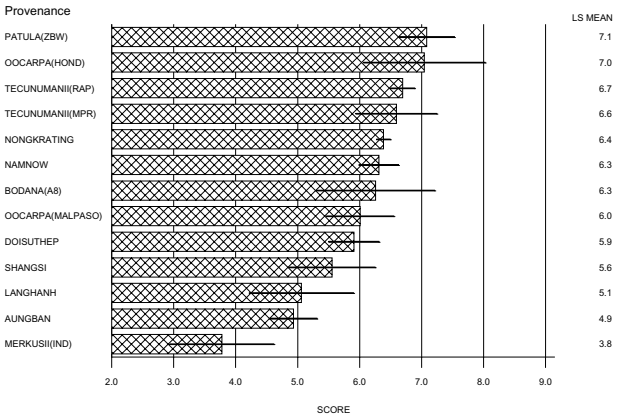


Pinus kesiya provenance trial, Habinsaran, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 8

Established October 1992. Assessed September 1999

Stemform (1-9 score)

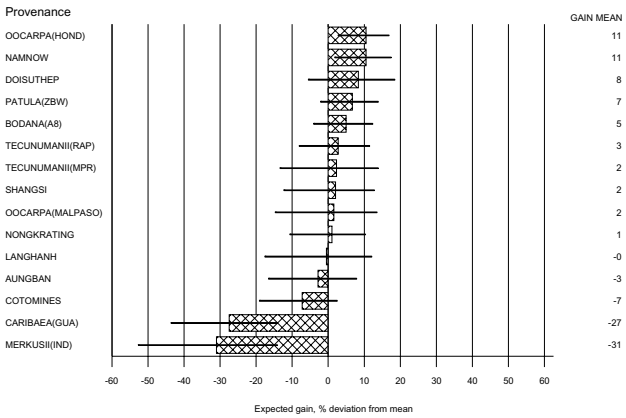


Pinus kesiya provenance trial, Aek Nauli, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 7

Established November 1992. Assessed September 1999

Stemform. Best linear un-biased predictors (BLUPs)

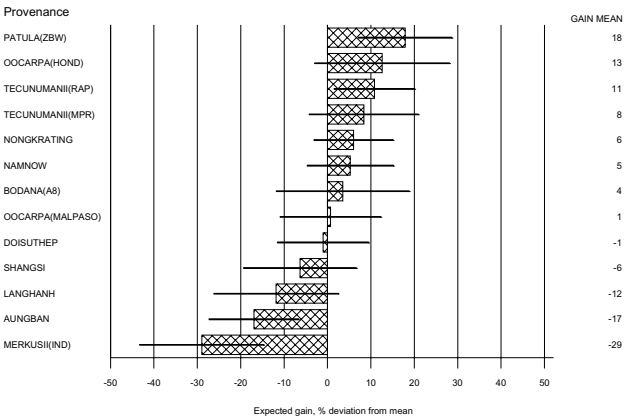


Pinus kesiya provenance trial, Habinsaran, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 8

Established October 1992. Assessed September 1999

Stemform. Best linear un-biased predictors (BLUPs)



5.7 Wood density (Pilodyn)

OVERVIEW OF ANALYSIS		
	Aek Nauli	**Habinsaran**
Co-variates	None	PLOTY2
Data transformation required	Yes. Square-root transformation	Yes. Ln transformation
Weight statement	No	Yes
Outliers	None	None
F-test	3.71(***)	7.68 (***)

Diameter adjusted pilodyn readings (ref. Annex 4) are used in the analysis.

Both the Aek Nauli and the Habinsaran trial reveal significant differences between provenances. The ranking of provenances, however, is different in the two trials. As we have seen for most other traits, the confidence intervals in the Aek Nauli trial are much wider than in the Habinsaran trial.

The sources with the fastest growth (diameter and total volume production), i.e. the *P. tecunumanii* and *P. oocarpa* sources, have the highest pilodyn values corresponding to the lowest wood densities. Consequently, the slow growing sources have in general the highest wood densities. This is the general picture, but there are exceptions, and the exact ranking, as mentioned above, is different in the two trials.

Most remarkable is *P. patula* that is ranked at the top at Habinsaran, but at the bottom end in the Aek Nauli trial. A ranking among the top sources is what would be expected considering the poor growth of *P. patula* in both trials. Also the Aungban (Myanmar) and *P. oocarpa* (Mal Paso) sources have very different rankings in the two trials.

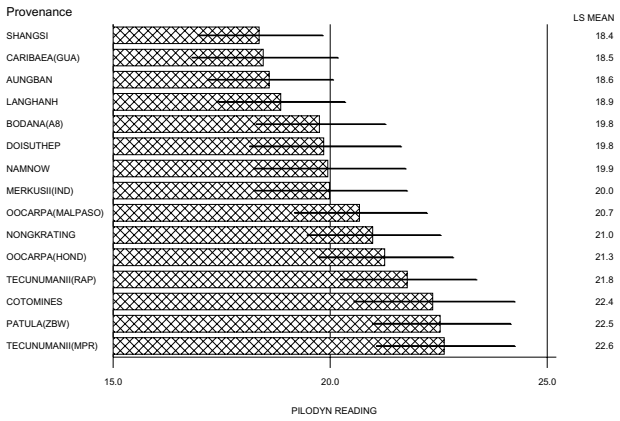
There are significant differences when comparing the top and bottom, but differences among many of the sources ranked in-between are only small, and not statistically significant.

Pinus kesiya provenance trial, Aek Nauli, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 7

Established November 1992. Assessed September 1999

Pilodyn

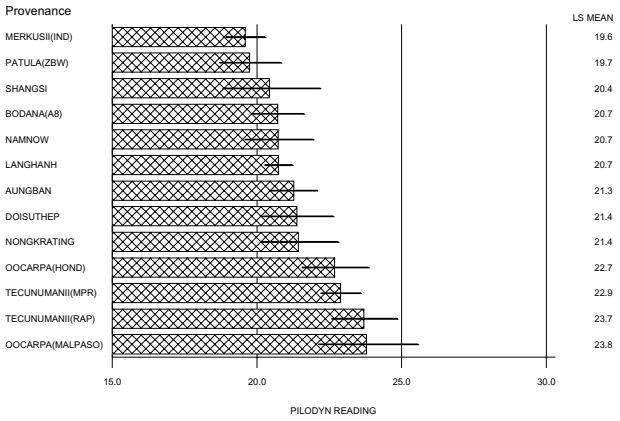


Pinus kesiya provenance trial, Habinsaran, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 8

Established October 1992. Assessed September 1999

Pilodyn

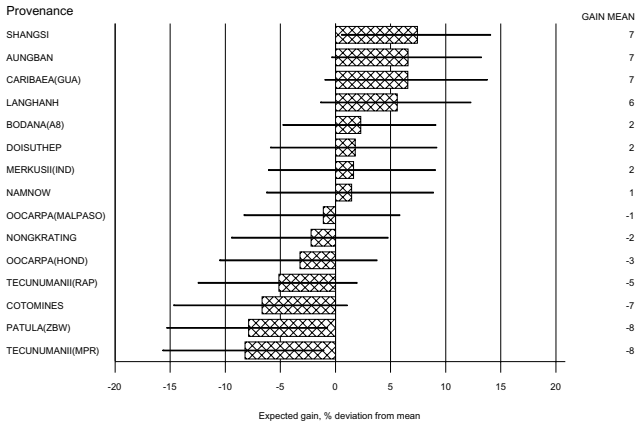


Pinus kesiya provenance trial, Aek Nauli, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 7

Established November 1992. Assessed September 1999

Pilodyn. Best linear un-biased predictors (BLUPs)

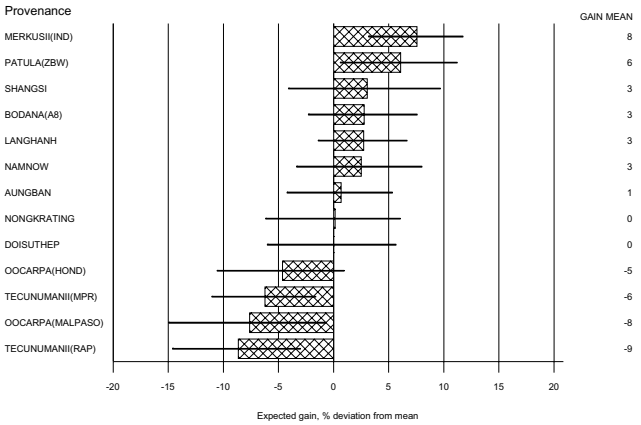


Pinus kesiya provenance trial, Habinsaran, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 8

Established October 1992. Assessed September 1999

Pilodyn. Best linear un-biased predictors (BLUPs)



5.8 Branching (branch diameter)

OVERVIEW OF ANALYSIS		
	Aek Nauli	**Habinsaran**
Co-variates	PLOTX2	PLOTY
Data transformation required	No	No
Weight statement	Yes	Yes
Outliers	None	None
F-test	11.87(***)	4.27 (***)

Branch diameter (largest branch in whorl at 1/10 of tree height) has only been assessed on the *P. kesiya* /*P. yunnanensis* sources, and therefore the analysis is restricted to these sources. The analysis reveals significant differences between provenances in both trials.

In both trials, the Shangsi (*P. yunnanensis*) source has considerably smaller branch diameters than the other sources. The growth potential of this source is very poor, and the small branches are related to this fact.

The results of the Aek Nauli trial, again, have to be interpreted with care as low survival most likely has influenced development of thick branches. This is e.g. the case for Doi Suthep (Thailand) which in the Habinsaran trial is among the provenances with smallest branch diameter but at the very top at Aek Nauli.

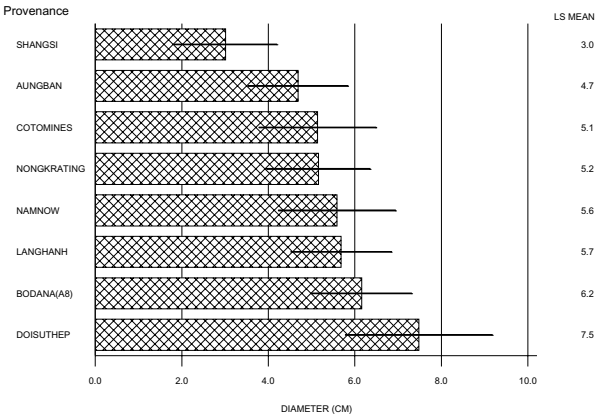
If we leave out Shangsi, there are not great differences among the sources, and differences are not statistically significant. There is maybe a slight tendency to provenances having better growth also having thicker branches.

Pinus kesiya provenance trial, Aek Nauli, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 7

Established November 1992. Assessed September 1999

Branch diameter (cm)

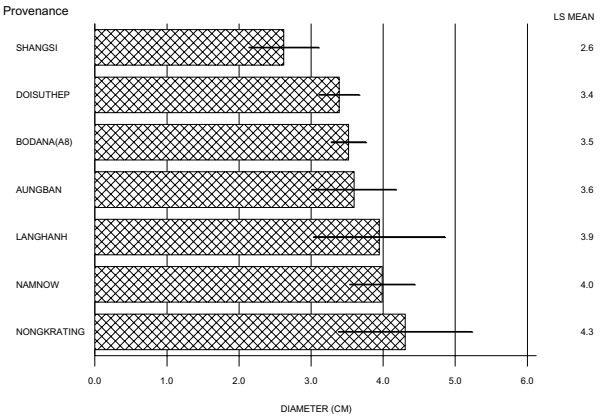


Pinus kesiya provenance trial, Habinsaran, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 8

Established October 1992. Assessed September 1999

Branch diameter (cm)

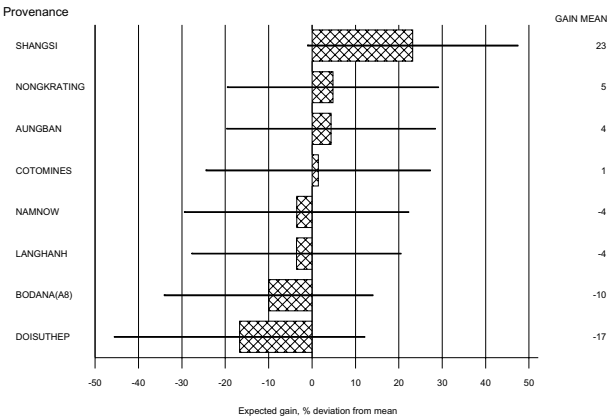


Pinus kesiya provenance trial, Aek Nauli, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 7

Established November 1992. Assessed September 1999

Branch diameter. Best linear un-biased predictors (BLUPs)

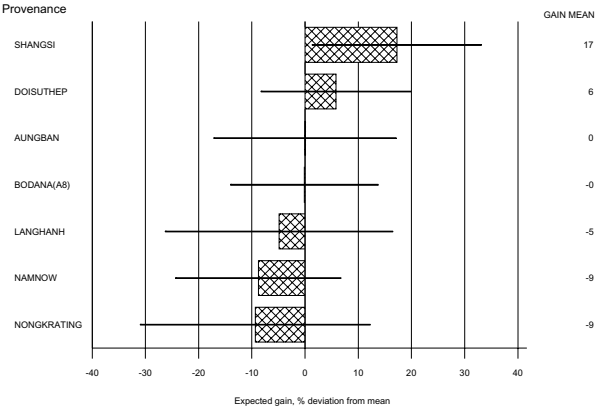


Pinus kesiya provenance trial, Habinsaran, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 8

Established October 1992. Assessed September 1999

Branch diameter. Best linear un-biased predictors (BLUPs)



5.9 Foxtailing

OVERVIEW OF ANALYSIS		
	Aek Nauli	**Habinsaran**
Co-variates	None	None
Data transformation required	No	No
Weight statement	Yes	Yes
Outliers	Block 1: P. tecunumanii (MPR), Lang Hanh and Doi Suthep; Block 2: Nong Krating; Block 3: Doi Suthep and Shangsi; and Block 4: Lang Hanh	None
F-test	1.45(NS)	8.91 (***)

Frequency of foxtails has only been assessed on the *P. kesiya*/*P. yunnanensis* sources.

There are not significant differences among sources in the Aek Nauli trial, whereas in the Habinsaran trial there are significant differences.

It looks as *P. yunnanensis* (Shangsi) has significantly fewer foxtails than the *P. kesiya* sources. For the *P. kesiya* sources the frequency of foxtails is high; between 55 and 75 percent. There are however not statistically significant differences among provenances. There is a tendency, although not statistically significant, to Thai sources having fewer foxtails than the other sources.

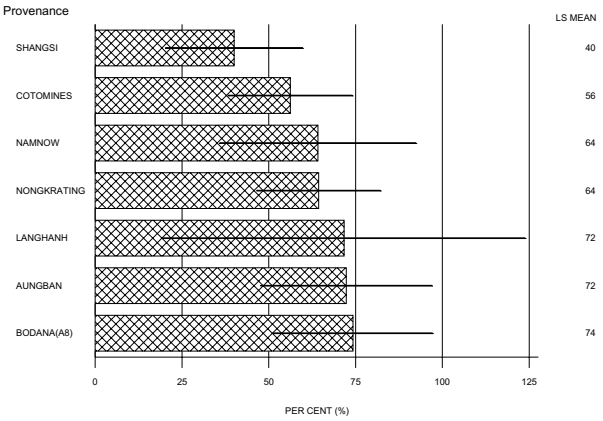
Foxtailing is an important trait to consider. First of all it gives an indication of the adaptability of the source to the site (a low frequency is in general an indication of good adaptation). Moreover, and probably of greater practical importance, foxtails will influence quality. Foxtails will result in ramicorns, i.e. thick branches growing (co-evolving) vertically along with the main stem as there are no branches on the foxtail to suppress this growth. Thick branches mean lower quality, especially if timber is the final products. In addition, harvesting operations become more difficult. Finally, foxtails will often result in broken stems because of the soft wood.

Pinus kesiya provenance trial, Aek Nauli, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 7

Established November 1992. Assessed September 1999

Foxtail percentage (%)

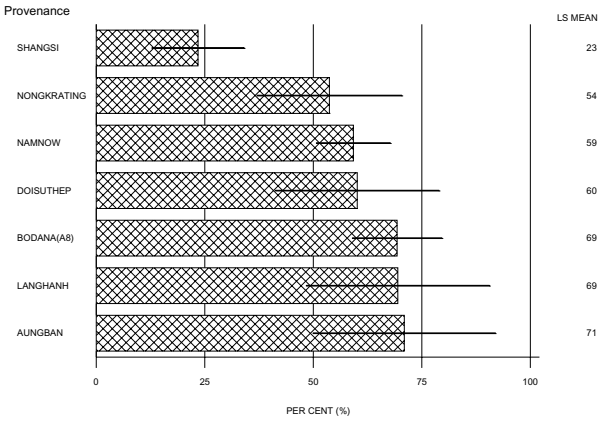


Pinus kesiya provenance trial, Habinsaran, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 8

Established October 1992. Assessed September 1999

Foxtail percentage (%)

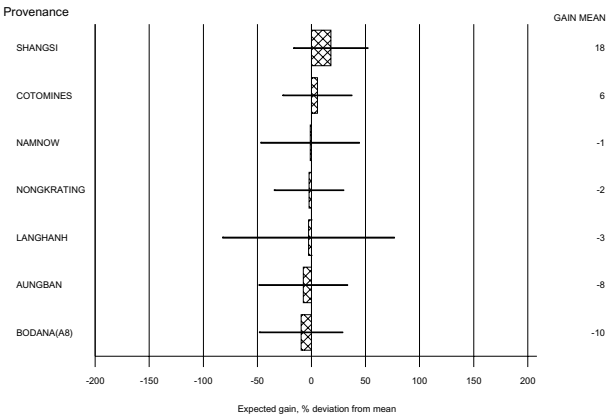


Pinus kesiya provenance trial, Aek Nauli, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 7

Established November 1992. Assessed September 1999

Foxtailing. Best linear un-biased predictors (BLUPs)

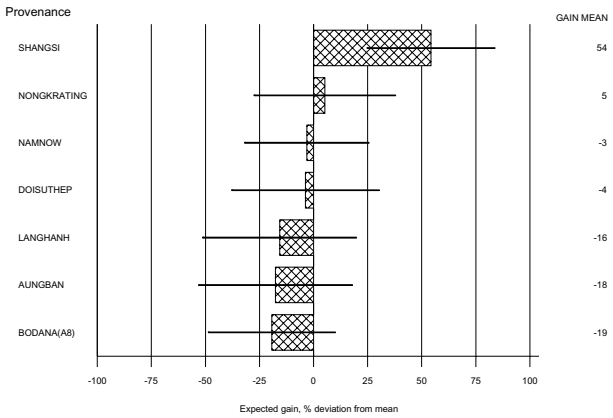


Pinus kesiya provenance trial, Habinsaran, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 8

Established October 1992. Assessed September 1999

Foxtailing. Best linear un-biased predictors (BLUPs)



5.10 Flowering

OVERVIEW OF ANALYSIS		
	Aek Nauli	**Habinsaran**
Co-variates	LEVEL, PLOTX and PLOTY	None
Data transformation required	No	No
Weight statement	Yes	Yes
Outliers	Block 1: P. tecunumanii (MPR), Lang Hanh and Doi Suthep; Block 2: Nong Krating; Block 3: Doi Suthep and Shangsi; and Block 4: Lang Hanh	None
F-test	3.52(***)	0.70 (NS)

Assessment of flowering has only been done on the *Pinus kesiya*/*P. yunnanensis* sources.

Frequency of flowers provides an indication of the adaptation of the sources to site. A good flowering and fruiting will generally be interpreted as a sign of good adaptation to the site, and vice versa.

The two trials are quite young, only about 7 years of age, and flowering and fruiting may have only just commenced. Consequently, male flowers were the only development stage that was present on most trees, and hence the only stage that could be assessed and analysed.

In the Habinsaran trial, there is very sparse flowering, and no statistical differences between the provenances.

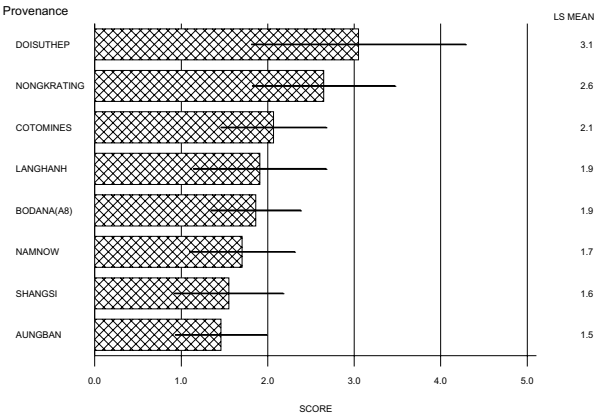
The Aek Nauli trial has more frequent male flowering and there are significant provenance differences. *P. yunnanensis* (Shangsi) and Aungban (Myanmar) have the lowest flowering scores, and Doi Suthep (Thailand) the highest. It is a question if not the uneven survival rates in the Aek Nauli trial have an influence here. The uneven survival rates may have lead to different light conditions in plots which have facilitated flowering to a variable degree. The differences may thus more be because of survival differences than 'true' provenance differences.

Pinus kesiya provenance trial, Aek Nauli, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 7

Established November 1992. Assessed September 1999

Male flowers (1-9 score)

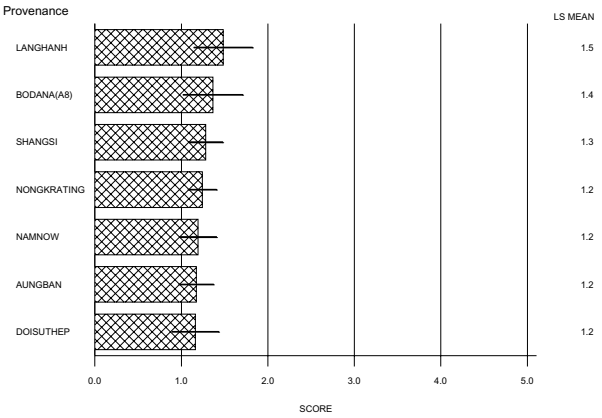


Pinus kesiya provenance trial, Habinsaran, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 8

Established October 1992. Assessed September 1999

Male flowers (1-9 score)

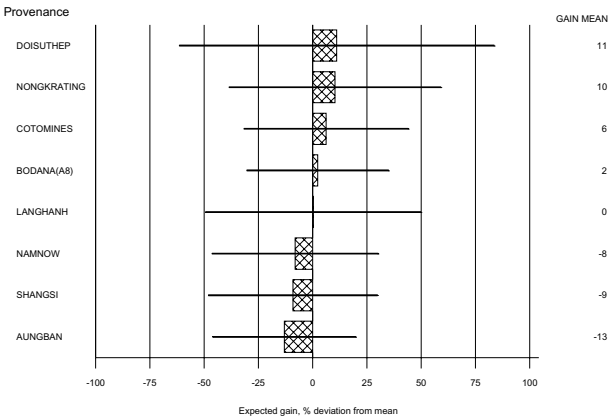


Pinus kesiya provenance trial, Aek Nauli, Indonesia

International Series of Pinus kesiya provenance trials, Trial No. 7

Established November 1992. Assessed September 1999

Male flowers. Best linear un-biased predictors (BLUPs)



No figure of BLUP-estimates for the Habinsaran trial as there are no statistical differences between provenances.

6. Conclusions

Conclusions are to be based mainly on the performance in the Habinsaran trial. This is because of the many lost seedlings in the Aek Nauli trial that has influenced the growth and development. Differences in ranking of seedlots in the two trials are believed to be mainly an effect of this, and not differences caused by different environments at the two sites (i.e. not believed to be genotype x environment interaction).

6.1 Growth

Growth traits should be given key importance in the interpretation of trial results, as production of pulpwood has high priority.

The analysis shows not much promise for the tested sources of *P. kesiya* in comparison to the included controls - most of the tested controls have a considerably faster growth than the *P. kesiya* sources.

The two *P. tecunumanii* sources are superior to the other sources in regard to growth in both trials, and is the most promising species at sites similar to the test sites. The San Raphael provenance has a slightly better growth than the Mt. Pine Ridge provenance, but differences are not statistically significant. It would be interesting to test more sources of *P. tecunumanii*, as other sources may have an even greater potential. The company has such trials under way. Mean annual production – based on the results of the Habinsaran trial – is approx. 40 m3/ha/year.

Following *P. tecunumanii* we find the two sources of *P. oocarpa*, but growth is considerably slower than that of *P. tecunumanii*. In the Aek Nauli trial the two *P. oocarpa* sources have almost the same growth, whereas at Habinsaran, the Honduran source has the fastest growth.

Next in ranking is the local (Indonesian) *P. merkusii* source, and only then we arrive at the best *P. kesiya* sources.

Lang Hanh (Vietnam) and Bodana (Madagascar) are the best growth performers among the *P. kesiya* sources. It is interesting to note that the Madagascar source (landrace) almost certainly originates from the Central plateau of Vietnam (Armitage & Burley, 1980), i.e. from the same region as the Lang Hanh seedsource. It was introduced from here to Madagascar in the 1920's.

Coto Mines (Philippines) is performing well in the Aek Nauli trial (height growth) but is unfortunately not included at Habinsaran.

Doi Suthep (Thailand) may be mentioned together with the above sources, mainly based on a relatively good growth in the Aek Nauli trial. It seems, however, that this source has a low survival rate.

P. patula shows little promise based on the two trials. It is very slow growing, has a low survival rate, and generally looks unhealthy.

The poorest growth performer is the *P. yunnanensis* source that has a volume production less than one fifth of the *P. tecunumanii* sources.

6.2 Adaptation

Adaptive traits include survival percentage, foxtail frequency and flowering. The two latter traits have only been assessed on the *P. kesiya*/*P. yunnanensis* sources.

There are no statistical significant differences among top ranking sources in regard to survival. The best *P. kesiya* performers in regard to growth, Lang Hanh (Vietnam) and Bodana (Madagascar), also have a good survival. In the other end of the scale, *P. patula*, Doi Suthep (Thailand) and Aungban (Myanmar) have a low survival rate.

The *P. yunnanensis* source has a considerably lower frequency of foxtails than the *P. kesiya* sources, but the result has little practical value because of the extremely poor growth of this source. The high frequency of foxtails for the *P. kesiya* sources may be another constraint for a more intensive use of the species.

6.3 Quality

Quality parameters are stemform, wood density (pilodyn) and branch diameter. The *P. tecunumanii* sources, the *P. oocarpa* ones and *P. patula* have the best stemform. *P. merkusii* has a considerably poorer stemform than the rest of sources, with the *P. kesiya* sources forming an intermediate group. The Bodana (Madagascar) source is again among the best, whereas the Lang Hanh (Vietnam) has a poorer stemform.

The more slow growing sources generally have a better wood density (esp. Shangsi and *P. merkusii*) and thinner branches than the faster growing sources (esp. *P. tecunumanii* and *P. oocarpa*). The Lang Hanh and Bodana sources are again here among the highest ranking sources of *P. kesiya*.

6.4 Conclusion

Based on the performance in the two trials, the two sources of *P. tecunumanii* are the most promising. Further testing and investigation of the genetic variation within this species is recommended. The Research & Development Division has trials under way with additional sources of *P. tecunumanii* and these trials will provide valuable information on the most appropriate sources of the species.

P. kesiya shows little promise as a plantation species on the tested sites. The growth is much slower than *P. tecunumanii* and *P. oocarpa*, and it also compares less favorable in regard to stemform. *P. kesiya* may have a larger potential on poorer and harsher sites more influenced by fires (Clegg, pers. comm.). If results of the present trials also are applicable under such conditions, the analysis indicates the Lang Hanh source (natural population from the central plateau of Vietnam) and Bodana A8 (offspring from seed orchard in Madagascar, material probably originally from Vietnam) as the most promising sources. The Lang Hanh source may show an even larger potential in subsequent generations as inbreeding depression from the natural population breaks down. Other sources from the Central plateau of Vietnam could also be of potential interest. The same holds for Philippine sources, which are only represented with one provenance and only in the Aek Nauli trial.

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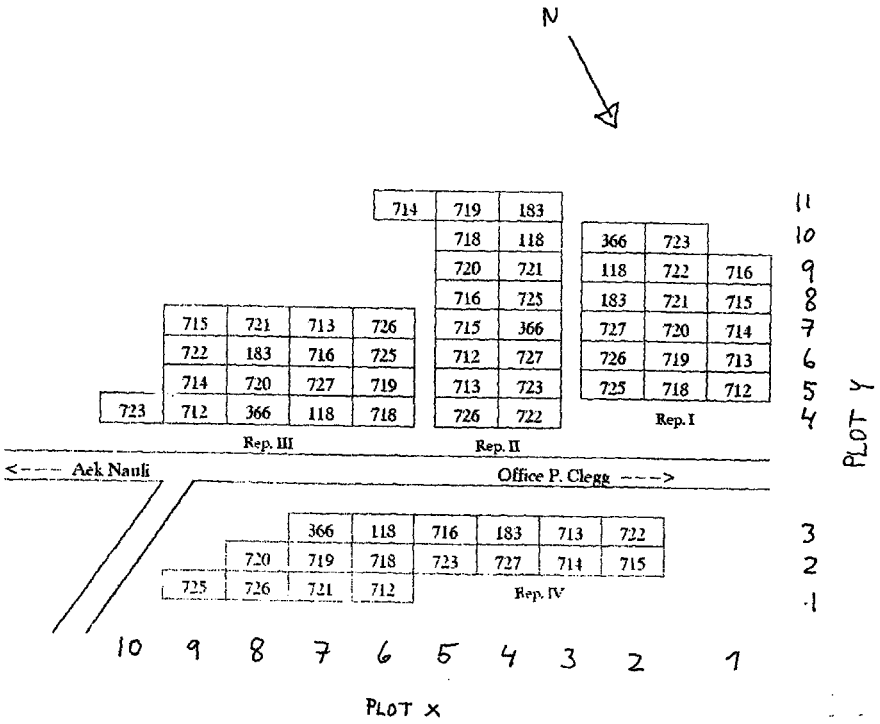
Annexes

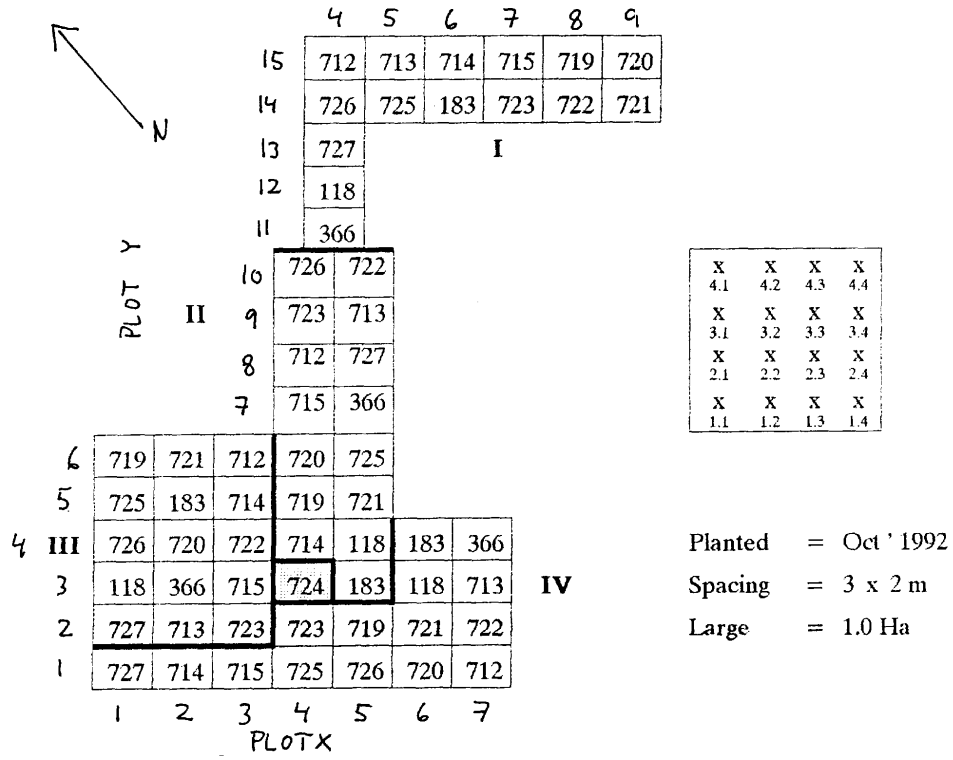
Annex 1. Maps

Aek Nauli



Local ID	DFSC Acc. No.	Species	Provenance	Country
712	-	*P. oocarpa*	Mal Paso	Guatemala
713	-	*P. tecunumanii*	Mt. Pine Ridge	Belize
714	-	*P. oocarpa*	El Paraiso	Honduras
715	-	*P. tecunumanii*	San Raphael	Nicaragua
716	-	*P. caribaea*	Guanaja	Honduras
718	1572/85	*P. kesiya*	Coto Mines	Philippines
719	1525/85	*P. kesiya*	Nam Now	Thailand
720	1521/85	*P. kesiya*	Nong Krating	Thailand
721	1519/85	*P. kesiya*	Lang Hanh	Vietnam
722	1522/85	*P. kesiya*	Doi Suthep	Thailand
723	1523/85	*P. kesiya*	Doi Inthanon	Thailand
724	1639/86	*P. kesiya*	Simao	China
725	1783/88	*P. kesiya*	Bodana A8	Madagascar
726	1773/88	*P. kesiya*	Aungban	Myanmar
727	1633/86	*P. yunnanensis*	Shangsi	China
183	-	*P. merkusii*	Indonesia	Indonesia
118	-	*P. patula*	Zimbabwe landrace	Zimbabwe
366	-	*E. grandis*	Coff's Harbour	Australia

Habinsaran



Local ID	DFSC Acc. No.	Species	Provenance	Country
712	-	*P. oocarpa*	Mal Paso	Guatemala
713	-	*P. tecunumanii*	Mt. Pine Ridge	Belize
714	-	*P. oocarpa*	El Paraiso	Honduras
715	-	*P. tecunumanii*	San Raphael	Nicaragua
716	-	*P. caribaea*	Guanaja	Honduras
718	1572/85	*P. kesiya*	Coto Mines	Philippines
719	1525/85	*P. kesiya*	Nam Now	Thailand
720	1521/85	*P. kesiya*	Nong Krating	Thailand
721	1519/85	*P. kesiya*	Lang Hanh	Vietnam
722	1522/85	*P. kesiya*	Doi Suthep	Thailand
723	1523/85	*P. kesiya*	Doi Inthanon	Thailand
724	1639/86	*P. kesiya*	Simao	China
725	1783/88	*P. kesiya*	Bodana A8	Madagascar
726	1773/88	*P. kesiya*	Aungban	Myanmar
727	1633/86	*P. yunnanensis*	Shangsi	China
183	-	*P. merkusii*	Indonesia	Indonesia
118	-	*P. patula*	Zimbabwe landrace	Zimbabwe
366	-	*E. grandis*	Coff's Harbour	Australia

Annex 2. Trial descriptions

Aek Nauli, Indonesia

TRIAL ESTABLISHMENT AND MANAGEMENT

Year and month of establishment: *November 1992*

Area (ha): *1.0 ha*

Initial spacing (m x m): *3 m x 3 m*

Soil preparation (time, method/intensity): *Site ripper mounded*

Planting method(age of seedlings, type): *Polybags, 6 cm diameter, 10 cm height, seedlings probably 25-30 cm*

Beating up (time, %): *No information*

Irrigation (time, amount): *None*

Fertilization (time, type, amount): *No information*

Weeding (time, intensity): *Irregular, none in 1993-94*

Thinning (time, intensity): *None*

Firelines: *None*

TRIAL DESIGN

Statistical design: *Randomized complete block design*

No. of replications (blocks): *4 replications*

No. of treatments (provenances): *16 provenances* (see list in Annex 1)

Plot size (No. of trees in plot): *16 (4 x 4)*

Demarcation (blocks, plots): *Labels, poles in plot corners . Note problems with identification of seedlot 723 (Doi Inthanon, Thailand)(not kesiya).*

PROTECTION STATUS

Status (describe any disturbances/damages): *Survival is generally low. Many plots with no surviving trees. Many trees are believed to have been cut by accident when undertaking weeding (irregular weeding). Maybe also by pesticide application...*

Guarding (permanent, regular, none): *Permanent guarding. Trial is close to office and R&D nursery*

Habinsaran, Indonesia

TRIAL ESTABLISHMENT AND MANAGEMENT

Year and month of establishment: *October 1992*

Area (ha): *1.0 ha*

Initial spacing (m x m): *3 m x 3 m*

Soil preparation (time, method/intensity): *Site ripper mounded*

Planting method(age of seedlings, type): *Polybags, 6 cm diameter, 10 cm height, seedlings probably 25-30 cm*

Beating up (time, %): *No information*

Irrigation (time, amount): *None*

Fertilization (time, type, amount): *No information*

Weeding (time, intensity): *No information*

Thinning (time, intensity): *None*

Firelines: *None*

TRIAL DESIGN

Statistical design: *Randomized complete block design*

No. of replications (blocks): *4 replications*

No. of treatments (provenances): *15 provenances (see list in Annex 1)*

Plot size (No. of trees in plot): *16 (4 x 4)*

Demarcation (blocks, plots): *Labels, poles in plot corners . Note problems with identification of seedlot 723 (Doi Inthanon, Thailand)(not kesiya).*

PROTECTION STATUS

Status (describe any disturbances/damages): *Good survival and growth. Problems with proper identification in some plots. Seedlot 723, Doi Inthanon is not P. kesiya but an un-identified source of P. tecunumanii. Problems in other plots identified as well.. ..*

Guarding (permanent, regular, none): *Regular guarding. Trial is 2.5 km from sector office*

Annex 3.

Site description – Aek Nauli

LOCATION

Province: *North Sumatra*
District: *Simalungun*
Latitude (degrees and minutes): *02°44'04"N*
Longitude (degrees and minutes): *98°53'39E*
Altitude (m above sea level): *1250 m above sea level*

Managing office/institution: *PT INTI Indorayon Utama, R&D Department*
Owner: *do*
User(s): *do*

Distance to nearest office responsible for management of the trial (km): *70*
Distance to nearest villages/towns (km): *Ujung Mauli, 2 km*
Number of inhabitants in the nearest villages/towns: *approx. 200*

Type of area (e.g. research station, managed forest, etc.): *Managed forest plantations, mainly Eucalyptus sp. for pulp*

CLIMATE

Nearest weather station:
Name of the station: *Aek Nauli base camp (9 km E of trial site)*
Latitude (degrees and minutes): *see above*
Longitude (degrees and minutes): *see above*
Altitude (m a.s.l.): *1200 m above sea level*

Climatic data[1]	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Rainfall (mm)	147.5	152.9	174.5	205.9	173.9	143.7	138.9	191.7	173.4	177.6	214.1	220.0	2114.2
Temp. mean (°C)	20.5	20.8	20.9	21.3	21.9	21.9	21.5	21.4	21.1	20.7	20.8	22.8	21.1
Temp. mean max.[2] (°C)	-	-	-	-	-	-	-	-	-	-	-	-	-
Temp. mean min.[3] (°C)	-	-	-	-	-	-	-	-	-	-	-	-	-
Evapotranspiration[4] (mm)	-	-	-	-	-	-	-	-	-	-	-	-	-

[1] Period of observations 1988-98 [2] Average of daily maximum temperatures
[3] Average of daily minimum temperatures [4] Potential evapotranspiration (ETP) - Penman's formula

Rainy season:

Number/type of seasons: ☐ one ☐ two ☒ Even

Period(s): (specify months)

Length of rainy season:
No. of intermediate days: (pre- and posthumid period of the growing season)
No. of wet days: (growing season)

Number of dry months per year (< 50 mm rain/month): *None*
Frost (number of days/year): *None*
Prevailing winds (direction, period, speed): *W to SW very occasionally strong*

Alternative weather station:

Name of the station:
Latitude (degrees and minutes):
Longitude (degrees and minutes):
Altitude (m a.s.l.):

Climatic data[1]	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Year**
Rainfall (mm)													
Temp. mean (°C)													
Temp. mean max.[2] (°C)													
Temp. mean min.[3] (°C)													
Evapotranspiration[4] (mm)													

[1] Period of observations [2] Average of daily maximum temperatures
[3] Average of daily minimum temperatures [4] Potential evapotranspiration (ETP) - Penman's formula

Rainy season:

Number/type of seasons: ☐ one ☐ two ☐ even/irregular

Period(s): (specify months)

Length of rainy season:

No. of intermediate days: (pre- and posthumid period of the growing season)
No. of wet days: (growing season)

Number of dry months per year (< 50 mm rain/month):
Frost (number of days/year):
Prevailing winds (direction, period, speed):

TOPOGRAPHY (slope) of trial site

☐ Flat/gentle (0-8%) ☒ Intermediate (9-30%) ☐ Steep (>30%)

GENERAL SOIL DESCRIPTION

Soil texture		**Soil depth**		**Soil drainage/ n**		**Gravel content, topsoil**	
1. Light/sandy		1. Shallow (< 50 cm)	X	1. Well drained	X	1. None (< 15 %)	
2. Medium/loamy		2. Deep (50-100 cm)		2. Seasonal		2. Gravelly (15-35 %)	X
3. Heavy/clayey	X	3. Very deep (> 100 cm)		3. Permanent		3. Stony (> 35 %)	

Organic matter content		**Reaction (pH)**		**Soil salinity**		**Groundwater**	
1. Poor (< 2 % DM)	X	1. Acid (pH < 6.5)	X	1. None	X	1. Shallow (< 50 cm)	
2. Medium (2-5 % DM)		2. Neutral (6.5-7.5)		2. Moderate		2. Deep (50 - 150 cm)	
3. Rich (> 5 %)		3. Alkaline (pH> 7.5)		3. High		3. Very deep (>150 cm)	X

Specify soil unit, soil association and phases (subdivisions of soil units) according to the Soil map of the world (FAO-Unesco 1971-1979), if known:

VEGETATION

Natural (original) vegetation type: *Natural forest*

Dominant natural (original) genera/species: *Many*

Land use history: *Natural forest -> degraded forest/scrub -> pines (+/- 50 years) -> eucalypts (4 yrs)*

RESULTS OF SOIL SAMPLE

Results of the laboratory analysis of the soil samples taken at the trial site.

The variables are:

Depth:	Soil sample depth
Clay:	Particle size less than 2 µm (0.002 mm) in diameter
Fine silt	Particle size between 2 and 20 µm (0.002 - 0.020 mm) in diameter
Coarse silt	Particle size between 20 and 63 µm (0.020 - 0.063 mm) in diameter
Fine sand	Particle size between 63 and 125 µm (0.063 - 0.125 mm) in diameter
Fine medium sand	Particle size between 125 and 250 µm (0.125 - 0.250 mm) in diameter
Coarse medium sand	Particle size between 250 and 500 µm (0.250 - 0.500 mm) in diameter
Coarse sand	Particle size between 500 and 2000 µm (0.500 - 2.0 mm) in diameter
Gravel	Particle size between 0.2 and 2 cm in diameter
Org. mat.	Organic material in various stages of decomposition
Lime	Lime content
pH-H2O	Reaction (pH)
P	Phosphorus content

Sample 1: Block 2, plot 719

Description	Unit	Result
Depth of sample	m	1.2
Clay (<2 µm)	%	28.8
Fine silt (2-20 µm)	%	23.1
Coarse silt (20-63 µm)	%	1.4
Fine sand (63-125 µm)	%	3.9
Fine medium sand (125-250 µm)	%	6.5
Coarse medium sand (250-500 µm)	%	10.2
Coarse sand (500-2000 µm)	%	26.1
Org. Mat.	%	1.8
Lime	%	0.0
pH-H_2O	-	5.4
P		- 1

Results noted as - 1: Amount not detectable

Sample 2: Block 2, plot 183

Description	Unit	Result
Depth of sample	m	1.2
Clay (<2 µm)	%	29.4
Fine silt (2-20 µm)	%	24.2
Coarse silt (20-63 µm)	%	3.9
Fine sand (63-125 µm)	%	4.4
Fine medium sand (125-250 µm)	%	6.5
Coarse medium sand (250-500 µm)	%	8.7
Coarse sand (500-2000 µm)	%	22.7
Org. Mat.	%	1.1
Lime	%	0.0
pH-H_2O	-	5.1
P		- 1

Results noted as - 1: Amount not detectable

Site description – Habinsaran

LOCATION

Province: *North Sumatra*
District:
Latitude (degrees and minutes): *02°17'29"N*
Longitude (degrees and minutes): *99°13'42E*
Altitude (m above sea level): *1315 m above sea level*
Managing office/institution: *PT INTI Indorayon Utama, R&D Department*
Owner: *do*
User(s): *do*

Distance to nearest office responsible for management of the trial (km): *30*
Distance to nearest villages/towns (km):
Number of inhabitants in the nearest villages/towns:

Type of area (e.g. research station, managed forest, etc.): Managed forest plantations, mainly *Eucalyptus* sp. for pulp

CLIMATE

Nearest weather station:
Name of the station: *Habinsaran base camp (2 km from trial site)*
Latitude (degrees and minutes): *see above*
Longitude (degrees and minutes): *see above*
Altitude (m a.s.l.): *see above*

Climatic data1	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Rainfall (mm)	101.1	79.9	163.1	205.9	165.1	84.8	117.2	147.9	217.5	157.8	173.4	150.9	1764.5
Temp. mean (°C)	20.3	20.7	20.6	21.2	21.7	21.4	20.8	20.9	20.6	20.6	20.8	20.4	20.8
Temp. mean max.2 (°C)	-	-	-	-	-	-	-	-	-	-	-	-	-
Temp. mean min.3 (°C)	-	-	-	-	-	-	-	-	-	-	-	-	-
Evapotranspiration4 (mm)	-	-	-	-	-	-	-	-	-	-	-	-	-

[1] Period of observations 1988-98 [2] Average of daily maximum temperatures
[3] Average of daily minimum temperatures [4] Potential evapotranspiration (ETP) - Penman's formula

Rainy season:

Number/type of seasons: [ ] one [ ] two [x] Even

Period(s): (specify months)

Length of rainy season:
No. of intermediate days: (pre- and posthumid period of the growing season)
No. of wet days: (growing season)

Number of dry months per year (< 50 mm rain/month): *None*
Frost (number of days/year): *None*
Prevailing winds (direction, period, speed): *W to SW very occasionally strong*

Alternative weather station:

Name of the station:
Latitude (degrees and minutes):
Longitude (degrees and minutes):
Altitude (m a.s.l.):

Climatic data[1]	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Rainfall (mm)													
Temp. mean (°C)													
Temp. mean max.[2] (°C)													
Temp. mean min.[3] (°C)													
Evapotranspiration[4] (mm)													

[1] Period of observations
[2] Average of daily maximum temperatures
[3] Average of daily minimum temperatures
[4] Potential evapotranspiration (ETP) - Penman's formula

Rainy season:

Number/type of seasons: ☐ one ☐ two ☐ even/irregular

Period(s): (specify months)

Length of rainy season:

No. of intermediate days: (pre- and posthumid period of the growing season)
No. of wet days: (growing season)

Number of dry months per year (< 50 mm rain/month):
Frost (number of days/year):
Prevailing winds (direction, period, speed):

TOPOGRAPHY (slope) of trial site

☒ Flat/gentle (0-8%) ☐ Intermediate (9-30%) ☐ Steep (>30%)

GENERAL SOIL DESCRIPTION

Soil texture		Soil depth		Soil drainage/ n		Gravel content, topsoil	
1. Light/sandy		1. Shallow (< 50 cm)	X	1. Well drained	X	1. None (< 15 %)	
2. Medium/loamy	X	2. Deep (50-100 cm)		2. Seasonal		2. Gravelly (15-35 %)	X
3. Heavy/clayey		3. Very deep (> 100 cm)		3. Permanent		3. Stony (> 35 %)	

Organic matter content		Reaction (pH)		Soil salinity		Groundwater	
1. Poor (< 2 % DM)		1. Acid (pH < 6.5)	X	1. None	X	1. Shallow (< 50 cm)	
2. Medium (2-5 % DM)	X	2. Neutral (6.5-7.5)		2. Moderate		2. Deep (50 - 150 cm)	
3. Rich (> 5 %)		3. Alkaline (pH> 7.5)		3. High		3. Very deep (>150 cm)	X

Specify soil unit, soil association and phases (subdivisions of soil units) according to the Soil map of the world (FAO-Unesco 1971-1979), if known:

VEGETATION

Natural (original) vegetation type: *Natural forest*

Dominant natural (original) genera/species: *Many*

Land use history: *Natural forest -> degraded forest/scrub -> eucalypts*

RESULTS OF SOIL SAMPLE

Results of the laboratory analysis of the soil samples taken at the trial site.

The variables are:

Depth:	Soil sample depth
Clay:	Particle size less than 2 µm (0.002 mm) in diameter
Fine silt	Particle size between 2 and 20 µm (0.002 - 0.020 mm) in diameter
Coarse silt	Particle size between 20 and 63 µm (0.020 - 0.063 mm) in diameter
Fine sand	Particle size between 63 and 125 µm (0.063 - 0.125 mm) in diameter
Fine medium sand	Particle size between 125 and 250 µm (0.125 - 0.250 mm) in diameter
Coarse medium sand	Particle size between 250 and 500 µm (0.250 - 0.500 mm) in diameter
Coarse sand	Particle size between 500 and 2000 µm (0.500 - 2.0 mm) in diameter
Gravel	Particle size between 0.2 and 2 cm in diameter
Org. mat.	Organic material in various stages of decomposition
Lime	Lime content
pH-H2O	Reaction (pH)
P	Phosphorus content

Sample 1: Block 2

Description	Unit	Result
Depth of sample	m	1.2
Clay (<2 µm)	%	7.7
Fine silt (2-20 µm)	%	6.3
Coarse silt (20-63 µm)	%	4.9
Fine sand (63-125 µm)	%	9.3
Fine medium sand (125-250 µm)	%	18.4
Coarse medium sand (250-500 µm)	%	22.2
Coarse sand (500-2000 µm)	%	31.2
Org. Mat.	%	3.4
Lime	%	0.0
pH-H_2O	-	5.7
P		- 1

Results noted as - 1: Amount not detectable

Sample 2: Block 1

Description	Unit	Result
Depth of sample	m	1.2
Clay (<2 µm)	%	23.1
Fine silt (2-20 µm)	%	8.2
Coarse silt (20-63 µm)	%	17.0
Fine sand (63-125 µm)	%	7.4
Fine medium sand (125-250 µm)	%	11.0
Coarse medium sand (250-500 µm)	%	14.9
Coarse sand (500-2000 µm)	%	18.4
Org. Mat.	%	7.5
Lime	%	0.0
pH-H_2O	-	5.7
P		- 1

Results noted as - 1: Amount not detectable

Annex 4. Plot data set

Aggregated data set at plot level. This annex describes the variables in the plot dataset, and displays the data. The plot data set has been prepared from the individual tree dataset and holds the following parameters.

PARAMETER NAME	EXPLANATION
SITE	Name of site
DATEEST	Establishment data of trial (MM/YY)
DATEASS	Date of assessment (MM/YY)
BLOCK	Block No.
PLOT	Plot No.
PLOTX	X- coordinate (see map)
PLOTY	Y-coordinate (see map)
SEEDLOT	Seedlot No.
PROVNAME	Name of provenance
SURV	Survival percentage (%)
DG	Diameter corresponding to mean basal area at breast height (cm)
GHA	Basal area (m2/ha)
GMEAN	Mean basal area per tree (m2)
HG	Height for tree with diameter corresponding to mean basal area (m)
MEANPILO	Mean pilodyn for plot
PILOCORR	Mean pilodyn reading adjusted for diameter effect
STEM	Average stemform
STEM1..STEM9	Frequency of individual stemform scores 1 to 9 (%)
WHORLS	Average number of whorls
BRANCH	Average number of branches in whorl
DIABRA	Diameter of largest branch (cm)
FORK	Frequency of trees with one or more forks (%)
FO_POS	Average position of lower fork (m above ground)
FO_INDEX	Forking index (m^{-1})
FLOWER	Flowering and fruiting frequency (%)
FOXTAIL	Frequency of foxtails in plot (%)
KRAFT	Average Kraft index
KRAFT1.. KRAFT5	Frequency of individual Kraft scores 1 to 5 (%)
CROWN	Average crown index
CROWN1..CROWN5	Frequency of individual crown index scores 1 to 5 (%)
BR_INDEX	Branching index (cm)
INTNODE	Average distance between whorls (m)
BRARATIO	Ratio between branch diameter and DBH

DG- Diameter corresponding to mean basal area at breast height (1.3 m)

DG is calculated using the following formula:

$$DG = \left(\sqrt{\frac{\sum_{i=1}^{n} \pi \times \left(Di/2\right)^2}{n}} \right) \times 2$$

where
D_i is the diameter at breast height of tree No. i (in cm);
n is the total number of trees in plot.

GHA - Basal area per hectare

Basal area in m^2 per hectare is calculated using the formula:

$$GHA = \frac{\sum_{i=1}^{n} \pi \times \left(Di/2 \times 100\right)^2}{n \times sp^2} \times 10000$$

where
D_i is the diameter at breast height of tree no. i (in cm);
n is the total number of trees in plot; and
sp is the spacing in m;

HG- Height of tree with diameter corresponding to mean basal area

A linear regression per plot is prepared using the model:

$$Height = \beta + \alpha \times \ln(DBH1)$$

where
DBH1 is the diameter of stem (first stem if more than one stem) in cm;
α is the slope of the regression line;
β is the intercept with y-axis;

For each plot, α and β are estimated using PROC REG (SAS 1990).

HG for the plot is then calculated using the linear regression estimates (α and β) and plot DG (as previously calculated).

PILOCORR - Correction of pilodyn readings

Tree diameter (ring width) influences the pilodyn reading, i.e. trees with larger diameter (rings) will normally have larger pilodyn readings (deeper penetration of the pilodyn pin) than trees with smaller diameter, all other factors equal (ceteris paribus).

In order to adjust pilodyn readings for the variation in diameter, a correction factor has been introduced. By doing so, we are reducing the variance due to differences in individual tree size, and the provenances are in the subsequent analysis compared assuming that they have the same average tree size. In other words, we compare the level of the trait rather than the actual value.

The adjustment has been made using the GLM procedure in SAS (SAS 1990). The following model is applied:

. . .

```
PROC GLM;
CLASS plot;
MODEL pilo = plot DBH1;
LSMEANS plot  OUT=A;
```

. . .

Forking index

The forking index is calculated using the formula:

$$FO_INDEX = \frac{\sum_{i=1}^{n} FORK_i / FO_POS_i}{n}$$

where
$_{FORKi}$ is the number of forks observed on tree i
FO_POS_i is position above ground of first fork (in m) on tree i; and
n is the total number of trees with forking data in the plot

Branching index

The branching index is calculated using the formula:

$$BR_INDEX = \frac{\sum_{i=1}^{n} BRANCH_i \times DIABRA_i}{n \times 10}$$

where
$BRANCH_i$ is the number of branches on tree i;
$DIABRA_i$ is the branch diameter on tree i; and
n is the total number of trees with branching data in the plot.

INTNODE - Average distance between whorls

The INTNODE parameter is calculated using the formula:

$$INTNODE = \frac{\sum_{i=1}^{n} (HEIGHT_i - 0.5) / WHORLS_i}{n}$$

where

$HEIGHT_i$ is the height of tree i
$WHORLS_i$ is the number of whorls on tree i; and
n is the total number of trees with observations on whorls in the plot.

Plot Data Set - Aek Nauli

BLOCK	SEEDLOT	PROVNAME	SITE	DATEESTAB	DATEASSESS	PLOTX	PLOTY	PLOTX2	PLOTY2	PLOTXY	PLOTYX	_TYPE	_FREQ	DBH	HEIGHT	SURV	GMEAN	GSUM	MEANPIL	WHORLS	BRANCH	DIABRA	FORK	FOXTAIL	NO_TOTAL	NO_NIGHT	NOHEIGHT	KRAF1	KRAF2	KRAF3	KRAF4	KRAF5	KRAFT	STEM1	STEM
1	118	PATULA(ZBW)	AekNauli	1192	999	3	9	4	12.25	27	9	0	16	14.17333333	9.02	93.75	0.0177958	0.266937	24.03333333						16	15	15							6.4	0
1	183	MERKUSII(IND)	AekNauli	1192	999	3	8	4	6.25	24	12	0	16	18.375	9.657142857	50	0.027033286	0.216266286	21						16	8	7							2.428571429	14.28571429
1	712	OOCARPA(MALPASO)	AekNauli	1192	999	1	5	16	0.25	5	7	0	16	18.88571429	11.44285714	43.75	0.029219816	0.204538714	21						16	7	7							5.285714286	0
1	713	TECUNUMANII(MPR)	AekNauli	1192	999	1	6	16	0.25	6	6	0	16	22.3	11.76666667	25	0.047542	0.190168	21.5						16	4	3	7	0	0	0	0	0	0	100
1	714	OOCARPA(HOND)	AekNauli	1192	999	1	7	16	2.25	7	5	0	16	17.48	9.95	31.25	0.027534257	0.137671286	21.5						16	5	4							6.6	0
1	715	TECUNUMANII(RAP)	AekNauli	1192	999	1	8	16	6.25	8	4	0	16	25.39230769	14.96363636	81.25	0.052182368	0.678370786	22.69230769						16	13	11							6.666666667	0
1	716	CARIBAEA(GUA)	AekNauli	1192	999	1	9	16	12.25	9	3	0	16	18.99	12.45	62.5	0.030365421	0.303654214	17						16	10	4							4.285714286	14.28571429
1	718	COTOMINES	AekNauli	1192	999	2	5	9	0.25	10	14	0	16	20.46666667	10.46666667	37.5	0.036542262	0.219253571	20.83333333	10.16666667	4.666666667	5.1	0.4	50	16	6	6	16.66666667	16.66666667	16.66666667	50	0	3	5.666666667	0
1	719	NAMNOW	AekNauli	1192	999	2	6	9	0.25	12	12	0	16	19.9	8.345454545	68.75	0.031922929	0.351152214	18.90909091	8.181818182	5.090909091	4.67	0.272727273	33.33333333	16	11	11	0	0	27.27272727	72.72727273	0	3.727272727	7.363636364	0
1	720	NONGKRATING	AekNauli	1192	999	2	7	9	2.25	14	10	0	16	17.175	7.3	75	0.02404528	0.288543357	19.41666667	7.583333333	8.916666667	5.333333333	0.5	63.63636364	16	12	12	0	8.333333333	75	16.66666667	0	3.083333333	6.583333333	0
1	721	LANGHANH	AekNauli	1192	999	2	8	9	6.25	16	8	0	16	18.26666667	9.25	18.75	0.028127	0.084381	16.5	9	6	4.75	0	50	16	3	2	0	0	0	100	0	4	7	0
1	722	DOISUTHEP	AekNauli	1192	999	2	9	9	12.25	18	6	0	16	25.56666667	9.266666667	18.75	0.051583976	0.154751929	18	8.333333333	4.333333333	8.3	0	0	16	3	3	0	0	0	33.33333333	66.66666667	4.666666667	6.333333333	0
1	723		14																															
1	725	BODANA(A8)	AekNauli	1192	999	3	5	4	0.25	15	21	0	16	23.21818182	9.554545455	68.75	0.043066143	0.473727571	19.59090909	11.09090909	7.272727273	6.245454545	0.272727273	38.46153846	16	11	11	0	0	18.18181818	81.81818182	0	3.818181818	7	0
1	726	AUNGBAN	AekNauli	1192	999	3	6	4	0.25	18	18	0	16	16.41818182	7.245454545	68.75	0.0252895	0.2781845	19.13636364	4.818181818	12.90909091	5.511111111	0.909090909	72.72727273	16	11	11	0	30.76923077	46.15384615	15.38461538	7.692307692	3	5.909090909	0
1	727	SHANGSI	AekNauli	1192	999	3	7	4	2.25	21	15	0	16	7.955555556	4.422222222	56.25	0.008130659	0.073175929	19.41666667	4.777777778	5.777777778	3.414285714	0	25	16	9	9	22.22222222	77.77777778	0	0	0	1.777777778	6.888888889	0
2	118	PATULA(ZBW)	AekNauli	1192	999	4	10	1	20.25	40	8	0	16	24.3625	11.6125	50	0.047528348	0.380226786	21.875						16	8	8	5.5	0	12.5	0	25	0	12.5	50
2	183	MERKUSII(IND)	AekNauli	1192	999	4	11	1	30.25	44	4	0	16	18.44166667	10.09	75	0.027205815	0.326469786	18.1						16	12	10							2.6	10
2	712	OOCARPA(MALPASO)	AekNauli	1192	999	5	6	0	0.25	30	30	0	16	21.89230769	12.66	81.25	0.038396044	0.499148571	22.46153846						16	13	10							6.166666667	0
2	713	TECUNUMANII(MPR)	AekNauli	1192	999	5	5	0	0.25	25	35	0	16	20.15833333	11.83636364	75	0.033505935	0.402071214	20.27272727						16	12	11							4.909090909	9.090909091
2	714	OOCARPA(HOND)	AekNauli	1192	999	6	11	1	30.25	66	6	0	16	15.55	9.933333333	37.5	0.021237726	0.127426357	20.9						16	6	6							6.333333333	0
2	715	TECUNUMANII(RAP)	AekNauli	1192	999	5	7	0	2.25	35	25	0	16	21.76875	14.28	100	0.038872772	0.621964357	21.5						16	16	15	6.625	0	0	0	6.25	6.25	12.5	68.75
2	716	CARIBAEA(GUA)	AekNauli	1192	999	5	8	0	6.25	40	20	0	16	18.76363636	8.77	68.75	0.028882429	0.317706714	17.36363636						16	11	10							3.636363636	0
2	718	COTOMINES	AekNauli	1192	999	5	10	0	20.25	50	10	0	16	22.125	11.35	25	0.039794268	0.159177071	23.625	16.75	4.5	3.875	0.5	50	16	4	4	0	0	50	50	0	3.5	5	0
2	719	NAMNOW	AekNauli	1192	999	5	11	0	30.25	55	5	0	16	17.74444444	7.2625	56.25	0.025836294	0.232526643	18.11111111	7.444444444	4.888888889	4.877777778	0.333333333	66.66666667	16	9	8	0	22.22222222	33.33333333	44.44444444	0	3.222222222	5.666666667	0
2	720	NONGKRATING	AekNauli	1192	999	5	9	0	12.25	45	15	0	16	17.3	6.8	6.25	0.023515643	0.023515643	22	5	11	3.2		0	16	1	1	0	0	0	100	0	4	2	0
2	721	LANGHANH	AekNauli	1192	999	4	9	1	12.25	36	12	0	16	21.53333333	9.566666667	56.25	0.038458794	0.346129143	18.16666667	8.777777778	7.222222222	5.822222222	0.25	100	16	9	9	0	11.11111111	22.22222222	44.44444444	22.22222222	3.777777778	5.888888889	0
2	722	DOISUTHEP	AekNauli	1192	999	4	4	1	2.25	16	32	0	16	22.5	9.975	25	0.055608143	0.222432571	17.75	11.75	4.5	5.75	0.75	50	16	4	4	0	25	0	0	75	4.25	7.25	0
2	723		11																															
2	725	BODANA(A8)	AekNauli	1192	999	4	8	1	6.25	32	16	0	16	16.86428571	8.335714286	87.5	0.023631199	0.330836786	19.64285714	6.785714286	5.928571429	6.7	0.090909091	78.57142857	16	14	14	0	7.142857143	42.85714286	50	0	3.428571429	6.571428571	0
2	726	AUNGBAN	AekNauli	1192	999	5	4	0	2.25	20	40	0	16	18.71666667	7.083333333	37.5	0.028211726	0.169270357	16.16666667	6.5	5.333333333	5.65	0	66.66666667	16	6	6	0	16.66666667	50	33.33333333	0	3.166666667	6.5	0
2	727	SHANGSI	AekNauli	1192	999	4	6	1	0.25	24	24	0	16	9.47	4.654545455	68.75	0.00839575	0.0839575	17.6875	5.8	4.3	2.75	0	60	16	10	11	0	40	0	30	30	3.5	7.1	0
3	118	PATULA(ZBW)	AekNauli	1192	999	7	4	4	2.25	28	56	0	16	14.40666667	9.085714286	93.75	0.018849967	0.2827495	23.60714286						16	15	14							6.857142857	0
3	183	MERKUSII(IND)	AekNauli	1192	999	8	6	9	0.25	48	48	0	16	17.14		31.25	0.0238205	0.1191025							16	5	0	0								
3	712	OOCARPA(MALPASO)	AekNauli	1192	999	9	4	16	2.25	36	72	0	16	17.26153846	11.16923077	81.25	0.031619863	0.411058214	20.41666667						16	13	13							6.461538462	0
3	713	TECUNUMANII(MPR)	AekNauli	1192	999	7	7	4	2.25	49	35	0	16	26.4125	13.71428571	50	0.056056295	0.448450357	23.5625						16	8	7	6.625	0	0	0	0	12.5	25	50
3	714	OOCARPA(HOND)	AekNauli	1192	999	9	5	16	0.25	45	63	0	16	18.55384615	11.82307692	87.5	0.028574253	0.371465286	21.5						16	13	13	7	0	0	0	0			
3	715	TECUNUMANII(RAP)	AekNauli	1192	999	9	7	16	2.25	63	45	0	16	22.64285714	11.91666667	43.75	0.041657112	0.291599786	20.42857143						16	7	6							5.333333333	0
3	716	CARIBAEA(GUA)	AekNauli	1192	999	7	6	4	0.25	42	42	0	16	22.3	10.425	31.25	0.040010614	0.200053071	20.3						16	5	4	4.75	0	0	0	50	25	25	0
3	718	COTOMINES	AekNauli	1192	999	6	4	1	2.25	24	48	0	16	22.5	11.9	68.75	0.040383929	0.444223214	21.36363636	11.45454545	6.636363636	6.32	0.363636364	63.63636364	16	11	11	0	0	45.45454545	54.54545455	0	3.545454545	6	0
3	719	NAMNOW	AekNauli	1192	999	6	5	1	0.25	30	42	0	16	18.1125	7.9375	50	0.026329188	0.2106335	23.25	7.625	4.75	7.1	0.375	87.5	16	8	8	0	25	37.5	37.5	0	3.125	6.875	0
3	720	NONGKRATING	AekNauli	1192	999	8	5	9	0.25	40	56	0	16	20.60909091	8.154545455	68.75	0.036115	0.397265	22	8.454545455	5.818181818	5.336363636	0.454545455	54.54545455	16	11	11	0	0	18.18181818	72.72727273	9.090909091	3.909090909	6.454545455	0
3	721	LANGHANH	AekNauli	1192	999	8	7	9	2.25	56	40	0	16	24.525	10.95	25	0.049352875	0.1974115	18.625	16	5	3.6	0.5	50	16	4	4	0	0	0	100	0	4	6.25	0
3	722	DOISUTHEP	AekNauli	1192	999	9	6	16	0.25	54	54	0	16	17.6	9.5	6.25	0.045729357	0.045729357	22.5	3	5	0	100	16	1	1	3								
3	723		4																															
3	725	BODANA(A8)	AekNauli	1192	999	6	6	1	0.25	36	36	0	16	19.36	8.87	62.5	0.033021686	0.330216857	20	7.5	4.6	5.866666667	0.6	100	16	10	10	0	20	30	40	10	3.4	5.888888889	0
3	726	AUNGBAN	AekNauli	1192	999	6	7	1	2.25	42	30	0	16	14.25714286	6.585714286	43.75	0.018058184	0.126407286	21.5	7.166666667	4	4.95	0.285714286	50	16	7	7	0	16.66666667	33.33333333	33.33333333	16.66666667	3.5	4.8	0
3	727	SHANGSI	AekNauli	1192	999	7	5	4	0.25	35	49	0	16	18.7	9.3	18.75	0.027684643	0.083053929	19.16666667	13.33333333	4.666666667	3.133333333	0	33.33333333	16	3	3	0	0	100	0	0	3	5.333333333	0
4	118	PATULA(ZBW)	AekNauli	1192	999	6	3	1	6.25	18	54	0	16	17.74444444	8.777777778	56.25	0.026298119	0.236683071	21.66666667						16	9	9							6.888888889	0
4	183	MERKUSII(IND)	AekNauli	1192	999	4	3	1	6.25	12	36	0	16	19.3	10.14	31.25	0.030297929	0.151489643	20						16	5	5							4.4	0
4	712	OOCARPA(MALPASO)	AekNauli	1192	999	6	1	1	20.25	6	66	0	16	18.4	10.23333333	37.5	0.027767929	0.166607571	18.83333333						16	6	6	7	0	0	0	0	0		
4	713	TECUNUMANII(MPR)	AekNauli	1192	999	3	3	4	6.25	9	27	0	16	19.25	12.93333333	87.5	0.030267903	0.423750643	23.42857143						16	14	12							6.846153846	0
4	714	OOCARPA(HOND)	AekNauli	1192	999	3	2	4	12.25	6	30	0	16	18.42727273	12.1	75	0.029971357	0.329684929	22						16	11	9							6.8	0
4	715	TECUNUMANII(RAP)	AekNauli	1192	999	2	1	9	20.25	2	22	0	16	23.37142857	15	43.75	0.044161408	0.309129857	19.85714286						16	7	3							6.333333333	0
4	718	COTOMINES	AekNauli	1192	999	6	2	1	12.25	12	60	0	16	0	16	0	0	0	5																
4	719	NAMNOW	AekNauli	1192	999	7	2	4	12.25	14	70	0	16	0	16	0	0	0	3																
4	720	NONGKRATING	AekNauli	1192	999	8	2	9	12.25	16	80	0	16	17.83	7.14	62.5	0.02861595	0.2861595	21.25	8.9	4.7	5.125	0.6	70	16	10	10	0	20	30	40	10	3.4	5.666666667	0
4	721	LANGHANH	AekNauli	1192	999	7	1	4	20.25	7	77	0	16	22.6	6.25	12.5	0.040285143	0.080570286	20	13.5	2.5	7.65	1	0	16	2	2	0	0	0	0	50	50	4.5	4	0
4	725	BODANA(A8)	AekNauli	1192	999	9	1	16	20.25	9	99	0	16	18.26	8.45	62.5	0.030552814	0.305528143	19.44444444	10.5	4.1	5.1	0.2	80	16	10	10	0	40	0	30	30	3.5	6.2	0
4	726	AUNGBAN	AekNauli	1192	999	8	1	9	20.25	8	88	0	16	14	6.525	25	0.017636143	0.070544571	19.75	9.25	4.25	3.366666667	0.75	100	16	4	4	25	50	0	0	0	25	2.5	6.25	0
4	727	SHANGSI	AekNauli	1192	999	4	2	1	12.25	8	40	0	16	11.34444444	5.355555556	56.25	0.010995722	0.0989615	21.5	8.5	3.875	4.2	0.444444444	33.33333333	16	9	9	0	22.22222222	66.66666667	11.11111111	0	2.888888889	5.777777778	0

STEM2	STEM3	STEM4	STEM5	STEM6	STEM7	STEM8	STEM9	BRATIO	FO_INDEX	INTNODE	CROWNPCT	FO_POS	TOP	VTREE	MF	FF	CL	CC	OC	DG	HG	PILOCORR	VHA	LEVEL
0	0	0	13.3333333	40	40	6.66666667	0						0	0.0878911						15.0496512	9.48043514	23.1835373	91.553228	14
42.8571429	28.5714286	14.2857143	0	0	0	0	0	0						0.13432887						18.5488544	9.62338276	20.9449317	74.6271493	13
0	14.2857143	14.2857143	42.8571429	0	14.2857143	14.2857143	0						0	0.16842811						19.2844127	11.7452148	20.9377691	81.8747775	13
0	0	6.25												0.23054769						24.5983739	12.2214009	22.0083877	64.0410243	11
20	0	0	0	0	20	60	0	6.25						0.13070833						18.7199359	11.1016394	21.2028366	45.3848372	10
0	8.33333333	0	0	25	41.6666667	25	0	12.5						0.38939845						25.7708989	14.9514421	23.7175029	351.540269	11
0	14.2857143	28.5714286	14.2857143	14.2857143	14.2857143	0	0	18.75						0.26199781						19.6588148	10.3617019	17.300673	181.942926	12
0	0	16.6666667	33.3333333	16.6666667	33.3333333	0	0	0.23762695	5.47420635	1.0025463	80.6122858	2.3	0	0.19491192	2	1	1	1	1	21.5657908	10.9376228	21.0353219	81.2133003	12
0	0	0	0	9.09090909	54.5454545	27.2727273	9.09090909	0.22497786	2.69888017	1.1007684	68.5336114	3.33333333	0	0.13256353	1.27272727	1	1	1	1	20.1566817	8.46895188	19.0163743	101.263807	11
0	0	8.33333333	0	33.3333333	41.6666667	16.6666667	0	0.30520457	2.3940734	1.05498764	70.762255	4.18333333	0	0.09089809	1	1	1	1	1	17.493737	7.45813892	19.0685296	75.7484063	11
0	0	0	0	0	100	0	0	0.21823467		1.12083333	87.1916843		0	0.1650546	1	1	1	1	1	18.9203594	1.37241538	16.916468	34.3863759	12
0	0	0	0	66.6666667	33.3333333	0	0	0.31739985		1.05648148	84.4721373		6.25	0.22627578	4	1	1	1	1	25.6227113	9.26666657	19.0543353	47.1407882	13
0	0	0	9.09090909	9.09090909	54.5454545	27.2727273	0	0.26182314	2.88986355	0.85177386	63.879367	3.25	6.25	0.19698249	2.81818182	1	1	1	1	23.4118463	9.5865563	20.2527496	150.472736	11
0	9.09090909	0	27.2727273	36.3636364	9.09090909	18.1818182	0	0.31467897	7.91418357	1.51555556	68.6977716	1.52222222	0	0.0957555	1.27272727	1	1	1	1	17.9406344	7.45442701	18.6617419	73.1465639	11
0	0	0	0	22.2222222	66.6666667	11.1111111	0	0.54048238		0.97441799	59.3976578		0	0.02799397	1.42857143	1	1	1	1	10.1725666	5.37640071	17.8136859	17.4962328	12
0	0	0												0.26513409						24.5948419	11.731436	22.7280867	147.296717	16
60	20	0	0	0	10	0	0	0						0.14167178						18.6079508	10.0710771	18.0769245	118.059819	17
0	8.33333333	0	8.33333333	33.3333333	50	0	0	18.75						0.22211822						22.1060382	13.2769335	22.9017899	200.523396	11
0	18.1818182	9.09090909	27.2727273	9.09090909	18.1818182	9.09090909	0						0	0.1971233						20.6504035	12.0181367	20.4377454	164.269419	10
0	0	16.6666667	16.6666667	0	50	16.6666667	0						0	0.1177711						16.4407522	10.7444009	20.592809	49.0712901	15
6.25	0	0												0.26706342						22.24285	14.3918021	21.9196016	296.737131	12
27.2727273	36.3636364	9.09090909	9.09090909	9.09090909	9.09090909	0	0	6.25						0.12845947						19.1727553	9.10580383	17.281003	98.1287646	13
0	50	0	0	25	0	25	0	0.17830331	2.56008772	0.68227606	85.4976438	4.9	0	0.22257924	2.5	1	1.75	1	1	22.5049439	11.5408346	24.1041405	61.827566	15
11.1111111	11.1111111	0	11.1111111	22.2222222	33.3333333	11.1111111	0	0.28394681	1.70960366	1.14129464	80.9426933	4.45	0	0.0941521	2	1	1	1	1	18.1335478	7.48687173	17.8581434	58.8450594	16
100	0	0	0	0	0	0	0	0.1849711		1.26	82.3529412		0	0.08044525	3	1	1	1	1	17.3	6.8	21.6727537	5.5864755	14
11.1111111	0	11.1111111	11.1111111	22.2222222	22.2222222	22.2222222	0	0.27461816	3.05660934	1.05494468	84.6786501	3.6	0	0.18294908	2	1	1	1	1	22.1240945	9.79496098	18.5469238	114.343172	15
0	0	0	25	25	0	0	50	0.17586116	5.20151515	0.90360119	88.3232387	3	0	0.28934718	3	1	1	1	1	26.6033832	11.2711021	18.2918131	80.3742166	10
7.14285714	0	7.14285714	0	21.4285714	35.7142857	21.4285714	7.14285714	0.35875336	1.86956522	1.24653912	72.2203313	4.6	6.25	0.10079036	1.35714286	1	1	1	1	17.3424541	8.52270046	19.2427914	97.990624	14
0	0	0	16.6666667	33.3333333	33.3333333	16.6666667	0	0.30721651		1.05888889	77.0685096		0	0.0999986	1.83333333	1	1	1	1	18.9488346	7.13877451	16.0761834	41.6660842	9
0	0	10	0	10	50	10	20	0.32090803		0.93268254	77.1468507		0	0.02992005	1.4	1	1	1	1	10.3370692	5.44054167	16.2697514	20.7778152	12
0	7.14285714	0	14.2857143	0	35.7142857	42.8571429	0						0	0.09409248						15.4889853	9.36428316	22.8429794	98.0129968	7
																				17.4117776				8
0	7.69230769	7.69230769	0	15.3846154	53.8461538	15.3846154	0						0	0.19776167						20.0607731	12.5719153	20.2802235	178.534837	5
12.5	0	0												0.35312499						26.7103678	13.9915797	24.7581967	196.180551	10
		8.33333333	8.33333333	0	41.6666667	41.6666667	0						0	0.17339041						19.0701942	12.344811	21.382305	156.533012	6
0	33.3333333	0	16.6666667	0	50	0	0	0						0.2250962						23.0256689	12.1617668	20.9942598	109.421765	8
0	0	0												0.21628281						22.5660364	10.4173178	20.8083877	75.0981996	9
0	10	10	10	10	60	0	0	0.29110162	3.4334507	1.51720822	79.0265247	4.6	0	0.23268846	2.09090909	1	1	1	1	22.6710669	12.0313527	21.9054494	177.748131	8
0	0	0	12.5	12.5	50	25	0	0.38040502	2.87426901	1.28619048	75.035373	3.23333333	6.25	0.10546661	1.125	1	1	1	1	18.3057027	8.041223	23.0585443	58.5925633	9
0	0	9.09090909	0	36.3636364	45.4545455	9.09090909	0	0.25945332	15.6230447	0.94277056	80.3024771	2.725	6.25	0.1448132	2.72727273	1	1	1	1	21.4393436	8.2183125	22.2257915	110.621197	7
0	0	25	0	25	25	25	0	0.14699179	4.11538462	0.77362013	85.5024846	5.2	12.5	0.26569576	2	1	1	1	1	25.0624719	11.2037622	19.5052448	73.8043783	9
											81.0526316		0	0.21344929	1	1	1	1	1	24.1248834	9.5	22.2228918	14.8228676	7
0	0	0	44.4444444	33.3333333	11.1111111	11.1111111	0	0.34819648	4.03188859	1.17636111	72.7844121	2.6	6.25	0.14440557	2	1	1.1	1	1	20.5006341	8.85882207	20.0170349	100.281643	10
20	0	20	20	20	20	0	0	0.30839714	4.16769231	1.07478175	73.9469646	1.9	0	0.06710856	1.42857143	1	1	1	1	15.1601922	7.07233145	20.9276344	32.6222154	11
0	0	66.6666667	0	0	0	33.3333333	0	0.16179295		0.76106061	68.5215593		0	0.1259128	1	1	1	1	1	18.7709883	9.33068169	19.0733979	26.2318336	8

Plot Data Set - Aek Nauli

Plot Data Set - Habinsaran

BLOCK	SEEDLOT	PROVNAME	SITE	DATEST	DATEASS	PLOTX	PLOTY	PLOTX2	PLOTY2	PLOTXY	PLOTYX	_TYPE_	_FREQ_	DBH1	HEIGHT	SURV	GMEAN	GSUM	MEANPILO	WHORLS	BRANCH	DIABRA	FORK	FOXTAIL	NO_TOTAL	NO_G	NOHEIGHT	KRAFT1	KRAFT2
1	118	PATULA(ZBW)	Habinsar	1092	999	4	12	2.25	20.25	48	16	0	16	11.0076923	9.37692308	81.25	0.01127409	0.14656321	21.9090909						16	13	13		
1	183	MERKUSII(IND)	Habinsar	1092	999	6	14	0.25	42.25	84	12	0	16	14.8692308	10.43	81.25	0.01978598	0.25721771	19.3333333						16	13	10		
1	712	OOCARPA(MALPASO)	Habinsar	1092	999	4	15	2.25	56.25	60	4	0	16	16.175	12.2363636	75	0.02257423	0.27089071	22.35						16	12	11		
1	713	TECUNUMANII(MPR)	Habinsar	1092	999	5	15	0.25	56.25	75	5	0	16	19.4916667	14.975	75	0.03222712	0.38672543	23.2727273						16	12	8	6	0
1	714	OOCARPA(HOND)	Habinsar	1092	999	6	15	0.25	56.25	90	6	0	16	18.93	14.7375	62.5	0.02960186	0.29601864	23.8						16	10	8		
1	715	TECUNUMANII(RAP)	Habinsar	1092	999	7	15	2.25	56.25	105	7	0	16	19.3733333	14.57	93.75	0.03673487	0.551023	22.9						16	15	10		
1	719	NAMNOW	Habinsar	1092	999	8	15	6.25	56.25	120	8	0	16	18.1466667	10.15	93.75	0.02915094	0.43726414	21.5333333	12	7.86666667	3.74	0.26666667	53.3333333	16	15	16	0	20
1	720	NONGKRATING	Habinsar	1092	999	9	15	12.25	56.25	135	9	0	16	17.08	9.41333333	93.75	0.02512699	0.37690479	19.3333333	7.86666667	8.4	5.31538462	0.33333333	60	16	15	15	6.66666667	26.6666667
1	721	LANGHANH	Habinsar	1092	999	9	14	12.25	42.25	126	18	0	16	18.975	11.9125	100	0.02964971	0.47439543	21.3125	10.25	6.5	3.05	0.1875	81.25	16	16	16	0	31.25
1	722	DOISUTHEP	Habinsar	1092	999	8	14	6.25	42.25	112	16	0	16	17.975	11.3714286	50	0.02602993	0.20823943	23.1875	9.5	7	3.4625	0.125	75	16	8	7	0	37.5
1	725	BODANA(A8)	Habinsar	1092	999	5	14	0.25	42.25	70	10	0	16	17.51875	11.48125	100	0.02509517	0.40152279	21.75	9.0625	7.1875	3.34	0	68.75	16	16	16	6.25	18.75
1	726	AUNGBAN	Habinsar	1092	999	4	14	2.25	42.25	56	8	0	16	15.4285714	8.45454545	87.5	0.02177781	0.30488936	20.8571429	7.57142857	8.21428571	3.69285714	0.42857143	71.4285714	16	14	11	0	14.2857143
1	727	SHANGSI	Habinsar	1092	999	4	13	2.25	30.25	52	12	0	16	10.0166667	5.9	75	0.00985404	0.11824843	21.625	7.41666667	7.25	2.81818182	0.25	25	16	12	12	8.33333333	41.6666667
2	118	PATULA(ZBW)	Habinsar	1192	999	5	4	0.25	12.25	20	60	0	16	11.8	8.58333333	50	0.01144255	0.09154043	19.9166667						16	8	6	7.25	0
2	183	MERKUSII(IND)	Habinsar	1192	999	5	3	0.25	20.25	15	65	0	16	18.9	12.5928571	93.75	0.03026105	0.45391579	19.9						16	15	14		
2	713	TECUNUMANII(MPR)	Habinsar	1192	999	5	9	0.25	2.25	45	35	0	16	20.6	16.9416667	100	0.03500262	0.49003664	24.1071429						14	14	12		
2	714	OOCARPA(HOND)	Habinsar	1192	999	4	4	2.25	12.25	16	48	0	16	19.6166667	13.13	75	0.03849123	0.46189471	21.625						16	12	10	6	0
2	715	TECUNUMANII(RAP)	Habinsar	1192	999	4	7	2.25	0.25	28	36	0	16	20.78	15.4846154	93.75	0.03645908	0.54688621	24.3						16	15	13		
2	719	NAMNOW	Habinsar	1192	999	4	5	2.25	6.25	20	44	0	16	18.05	9.76	80	0.0282116	0.33853914	21.75	8.5	8.91666667	4.55	0.75	66.6666667	15	12	10	0	16.6666667
2	720	NONGKRATING	Habinsar	1192	999	4	6	2.25	2.25	24	40	0	16	15.5153846	9.39230769	81.25	0.02228999	0.28976986	22.1538462	9	8.84615385	5.03076923	0.53846154	61.5384615	16	13	13	0	23.0769231
2	721	LANGHANH	Habinsar	1192	999	5	5	0.25	6.25	25	55	0	16	16.24	9.8	100	0.02263203	0.33948043	21.3333333	11.0666667	8.26666667	5.69333333	0.33333333	66.6666667	16	15	15	0	20
2	722	DOISUTHEP	Habinsar	1192	999	5	10	0.25	6.25	50	30	0	16	13.1727273	7.56363636	68.75	0.01652621	0.18178836	20.125	7.81818182	7.54545455	3.29090909	0.18181818	45.4545455	16	11	11	27.2727273	18.1818182
2	725	BODANA(A8)	Habinsar	1192	999	5	6	0.25	2.25	30	50	0	16	21.3333333	11.1166667	75	0.03729393	0.44752714	21.25	10.5833333	6.58333333	4.16666667	0.41666667	58.3333333	16	12	12	0	8.33333333
2	726	AUNGBAN	Habinsar	1192	999	4	10	2.25	6.25	40	24	0	16	12.2	6.925	50	0.0127325	0.10186	21.8125	6.375	5.875	2.85	0.25	62.5	16	8	8	0	62.5
2	727	SHANGSI	Habinsar	1192	999	5	8	0.25	0.25	40	40	0	16	8.81428571	5.55714286	87.5	0.00892016	0.12488221	21.7142857	6.85714286	4.64285714	3.43846154	0.35714286	35.7142857	16	14	14	14.2857143	50
3	118	PATULA(ZBW)	Habinsar	1192	999	1	3	20.25	20.25	3	13	0	16	10.7666667	7.08888889	75	0.00982915	0.11794986	17.9444444						16	12	9		
3	183	MERKUSII(IND)	Habinsar	1192	999	2	5	12.25	6.25	10	22	0	16	17.5533333	11.8166667	93.75	0.02604339	0.39065086	20.6785714						16	15	12		
3	712	OOCARPA(MALPASO)	Habinsar	1192	999	3	6	6.25	2.25	18	30	0	16	17.09375	13.05	100	0.03077137	0.49234193	24.625						16	16	16	5.9375	0
3	713	TECUNUMANII(MPR)	Habinsar	1192	999	2	2	12.25	30.25	4	28	0	16	21.7	16.8142857	62.5	0.03909062	0.39090621	21.5555556						16	10	7	7	0
3	714	OOCARPA(HOND)	Habinsar	1192	999	3	5	6.25	6.25	15	33	0	16	18	13.325	75	0.02822305	0.33867664	23.75						16	12	12		
3	715	TECUNUMANII(RAP)	Habinsar	1192	999	3	3	6.25	20.25	9	39	0	16	21.975	14.7777778	75	0.0435932	0.52311836	23.5						16	12	9		
3	719	NAMNOW	Habinsar	1192	999	1	6	20.25	2.25	6	10	0	16	15.75	9.29333333	100	0.02129855	0.34077686	21.65625	10	7.125	3.33333333	0.1875	62.5	16	16	15	6.25	25
3	720	NONGKRATING	Habinsar	1192	999	2	4	12.25	12.25	8	24	0	16	17.75	9.375	75	0.02849818	0.34197821	22.6666667	11.4166667	6.91666667	3.56666667	0.41666667	33.3333333	16	12	12	0	16.6666667
3	721	LANGHANH	Habinsar	1192	999	2	6	12.25	2.25	12	20	0	16	17.8909091	11.2444444	68.75	0.02922386	0.32146243	21.5	12.0909091	5	3.9	0.54545455	45.4545455	16	11	9	9.09090909	18.1818182
3	722	DOISUTHEP	Habinsar	1192	999	3	4	6.25	12.25	12	36	0	16	18.3	10.03	62.5	0.02851514	0.28515143	22.35	10.5	5.9	3.52	1	80	16	10	10	0	20
3	725	BODANA(A8)	Habinsar	1192	999	1	5	20.25	6.25	5	11	0	16	15.88	9.03076923	93.75	0.02081975	0.31229629	22.6333333	10.3333333	6	3.20666667	0.13333333	73.3333333	16	15	13	6.66666667	13.3333333
3	726	AUNGBAN	Habinsar	1192	999	1	4	20.25	12.25	4	12	0	16	12.5333333	6.46666667	18.75	0.01366252	0.04098757	22.3333333	6.33333333	12.6666667	3.86666667	0.66666667	100	16	3	3	0	0
3	727	SHANGSI	Habinsar	1192	999	1	2	20.25	30.25	2	14	0	16	6.44615385	3.90714286	93.75	0.0040561	0.05272929	20.5	5.38461538	6.07692308	2.28333333	0.15384615	23.0769231	16	13	14	30.7692308	30.7692308
4	118	PATULA(ZBW)	Habinsar	1092	999	6	3	0.25	20.25	18	78	0	16	14.3363636	10.3545455	73.3333333	0.01773364	0.19507007	20.1						15	11	11		
4	183	MERKUSII(IND)	Habinsar	1092	999	6	4	0.25	12.25	24	72	0	16	18.6333333	12.4909091	93.75	0.03081179	0.46217679	19.9285714						16	15	11		
4	712	OOCARPA(MALPASO)	Habinsar	1092	999	7	1	2.25	42.25	7	105	0	16	17.35	12.9142857	93.75	0.0256997	0.35979586	23.3571429						16	14	14	0	
4	713	TECUNUMANII(MPR)	Habinsar	1092	999	7	3	2.25	20.25	21	91	0	16	20.8153846	15.1777778	100	0.03532704	0.45925157	23.0384615						13	13	9		
4	714	OOCARPA(HOND)	Habinsar	1092	999	2	1	12.25	42.25	2	30	0	16	17.9	14.3333333	75	0.02657679	0.07973036	20.8333333						4	3	3	8	0
4	715	TECUNUMANII(RAP)	Habinsar	1092	999	3	1	6.25	42.25	3	45	0	16	20.0833333	15.225	75	0.03561571	0.4273885	23.5						16	12	8	6.5	0
4	719	NAMNOW	Habinsar	1092	999	5	2	0.25	30.25	10	70	0	16	16.5181818	9.37777778	68.75	0.02246036	0.24706393	18.5	11.4545455	5.45454545	4.15454545	0.63636364	54.5454545	16	11	9	0	36.3636364
4	720	NONGKRATING	Habinsar	1092	999	6	1	0.25	42.25	6	90	0	16	15.82	8.81	62.5	0.02082528	0.20825279	20.65	7.6	8.9	3.52	0.3	60	16	10	10	0	20
4	721	LANGHANH	Habinsar	1092	999	6	2	0.25	30.25	12	84	0	16	18.9307692	10.1090909	81.25	0.0321336	0.41773679	20.3846154	12	5.07692308	3.16153846	0.53846154	84.6153846	16	13	11	0	15.3846154
4	722	DOISUTHEP	Habinsar	1092	999	7	2	2.25	30.25	14	98	0	16	17.8	10.9625	62.5	0.02579547	0.25795471	20.75	9.6	6.5	2.74	0	40	16	10	8	20	20

STEM2	STEM3	STEM4	STEM5	STEM6	STEM7	STEM8	STEM9	BRATIO	FO_INDEX	INTNODE	CROWNPCT	FO_POS	TOP	VTREE	MF	FF	CL	CC	OC	DG	HG	PILOCORR	VHA
0	0	0	15.3846154	23.0769231	30.7692308	30.7692308	0						0	0.06495408						11.9786669	10.2046049	22.2435705	58.6391009
45.454545	36.3636364	0	0	9.09090909	0	0	0	6.25						0.12242868						15.8688859	10.9382631	19.4506582	110.525896
0	9.09090909	0	9.09090909	36.3636364	36.3636364	0	9.09090909						0	0.15139424						16.9501721	12.6801869	22.3250146	126.161868
0	0	31.25												0.27305302						20.2524896	15.0416317	23.0728829	227.544182
0	0	10	10	20	40	10	10	12.5						0.19708072						19.4100747	15.0787545	23.6904036	136.861609
0	0	0	7.14285714	21.4285714	57.1428571	7.14285714	7.14285714						12.5	0.3239852						21.62255	14.8536708	22.7617693	337.484579
0	0	6.66666667	0	46.6666667	33.3333333	6.66666667	0	0.21848099	12.0214815	0.94680734	65.8831209	3.45	0	0.1507359	1.06666667	1	1	1	1	19.2616718	10.8027757	21.4743313	157.016562
0	0	0	6.66666667	73.3333333	13.3333333	0	6.66666667	0.30168029	31.0328235	1.34544877	53.6257016	2.52	0	0.12027872	1.13333333	1	1	1	1	17.8828969	9.71489552	19.3432258	125.290338
0	6.25	6.25	12.5	37.5	18.75	18.75	0	0.16264974	9.3842246	1.24043448	69.917734	3.53333333	0	0.17373161	1.3125	1	1	1	1	19.4257561	12.1448756	21.1999971	193.035121
0	25	0	0	62.5	0	0	12.5	0.1926254	3.45945946	1.36406245	73.8001852	3.7	0	0.14827487	1	1	1	1.125	1	18.2013736	11.4791355	23.1395857	82.3749261
0	0	0	6.25	31.25	18.75	6.25	37.5	0.19920915		1.55334619	68.7753532		0	0.14020684	1.5	1	1	1	1	17.8715731	11.5307166	21.7315542	155.785379
0	7.14285714	21.4285714	28.5714286	21.4285714	14.2857143	7.14285714	0	0.24269199	31.7180312	1.35386068	73.6382918	0.9	12.5	0.09695228	1.35714286	1	1	1	1	16.6484877	8.54970683	20.9736988	94.2591626
0	0	0	25	50	16.6666667	8.33333333	0	0.28278423	21.2778592	0.82075397	70.2287632	2.125	0	0.03930963	1.41666667	1	1	1	1	11.1988839	6.51420118	22.0911033	32.7580223
12.5	25	0												0.05812116						12.0678291	8.56720652	20.2277574	32.289534
0	26.6666667	46.6666667	20	6.66666667	0	0	0	0						0.18785683						19.6250011	12.7100463	19.7923412	195.684196
0	0	7.14285714	0	28.5714286	7.14285714	28.5714286	28.5714286						18.75	0.29625906						21.1065833	16.936463	23.8896835	329.176738
	8.33333333	0	25	25	33.3333333	8.33333333	0						12.5	0.28623164						22.1334212	14.8535891	21.4710527	238.526368
0	0	6.66666667	26.6666667	13.3333333	13.3333333	33.3333333	6.66666667						12.5	0.27943167						21.5412318	15.6271749	24.0709146	291.074661
0	0	0	33.3333333	25	25	8.33333333	8.33333333	0.26730986	11.759578	1.22184921	80.1826955	3.6	0	0.12736355	1.08333333	1	1	1.08333	1	18.9487906	10.4018219	21.6972415	113.212041
0	0	7.69230769	7.69230769	38.4615385	30.7692308	7.69230769	7.69230769	0.33538093	11.2367035	1.08336192	57.6331055	2.21428571	0	0.10513946	1.15384615	1	1	1	1	16.8431223	9.55452317	22.264795	94.9175708
7.1428571	21.4285714	21.4285714	14.2857143	21.4285714	7.14285714	0	0	0.363101	6.76193062	0.9071169	75.7636649	1.8	0	0.11626774	1.53333333	1	1	1	1	16.9718591	10.2468559	21.3974803	121.112231
0	0	9.09090909	9.09090909	36.3636364	45.4545455	0	0	0.2532862	4.74537037	0.97017538	63.2802191	3.3	0	0.07981996	1.54545455	1	1	1	1	14.5028837	8.75412391	20.1917305	60.9735828
0	0	8.33333333	25	8.33333333	50	0	8.33333333	0.19894465	3.25811809	1.04653287	66.5894164	4.56	0	0.21011514	1.75	1	1	1	1	21.7864637	11.4893926	20.9851756	175.095947
0	12.5	37.5	25	12.5	12.5	0	0	0.23624928	23.6875	1.03927624	68.3175314	1.3	0	0.05362899	1	1	1	1	1	12.7298861	7.39850507	22.1375849	29.7938844
0	7.14285714	0	42.8571429	21.4285714	7.14285714	14.2857143	7.14285714	0.39818084	28.7333333	0.80636621	64.1163588	0.34	0	0.0401711	1.28571429	1	1	1	1	10.6550122	7.0203709	22.0522883	39.055232
0	0	0	0	41.6666667	25	16.6666667	16.6666667						0	0.04732285						11.1847366	7.02619879	18.2774235	39.4357068
14.285714	7.14285714	28.5714286	21.4285714	28.5714286	0	0	0	12.5						0.1605487						18.2060796	11.8665535	20.616586	167.238228
6.25	0	0												0.20270928						19.7897859	13.979371	24.6340044	225.232533
				44.4444444	22.2222222	22.2222222	11.1111111						18.75	0.38025775						22.3050891	15.4255182	21.2053307	264.067883
0	0	0	8.33333333	25	8.33333333	33.3333333	25						0	0.1866828						18.9526383	13.8103875	23.700471	155.568996
0	0	0	18.1818182	27.2727273	27.2727273	27.2727273	0						12.5	0.3407426						23.5546704	15.0690025	23.1937313	283.952168
0	0	0	0	37.5	43.75	6.25	12.5	0.23188741	36.0520833	1.36664646	78.3596719	3	6.25	0.1056429	1.625	1	1	1	1	16.4642795	9.7609233	21.7520453	117.380996
0	0	0	16.6666667	33.3333333	33.3333333	8.33333333	8.33333333	0.20663287	11.2049708	0.8141809	79.0381409	2.52	0	0.13520272	1.58333333	1	1	1	1	19.0447937	9.77161242	22.6332848	112.668931
9.0909091	0	9.09090909	0	36.3636364	18.1818182	9.09090909	0	0.24781772	36	0.94083136	75.9890246	1.1	0	0.18587436	2.09090909	1	1	1	1	19.285746	11.7179504	21.457517	141.987362
0	10	0	20	40	30	0	0	0.2155214	25.1011048	0.99050333	69.4306921	3.2125	0	0.14363336	1.1	1	1	1.8	1	19.0504593	10.3010824	22.2810944	99.7453857
0	0	0	20	40	20	6.66666667	13.3333333	0.22669213	3.36111111	0.94051552	81.7586126	3.6	12.5	0.10191429	1.13333333	1	1	1	1	16.2781653	9.03183301	22.7207321	106.160722
0	0	33.3333333	0	66.6666667	0	0	0	0.27875254	2.22463768	1.11666667	62.9166667	2.35	0	0.05478617	1.33333333	1	1	1	1	13.1866094	7.06986173	22.6368887	11.4137855
0	0	15.3846154	30.7692308	15.3846154	30.7692308	7.69230769	0	0.36508825	23.4375	0.84582334	67.047504	0.85	0	0.01639253	1.23076923	1	1.076923	1	1	7.18492011	4.55349699	21.084362	14.7988078
0	0	9.09090909	0	0	54.5454545	0	36.3636364						0	0.10140735						15.0233455	10.9396018	20.2410074	82.6282115
14.285714	7.14285714	28.5714286	28.5714286	7.14285714	0	7.14285714	0						18.75	0.21225999						19.8027776	12.516546	19.8015361	221.104159
														0.16550834						18.0855507	13.4882943	23.3495964	160.910883
0	0	23.0769231	7.69230769	38.4615385	15.3846154	15.3846154	0						25	0.26499399						21.2041723	15.215426	22.8070907	294.437763
				33.3333333	0	0	66.6666667						0	0.18165335						18.3915742	14.3013755	20.7902632	151.377791
			8.33333333	8.33333333	25	16.6666667	16.6666667						25	0.2847174						21.2906278	15.3253941	23.3159114	237.264497
9.0909091	0	0	18.1818182	36.3636364	18.1818182	18.1818182	0	0.26542015	2.27681941	0.87608532	75.8043559	4.18571429	0	0.10755928	1	1	1	1	1	16.9073679	9.55662724	18.5461795	82.1633354
0	0	10	20	20	50	0	0	0.22594353	19.1887446	1.28911616	73.2017587	3.3	0	0.09263728	1.1	1	1	1	1	16.2803255	8.86770111	20.7412741	64.3314462
7.6923077	0	38.4615385	7.69230769	23.0769231	15.3846154	7.69230769	0	0.16893825	39.9274074	0.87948832	76.1447805	2.88333333	12.5	0.15382145	1	1	1	1	1	20.2230828	10.7672579	20.2749693	138.866584
0	0	10	10	40	40	0	0	0.15724924		1.1125845	73.2157926		12.5	0.15427509	1	1	1	1	1	18.1192163	11.0074077	20.7133887	107.135479

Plot Data Set - Habinsaran