Evaluation of an Acacia nilotica provenance trial at Dagar Kotli, Pakistan

Trial no. 22 in the arid zone series

Ræbild, Anders; Graudal, Lars Ole Visti; Khan, Shams-ur-Rehman

Publication date:
2003

Document version
Publisher's PDF, also known as Version of record

Citation for published version (APA):
Ræbild, A., Graudal, L. O. V., & Khan, S-R. (2003). *Evaluation of an Acacia nilotica provenance trial at Dagar Kotli, Pakistan: Trial no. 22 in the arid zone series*. Danida Forest Seed Centre. Results and Documentation No. 27

Evaluation of an *Acacia nilotica* provenance trial at Dagar Kotli, Pakistan

Trial no. 22 in the arid zone series

by

Anders Ræbild[1], Lars Graudal[1] and Shams-ur-Rehman Khan[2]

Pakistan Forest Institute[2], Pakistan

Food and Agriculture Organization, Rome

Danida Forest Seed Centre[1], Denmark

Results and Documentation No. 27

Danida Forest Seed Centre

December 2003

Citation:
A. Ræbild, Lars Graudal and Shams-ur-Rehman Khan. 2003. Evaluation of an *Acacia nilotica* provenance trial at Dagar Kotli, Pakistan. Trial no. 22 in the arid zone series. Results and Documentation No. 27. Danida Forest Seed Centre, Humlebaek, Denmark.

ISSN 0902-3224

Cover photo:
The *Acacia nilotica* provenance trial at Dagar Kotli, Pakistan. Phot: Lars Graudal. 1992.

This publication can be requested from:

Danida Forest Seed Centre
Krogerupvej 21. DK-3050 Humlebaek, Denmark
Phone: +45-49190500
Fax: +45-49190258
Email: dfsc@sns.dk
Web Site: www.dfsc.dk

and/or be downloaded from the DFSC homepage:
www.dfsc.dk/publications/

Technical Editor: Melita Jørgensen

Print:
Toptryk A/S, Graasten

Results and documentations are publications of analyses of e.g. provenance trials, carried out between DFSC and other institutions. DFSC publications are distributed free of charge.

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 belongs to series of analysis reports published by the Danida Forest Seed Centre. It is the intention that the series should serve as a place for publication of trial results for the Centre itself as well as for our collaborators. The reports will be made available from the DFSC publication service and online from the web-site www.dfsc.dk. The scope of the series is in particular the large number of trials from which results have not yet been made available to the public, and which are not appropriate for publication in scientific journals. We believe that the results from these trials will contribute considerably to the knowledge on genetic variation of tree species in the tropics. Also, the analysis report will allow a more detailed documentation than is possible in scientific journals.

The report presents results from a trial within the framework of the 'International Series of Trials of Arid and Semi-Arid Zone Arboreal Species', initiated by the FAO. Following collection and distribution of seed between 1983-87, a large number of trials were established by national institutions during 1984-1989. An international assessment of 26 trials took place from 1990 to 1994. DFSC is responsible for the reporting of this assessment.

This trial was established and maintained by the Pakistan Forest Institute (PFI).

The assessment team in April/May 1992 consisted of M. Noor, M.S. Mughal (PFI), Agnete Thomsen (FAO), and Lars Graudal (DFSC), assisted by M.I. Shah, Mushlaq and R. Zahn (PFI) and 3 villagers at the trial site.

The authors wish to acknowledge the help of the personnel at PFI with the establishment, maintenance and assessment of the trials, and thank the personnel of DFSC for their help with the data management and preliminary analyses. Drafts of the manuscript were commented on by Marcus Robbins, consultant to FAO.

Abstract

This report describes results from a trial with 11 provenances of *Acacia nilotica* from India and Pakistan. The six Indian provenances represented the subspecies *indica* var. *cupressiformis*, subsp. *indica* var. *jaquemontii* and subsp. *indica* var. *vediana*. The trial was established at Dagar Kotli, Pakistan in 1984 with a spacing of 3x3 metres, and assessed after eight years in 1992. Different growth parameters were measured and subjected to analyses of variance and multivariate analyses.

Survival in the trial was moderate, and there was a large variation in the growth between different parts of the trial. There were significant provenance differences in survival, number of stems, basal area and dry weight. Indian provenances represented both the best and the poorest provenances, whereas the provenances from Pakistan had an intermediate performance. The fastest growing provenances had a basal area increment rate of 1.6 m^2 ha^{-1} y^{-1}, corresponding to a dry weight production of approximately 6.5 t ha^{-1} y^{-1}.

Contents

1. Introduction

This report describes the results from trial no. 22 in a large series of provenance trials within the 'International Series of Trials of Arid and Semi-Arid Zone Arboreal Species'. The main goals of the series were to contribute to the knowledge on the genetic variation of woody species, their adaptability and productivity and to give recommendations for the use of the species. The species included in this series of trials are mainly of the genera *Acacia* and *Prosopis*. A more detailed introduction to the series is given by Graudal *et al.* (2003).

The present trial includes 11 provenances of *Acacia nilotica* (see Fagg & Greaves (1990) for an annotated bibliography of *A. nilotica*). *A. nilotica* is a very variable species with a natural distribution covering large tracts of tropical and subtropical Africa and Asia, and 9 subspecies or varieties are recognised (Brenan 1983, Ross 1979). The provenances in this trial were from India and Pakistan.

The varieties of the provenances from Pakistan have not been registered, but according to the collection sheets, the provenances from India represent at least three different varieties: subsp. *indica* var. *cupressiformis*, subsp. *indica* var. *jaquemontii*, and subsp. *indica* var. *vediana*. In the view of Brenan (1983), this nomenclature is not justified. He states that the subsp. *indica* is a separate subspecies, and that subsp. *indica* var. *cupressiformis* is rightfully the subsp. *cupressiformis*. Furthermore, subsp. *indica* var. *vediana* is considered a synonym of subsp. *subalata*, which is native to East-Africa. The occurrence of subsp. *subalata* in India could be due to crossing between two other subspecies, subsp. *indica* and subsp. *hemispherica*. Finally, subsp. *indica* var. *jaquemontii* is considered a separate species, *A. jaquemontii*. Thus there is some confusion with regard to the taxonomy, and the material should be verified before drawing conclusions regarding varieties of this group of provenances. In this report we shall for simplicity use the terminology applied by the seed collectors.

2. Materials and methods

2.1 Site and establishment of the trial

The trial is placed at Dagar Kotli (31°33′N, 71°07′E) in the Thal desert of Pakistan, at an altitude of 200 m. The mean annual temperature is approximately 25 °C, but the site experiences temperatures up to 48 °C. Precipitation is variable, ranging from below 200 to 300 mm (DFSC 1994, Hussain no date). The sparse rainfall is scattered around the year, and the number of dry months (with rainfall below 50 mm) is high, ten - eleven months. There are occasional frosts at the site.

The site is characterised by moderately calcareous, clayey loam soils, overlaid in part by sand dunes. The terrain is essentially flat. Further information is summarised in Annex 1.

Seed were sown in March 1984, and the trial was established in July the same year. After planting hand watering was at weekly intervals in summer, and every two weeks during winter, in total for one year. At each watering, the quantity of water was 4 l $plant^{-1}$ (Hussain, no date).

2.2 Species and provenances

Table 1 presents the provenances with identification numbers relating to their geographical origin (name of province or country followed by a number). Note that the provenances cover a large geographical range in India and Pakistan. As mentioned in the introduction, the trial includes 11 provenances of *Acacia nilotica*, of which 5 are from Pakistan and 6 are from India. The provenances from India have been further classified into the subspecies *indica* var. *cupressiformis* (two provenances), subsp. *indica* var. *jaquemontii* (three provenances) and subsp. *indica* var. *vediana* (one provenance). The three provenances from Maharashtra were collected at the same site, but on trees from the three different varieties or subspecies. The original seedlot numbers appear in annex 2.

The provenance Baluchistan1 was not part of the international seed collections, but was included as a control from Pakistan. In the assessment report (DFSC 1994) the latitude and longitude of this provenance is given as 25° 06’ N and 66° 13’ E, but as this is in the Arabian Sea we believe that the coordinates stated in table 1 are correct, corresponding to the position of the location Gadani.

2.3 The experimental design

The experimental design is a randomised block design with five blocks. In four of the blocks there were 10 provenances, whereas the fifth had only four provenances (annex 3). Since eleven provenances are included, this means that each provenance is replicated four times. The design is therefore an incomplete block design. In each replicate block each provenance is represented by 36 trees in a plot, planted in a square of 6×6 trees. The trees are placed with a spacing of 3×3 m, and only the 16 central trees were assessed. The layout of the design is shown in annex 3, and further details are given in DFSC (1994).

2.4 Assessment of the trial

In April/May 1992 PFI, FAO and DFSC undertook a joint assessment. The assessment included the following characters (DFSC 1994):

- Survival
- Health status
- Vertical height
- Diameter of the three largest stems at 0.3 m
- Number of stems at 0.3 m
- Crown diameter

Raw data from the assessment are documented in DFSC (1994). The plot data set on which the statistical analyses in this report are performed is shown in annex 4. This data set includes directly observed values as well as derived variable values.

Table 1. Provenances of *Acacia nilotica* tested in trial no. 22 at Dagar Kotli, Pakistan.

Provenance	Subspecies	Seed Collection Site	Country of origin	Latitude	Longi-tude	Altitude (m)	Rain-fall (mm)	No. of mother trees
Andra Pradesh2	*indica* var. *jaquemontii*	Anantapur	India	14° 41' N	77° 37' E	350	562	
Baluchistan1		Gadani, Sind	Pakistan	25° 06'N	66° 43' E	25	200	
Haryana1	*indica* var. *cupressiformis*	Nornaul Singhana Road, Bhiwani (Hissar)	India	28° 03' N	76° 07' E	250	714	4
Maharashtra1	*indica* var. *jaquemontii*	Pune	India	18° 32' N	73° 51' E	559	715	25
Maharashtra2	*indica* var. *vediana*	Pune	India	18° 32' N	73° 51' E	559	715	25
Maharashtra4	*indica* var. *cupressiformis*	Pune	India	18° 32' N	73° 51' E	559	714	25
Punjab2		Patoki	Pakistan	31° 05' N	73° 30' E	200	350	25
Punjab3		Fazal Abad Rice Mill, D.I. Khan	Pakistan	31° 15' N	70° 45' E	330	300	25
Punjab4		Dargai-Jehangira	Pakistan	33° 50' N	72° 20' E	500	750	25
Punjab5		Muzaffar Garh	Pakistan	30° 05' N	71° 10' E	170	200	25
Uttar Pradesh1	*indica* var. *jaquemontii*	Bawain Forest Block, Etawah (Mainpuri)	India	26° 45' N	79° 00' E	157	762	26

3. Statistical analyses

3.1 Variables

In this report the following eight variables are analysed:

- Survival
- Vertical height
- Crown area
- Number of stems at 0.3 m
- Basal area of the mean tree at 0.3 m
- Total basal area at 0.3 m
- Dry weight of the mean tree
- Total dry weight
- Damage score

The values were analysed on a plot basis, i.e. ratio, mean or sum as appropriate. Survival was analysed as the rate of surviving trees to the total number of trees per plot. Height, crown area, number of stems and damage score were analysed as the mean of surviving trees on a plot, as were the basal area and the dry weight of the mean tree. The total basal area and the total dry weight represent the sum of all trees in a plot, expressed on an area basis. Note that the calculations of basal area are based on measurements of the three largest stems per tree.

In the assessment data it appeared that for trees with heights below 1 m, no assessment of diameter, number of stems and crown diameter was made. Of the 376 surviving trees, crown area measurements were missing for 60 trees and diameter and number of stems were missing for 63 trees. As ignoring these data will produce biased results and result in over-estimation of the provenances in question, the values for crown area, basal area and dry weight for these trees have been set to zero. There is no reasonable way to estimate the number of stems of such trees, and no default value have been set for this variable. In any case, the estimates of the variables will be biased, but hopefully to a lesser degree than without the correction.

The dry weight values were calculated from regressions between biomass and basal area, established in another part of this study (Graudal *et al.* in prep.). For *A. nilotica* the regression used was

$$TreeDW = e^{(2.582 \times \ln(basalarea) - 2.518)}$$

where *TreeDW* expresses the dry weight of the tree in kg tree^{-1}, and *basalarea* expresses the basal area of the tree in cm^{-2}.

3.2 Statistical model and estimates

The test of provenance differences was based on the model:

$$X_{ij} = \mu + provenance_i + block_j + \varepsilon_{ij}$$

where X_{ij} is the value of the trait in plot *ij*, μ is the grand mean, $provenance_i$ is the fixed effect of provenance number *i*, $block_j$ is the fixed effect of block *j*, and ε_{ij} is the residual of plot *ij* and is assumed to follow a normal distribution $N(0, \sigma_e^2)$.

To complement blocks in adjusting for uneven environments, co-variates related to the plot position were included in the initial model. The co-variates were distance along the axis of the blocks, plotx, and squared values of this distance, plotx2. Furthermore a co-variate called level was included. This co-variate gives the level of the plot in comparison to a reference plot, which has been given the level 0. The co-variates were excluded successively if they were not significant at a 10% level. Only in survival did we find significant co-variates.

Standard graphical methods and calculated standard statistics were applied to test model assumptions of independence, normality and variance homogeneity (Snedecor & Cochran 1980, Draper & Smith 1981, Ræbild *et al.* 2002). For all variables there were signs of variance heterogeneity. Normality of the residuals was obtained by weighting of data with the inverse of the variance for the seedlots (ibid.).

The P-values from the tests of provenance differences were corrected for the effect of multiple comparisons by the sequential tablewide Bonferroni method (Holm 1979). The tests were ranked according to their P values. The test corresponding to the smallest P value (P_1) was considered significant on a 'table-wide' significance level of α if $P_1 < \alpha/n$, where n is the number of tests. The second smallest P value (P_2) was declared significant if $P_2 < \alpha/(n-1)$, and so on (c.f. Kjaer & Siegismund 1996). In this case the number of tests was set to nine, thus equalling the number of variables analysed. The significance levels are indicated by (*) (10%), * (5%), ** (1%), *** (1 ‰) and N.S. (not significant).

Based on the models, two sets of estimates are presented: The least square means (LS-means) and the Best Linear Unbiased Predictors (BLUPs) (White & Hodge 1989). In brief, the LS-means give the best estimates of the performance of the chosen provenances at the trial site, whereas the BLUPs give the best indication of the range of variation within the species. It should be noted that in the calculation of BLUPs it is assumed that the provenances represent a random selection.

A multivariate analysis providing canonical variates, and Wilk's lambda and Pillai's trace statistics, complemented the univariate analyses (Chatfield & Collins 1980, Afifi & Clark 1996, Skovgård & Brockdorf 1998).

The statistical software package used was the Statistical Analysis System (SAS 1988a, 1988b, 1991, Littell *et al.* 1996). A short description of the analysis of each variable is given in the result section, and a more detailed description of the statistical methods is given in Ræbild *et al.* (2002).

4. Results

Most characteristics were extremely variable in this trial. It appeared that trees at the centre of the trial were much taller than at the edges, probably reflecting favourable soil conditions and higher water availability. This means that even within the same provenance, the four replications may have very different values. Such variability usually weakens the analyses, because it adds to the residual variance.

4.1 Survival

Survival is regarded as one of the key variables when analysing tree provenance trials, since it indicates the adaptability of the provenance to the environment at the trial site. It should be noted that the survival reflects only the conditions experienced during the first years of the trial and not necessarily the climatic extremes and conditions that may be experienced during the life span of a tree.

The average survival varied between 37 and 77 % (Fig. 1). The differences between seedlots were highly significant, even when the Bonferroni correction for multiple comparisons was made (Table 2). Both plotx and plotx2 were significant. The provenance Maharashtra2 took the lead, whereas survival in the provenance with origin closest to the trial, Punjab3, had the lowest survival. Apart from this, there were no apparent differences between the provenances from Pakistan and India.

The BLUP-values indicated that there were substantial gains by choosing the best provenance – more than 20 percentage point for Maharashtra2 (Fig. 2). The other provenances were only differing moderately from the average value – from – 10 to + 3 percentage point.

Table 2. Results from analysis of variance of provenance differences of survival in trial 22.

Effect	DF	MS	F-value	P-value	Bonferroni sequential tablewide correction
Provenance	10	4.7	4.3	0.001	**
Block	4	14.7	13.6	<0.0001	
Plotx	1	31.0	28.8	<0.0001	
Plotx2	1	7.2	6.7	0.02	
Error	27	1.1			

Figure 1. Survival in the *Acacia nilotica* provenance trial at Dagar Kotli, Pakistan (Trial no. 22 in the arid zone series). Values presented are least square means with 95 % confidence limits. The confidence intervals have different length because the analysis was performed with a weighted model (see text).

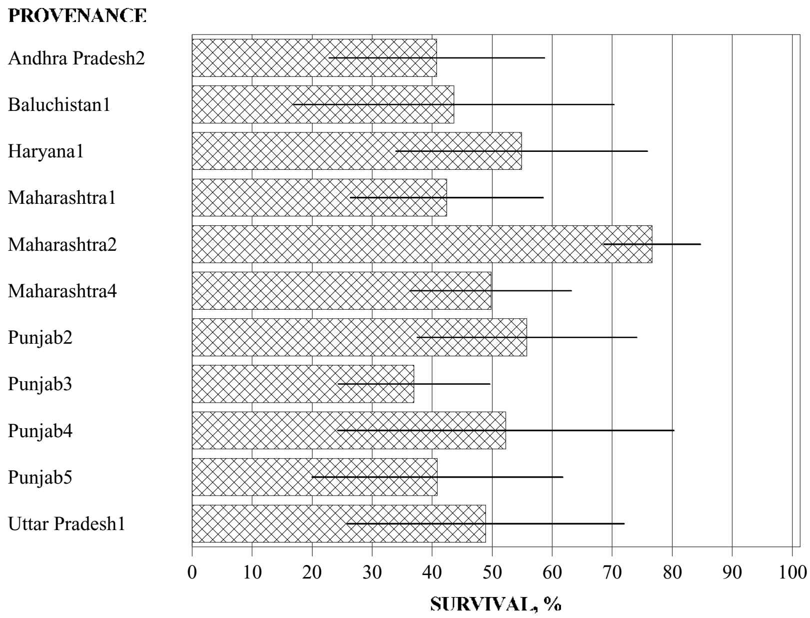
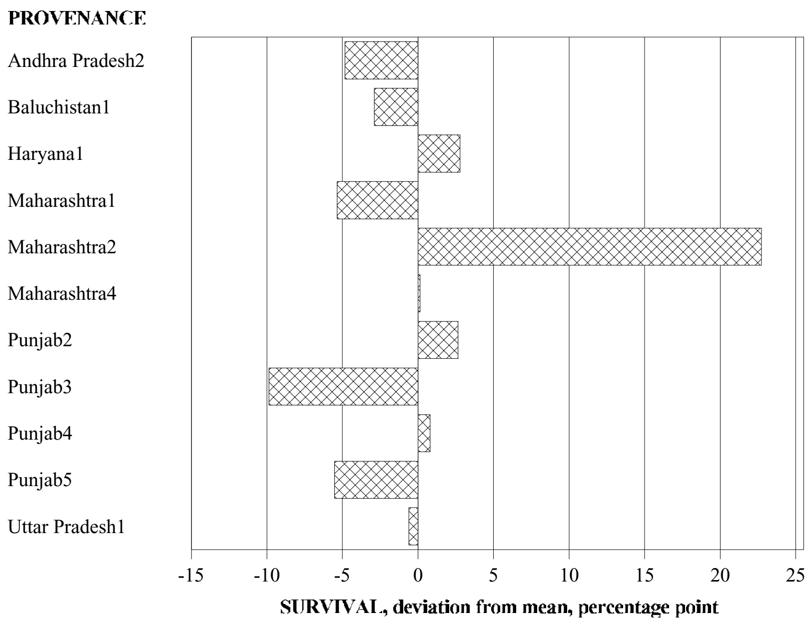


Figure 2. Best linear unbiased predictors (BLUP's) for survival in the *A. nilotica* provenance trial at Dagar Kotli, Pakistan (Trial no. 22 in the arid zone series). Values presented are deviations from the mean value in percentage point.



4.2 Height

Height is usually considered an important variable in the evaluation of species and provenances, even though this depends on the main uses of the trees. Apart from indicating productivity, height may also be seen as a measure of the adaptability of trees to the environment, tall provenances/trees usually being better adapted to the site than short provenances/trees.

The tallest tree of the trial had reached a height of 13 m, whereas other trees had only just passed a height of 1 m. Also the average values varied a lot, as can be seen from fig. 3. The smallest provenance (Uttar Pradesh1) had an average height below 2 m, whereas the tallest provenance, Haryana1, had a height of 7 m. Nevertheless, the provenance effect was only at the limit of significance, and the correction for multiple comparisons eliminated significance (Table 3). Thus differences between provenances should be interpreted cautiously. None of the co-variates were significant, as could have been expected considering the large apparent variation in conditions within the trial.

The predicted values by provenance selection (BLUPs) varied between ±30 % (Fig. 4)**.**

Table 3. Results from analysis of variance of provenance differences of height in trial 22.

Effect	DF	MS	F-value	P-value	Bonferroni sequential tablewide correction
Provenance	10	434	2.2	0.05	n.s.
Block	4	1883	9.5	<0.0001	
Error	27	197			

Figure 3. Vertical height in the *Acacia nilotica* provenance trial at Dagar Kotli, Pakistan (Trial no. 22 in the arid zone series). Values presented are least square means with 95 % confidence limits. The confidence intervals have different length because the analysis was performed with a weighted model (see text).

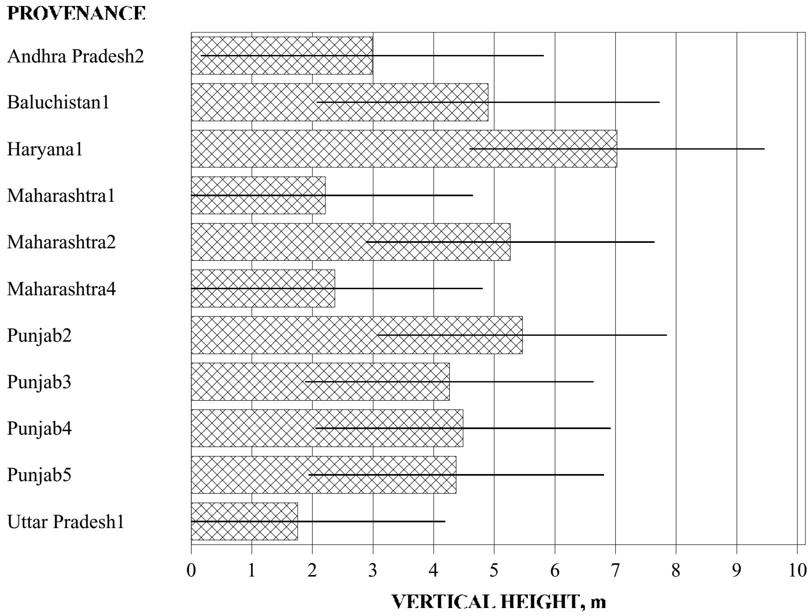
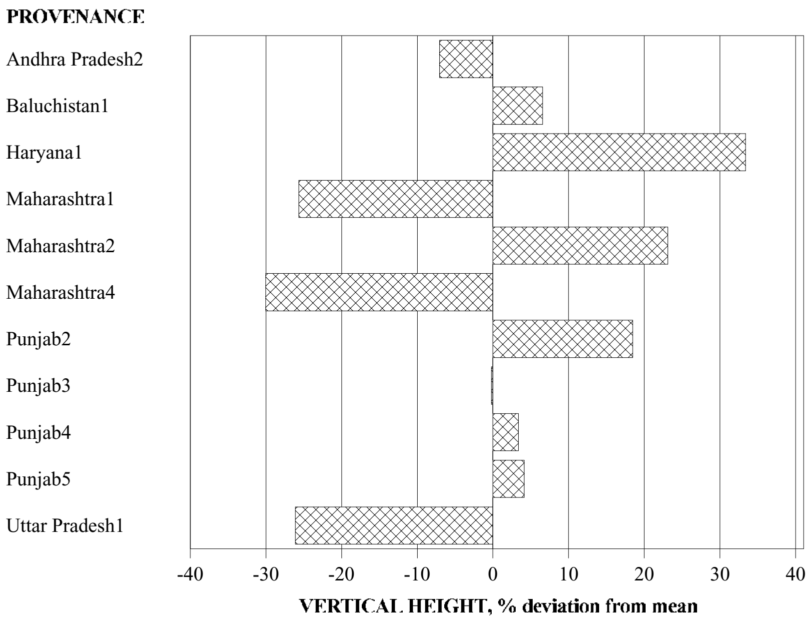


Figure 4. Best linear unbiased predictors (BLUP's) for vertical height in the *A. nilotica* provenances in the trial at Dagar Kotli, Pakistan (Trial no. 22 in the arid zone series). Values are presented as deviations in percent of the mean value



4.3 Crown area

The crown area variable gives the ability of the trees to cover the ground. The character is of importance in shading for agricultural crops, in evaluating the production of fodder and in protection of the soil against erosion. Note that crown area was not measured for 60 of the smallest trees, and that the crown area for these trees has therefore been set to zero (section 3.1).

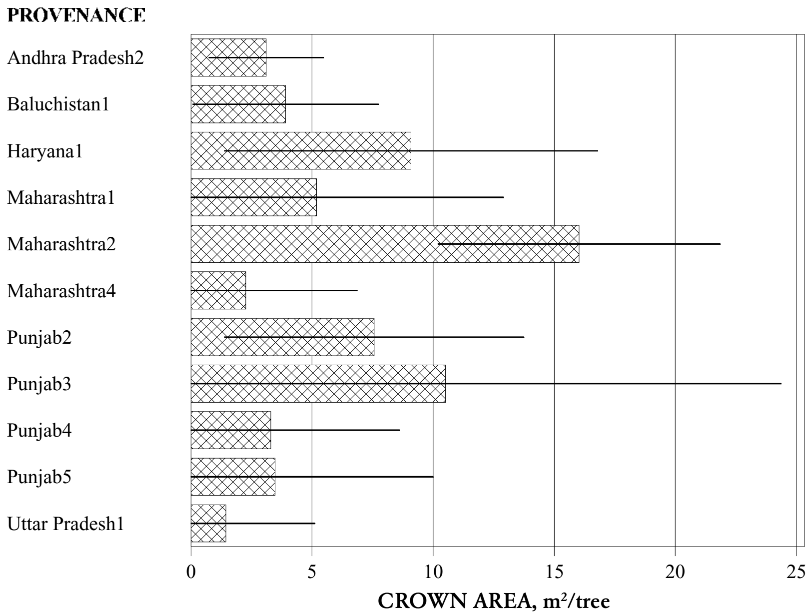
The variation in crown area was large, ranging from 2 m^2 $tree^{-1}$ for the provenance from Uttar Pradesh to more than 15 m^2 $tree^{-1}$ for Maharashtra2 (Fig. 5). The canopy for Maharastra2 had closed at the time of assessment. Trees of the provenance Haryana1 (of the variety *cupressiformis*) did not appear to have especially narrow crowns, whereas Maharashtra4 (also *cupressiformis*) had narrow crowns compared to the other Maharashtra provenances. The analysis of variance demonstrated that the effect of provenance was only at the limit of significance, and again the Bonferroni correction made significance disappear (Table 4). None of the co-variates were significant.

For the calculation of the BLUP values it turned out that the variance component for crown area was zero. Therefore no BLUP values could be calculated, and the usual BLUP-figure is not presented.

Table 4. Results from analysis of variance of provenance differences of crown area in trial 22.

Effect	DF	MS	F-value	P-value	Bonferroni sequential tablewide correction
Provenances	10	2.4	2.3	0.04	n.s.
Blocks	4	8.7	8.3	0.0002	
Error	27	1.0			

Figure 5. Crown area in the *Acacia nilotica* provenance trial at Dagar Kotli, Pakistan (Trial no. 22 in the arid zone series). Values presented are least square means with 95 % confidence limits. The confidence intervals have different length because the analysis was performed with a weighted model (see text).



4.4 Number of stems

The number of stems gives an indication of the growth habit of the species. Trees with large number of stems are considered bushy, whereas trees with only one stem have a more tree-like growth. Note again that for some small trees, the number of stems was not assessed (section 3.1). This introduces a systematic error in the analysis, and the results should therefore be interpreted cautiously.

Punjab4 had the smallest number of stems, corresponding to only 1.2 stems per tree (Fig. 6). On the other hand, the provenances from Andra Pradesh, Maharasthra and Uttar Pradesh all had relatively large number of stems, varying between 2.2 and 2.5 stems tree^{-1}. The differences between provenances were highly significant, but no co-variates were significant (Table 5). According to the calculated BLUP values, the gains by provenance selection were large, varying between – 35 % to + 30 % from the overall average.

Table 5. Results from analysis of variance of provenance differences of number of stems in trial 22.

Effect	DF	MS	F-value	P-value	Bonferroni sequential tablewide correction
Provenance	10	9.9	10.0	<0.0001	***
Block	4	5.4	5.5	0.003	
Error	24	1.0			

Figure 6. Number of stems in the *Acacia nilotica* provenance trial at Dagar Kotli, Pakistan (Trial no. 22 in the arid zone series). Values presented are least square means with 95 % confidence limits. The confidence intervals have different length because the analysis was performed with a weighted model (see text).

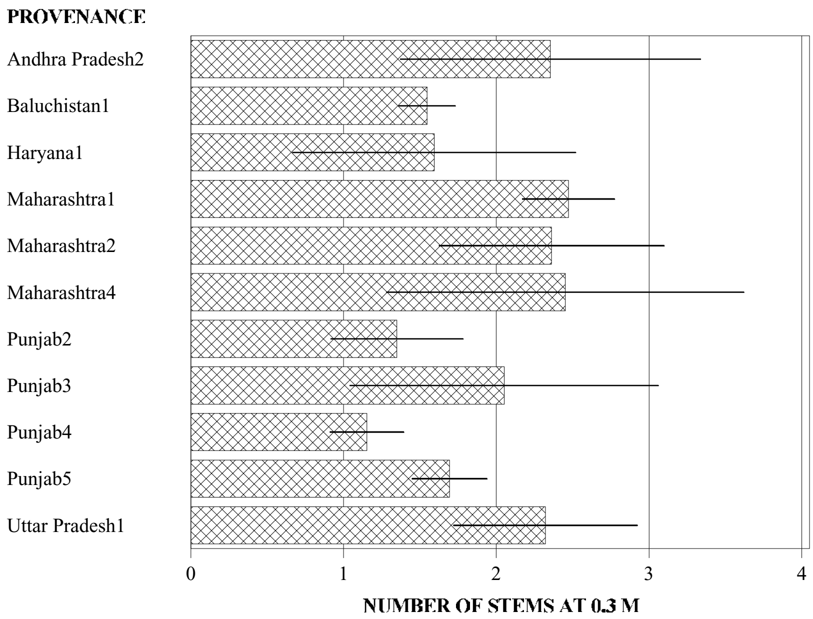
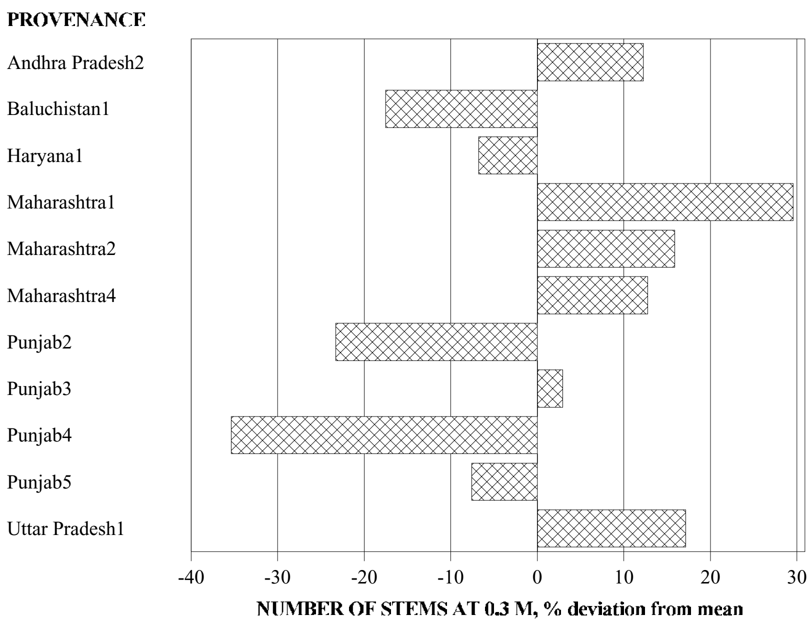


Figure 7. Best linear unbiased predictors (BLUP's) for number of stems in the *A. nilotica* provenances in the trial at Dagar Kotli, Pakistan (Trial no. 22).



4.5 Basal area of the mean tree

The basal area is often used as a measure of the productivity of stands, since it is correlated to the production of wood. The basal area of the mean tree is calculated on the live trees only and can be interpreted as an account of the potential basal area production of the provenance provided that all trees survive. Note that the basal area for a number of small trees were set to zero due to lack of diameter measurements (section 3.1). This may introduce a bias in the analysis.

The provenances had average values ranging from approximately 20 cm^2 $tree^{-1}$ to 180 cm^2 $tree^{-1}$ (Fig. 8). Maharashtra4 and Uttar Pradesh1 had the lowest values, whereas Maharashtra2 and Haryana1 were the leaders. The provenances from Pakistan were intermediate. According to the analysis of variance, the effect of provenances was only at the limit of significance, and the correction for multiple comparisons made the effect non-significant (Table 6).

Even though the analysis of variance gave no convincing result as regard provenance differences, the BLUP values nevertheless indicated that there were substantial gains by selection of provenances (Fig. 9). The values ranged between –25 and +20 %. Note that in comparison with fig. 9, the ranking of provenances has changed. This is because of the weighted analysis, putting more weight on provenances that have less variation than on provenances that are highly variable.

Table 6. Results from analysis of variance of provenance differences of basal area of the mean tree in trial 22.

Effect	DF	MS	F-value	P-value	Bonferroni sequential tablewide correction
Provenance	10	2.6	2.4	0.04	n.s.
Block	4	12.4	11.4	<0.0001	
Error	29	1.1			

Figure 8. The basal area of the mean tree in the *Acacia nilotica* provenance trial at Dagar Kotli, Pakistan (Trial no. 22 in the arid zone series). Values presented are least square means with 95 % confidence limits. The confidence intervals have different length because the analysis was performed with a weighted model (see text).

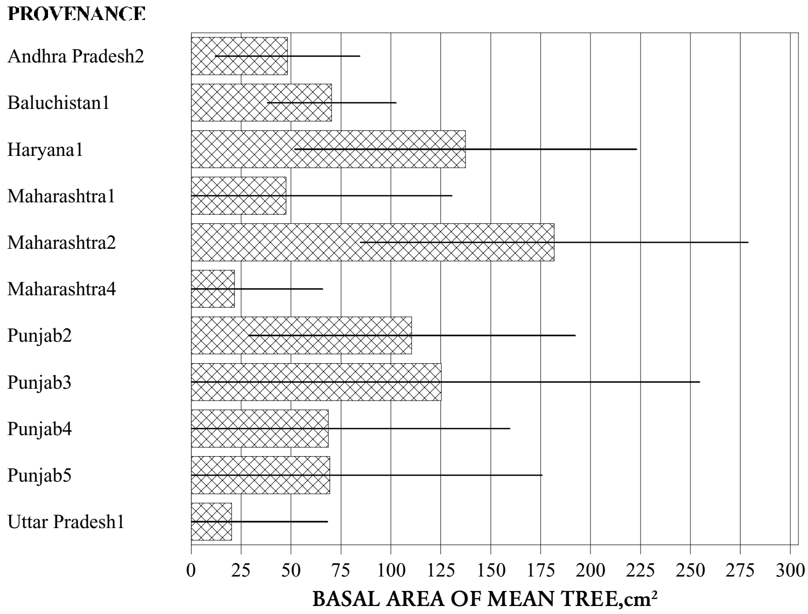
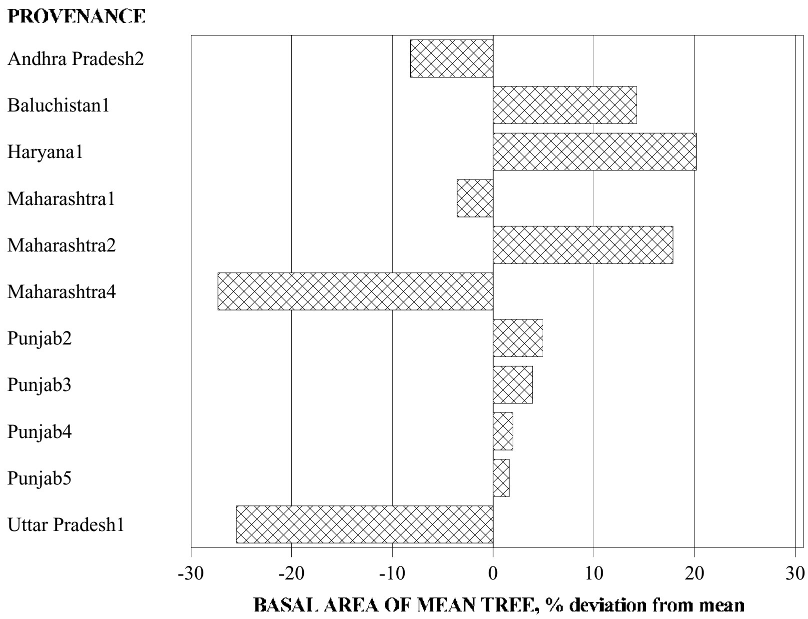


Figure 9. Best linear unbiased predictors (BLUP's) for basal area of the mean tree in the *A. nilotica* provenances in the trial at Dagar Kotli, Pakistan (Trial no. 22 in the arid zone series). Values are presented as deviations in percent of the mean value.



4.6 Total basal area

In comparison to the basal area of the mean tree, the total basal area accounts for missing trees and is thus a better measure of the actual production on the site. The provenances Maharashtra1, Maharashtra4 and Uttar Pradesh2 all had values below 1 m^2 ha^{-1}, whereas Haryana1 and Maharashtra2 took the lead with 13 m^2 ha^{-1} (Fig. 10). The growth in these two provenances corresponded to 1.6 m^2 ha^{-1} y^{-1}. The provenances from Pakistan were again intermediate, with the best being Punjab2.

According to the analysis of variance, the effect of provenances was highly significant, also after correction for multiple comparisons (Table 7). The BLUP values were very valuable, ranging from –80 to +100 % compared to the average. This indicates that there are substantial gains by choosing the provenances with the fastest growth (Fig. 11).

Table 7. Results from analysis of variance of provenance differences of total basal area in trial 22.

Effect	DF	MS	F-value	P-value	Bonferroni sequential tablewide correction
Provenance	10	5.0	6.01	<0.0001	***
Block	4	10.9	13.1	<0.0001	
Error	29	0.8			

Figure 10. Total basal area in the *Acacia nilotica* provenance trial at Dagar Kotli, Pakistan (Trial no. 22 in the arid zone series). Values presented are least square means with 95 % confidence limits. The confidence intervals have different length because the analysis was performed with a weighted model (see text).

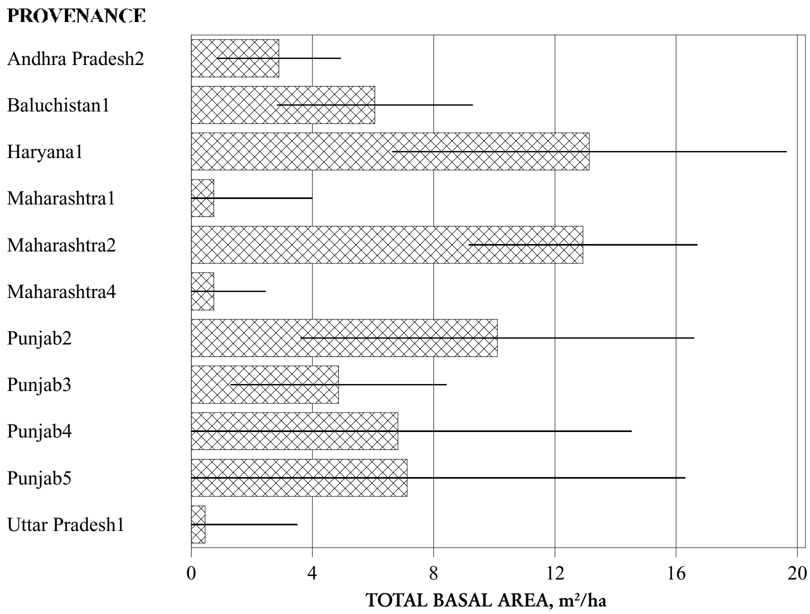
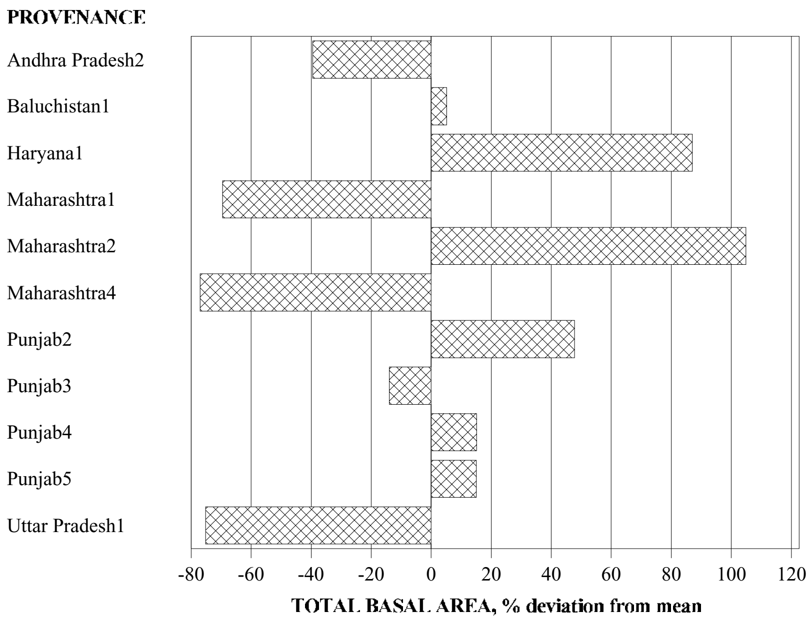


Figure 11. Best linear unbiased predictors (BLUP's) for total basal area in the *A. nilotica* provenances in the trial at Dagar Kotli, Pakistan (Trial no. 22 in the arid zone series). Values are presented as deviations in percent of the mean value.



4.7 Dry weight of the mean tree

The dry weight of the mean tree is comparable to the basal area of the mean tree in that they both are calculated on the live trees only and thus serve as a measure of the potential production at the site, provided that all trees survive. Furthermore, the two variables are linked closely together as the basis for calculation the dry weight is the basal area. However, an important difference is that the dry weight include a cubic term (in comparison to basal area having only a square term), meaning that large trees are weighted heavily in this variable.

The dry weight of the mean tree varied between 3 and 75 kg $tree^{-1}$ (Fig. 12). Haryana1, Maharashtra2, and Punjab3 had the largest trees, whereas the smallest trees were in the provenances Maharashtra4 and Uttar Pradesh1. Despite this large variation, the difference between provenances was only at the limit of significance, disappearing completely with the Bonferroni correction (Table 8).

The corresponding predicted values were ranging from −30 to +20 % (Fig. 13). Note again that the weight statement has changed the ranking of the provenances compared to the ranking when calculated as least square means (Fig. 12).

Table 8. Results from analysis of variance of provenance differences of dry weight of the mean tree in trial 22.

Effect	DF	MS	F-value	P-value	Bonferroni sequential tablewide correction
Provenance	10	2.5	2.4	0.03	n.s.
Block	4	19.5	18.7	<0.0001	
Error	27	1.0			

Figure 12. Dry weight of the mean tree in the *A. nilotica* provenance trial at Dagar Kotli, Pakistan (Trial no. 22 in the arid zone series). Values presented are least square means with 95 % confidence limits. The confidence intervals have different length because the analysis was performed with a weighted model (see text).

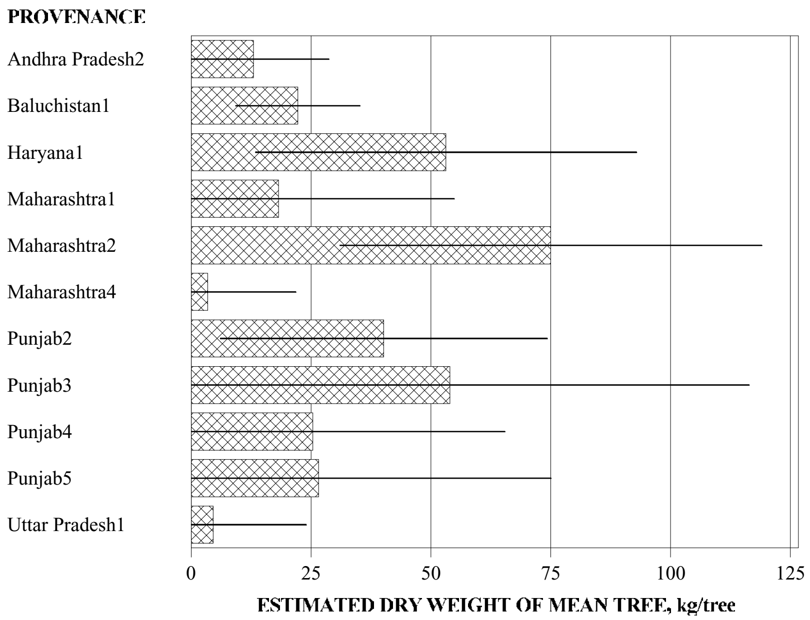
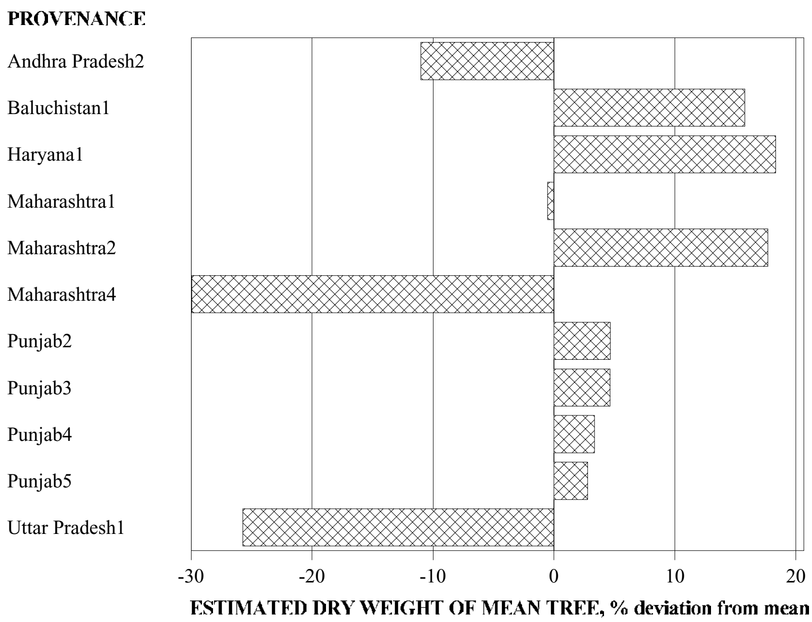


Figure 13. Best linear unbiased predictors (BLUP's) for dry weight of the mean tree in the *A. nilotica* provenance trial at Dagar Kotli, Pakistan (Trial no. 22 in the arid zone series). Values are presented as deviations in percent of the mean value.



4.8 Total dry weight

In parallel with the total basal area, the total dry weight account for missing trees and gives the best measure of the actual production on the site. Results for this variable also resembled total basal area with respect to ranking of the provenances. The least productive provenances were Maharashtra1, Maharashtra4 and Uttar Pradesh1 with values below 3 t ha^{-1}, and Haryana1 and Maharashtra2 had the largest production with the impressive 52 t ha^{-1} (Fig. 14). The average annual production thus reached 6.5 t ha^{-1} for the best provenances.

The differences between provenances were highly significant, both with and without the Bonferroni correction (Table 9). The gains by selection of provenances were large, varying between -80 and +110 % (Fig. 15).

Table 9. Results from analysis of variance of provenance differences of total dry weight in trial 22.

Effect	DF	MS	F-value	P-value	Bonferroni sequential tablewide correction
Provenance	10	3.9	4.9	0.0004	**
Block	4	8.9	11.1	<0.0001	
Error	29	0.8			

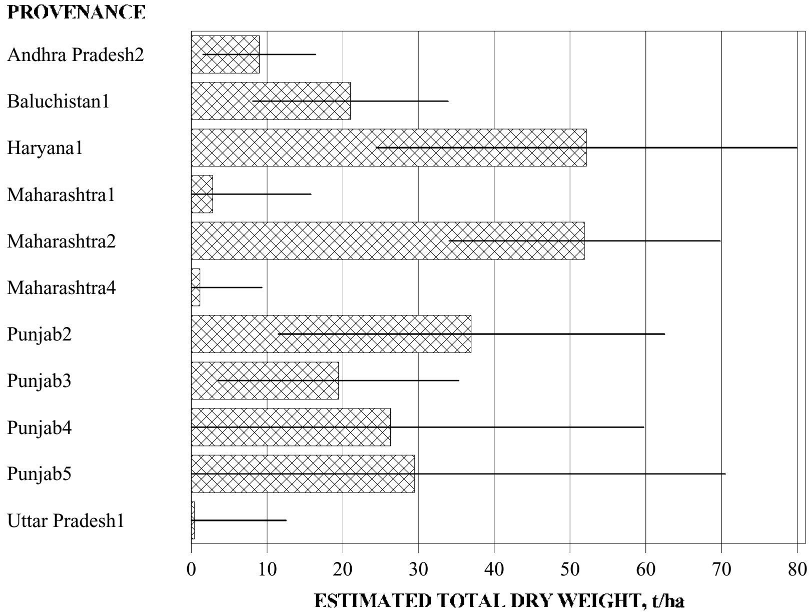


Figure 14. Total dry weight in the *Acacia nilotica* provenance trial at Dagar Kotli, Pakistan (Trial no. 22 in the arid zone series). Values presented are least square means with 95 % confidence limits. The confidence intervals have different length because the analysis was performed with a weighted model (see text).

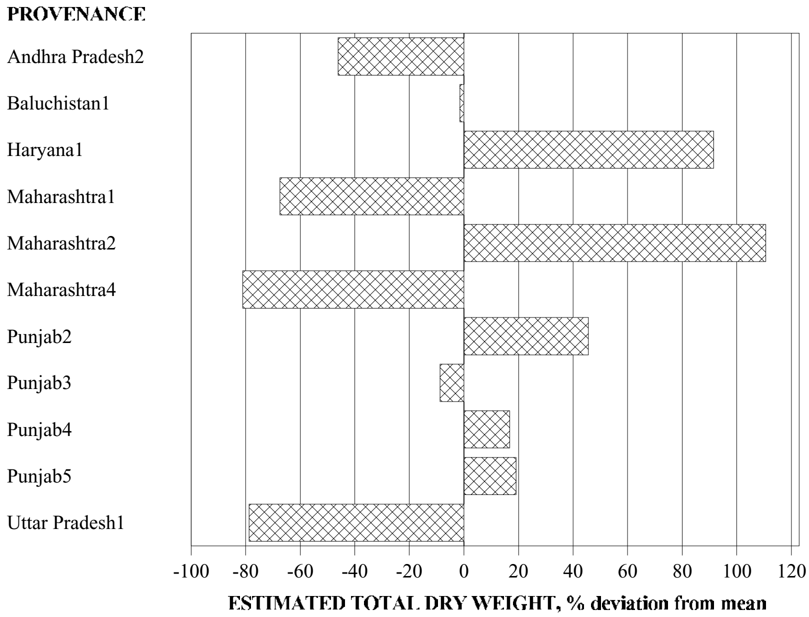


Figure 15. Best linear unbiased predictors (BLUP's) for total dry weight in the *A. nilotica* provenance trial at Dagar Kotli, Pakistan (Trial no. 22 in the arid zone series). Values are presented as deviations in percent of the mean value.

4.9 Damage score

The damage score was determined on a scale from 0 to 3, where 0 means no damage, 1 = light damage, 2 = moderate damage and 3 = severe damage. The damage to trees in the trial was primarily due to frost.

There are two problems with the scale that should be kept in mind when interpreting the results: First, the scores are subjective and do not necessarily reflect the real damage level of the trees. It may be difficult to give the proper scores to trees of different sizes, because the damage affects the trees differently. Second, the scores are not necessarily equidistant. For the growth of a tree it may mean less going from a damage score of 0 to 1 than going from a score of 1 to 2.

The average values varied between 0.5 (no damage - slightly damaged) to 2 (moderate damage). It appeared that the provenances with slow growth were also those that had the largest damage scores (Maharashtra1, Maharashtra4 and Uttar Pradesh1). Provenances with fast growth such as Haryana1, Maharashtra2 and Punjab2 were less affected by damage (Fig. 16). It should be noted that small values in fig. 16 and negative deviations from the mean in fig. 17 are desirable traits, meaning limited damages.

The differences between provenances were at the limit of significance, but became insignificant after the correction for multiple comparisons (Table 9). However, the BLUP values indicated that the gains from provenance selection were varying between −0.4 and +0.5 point on the scale, a considerable reduction if the best provenances are chosen (Fig. 17).

Table 9. Results from analysis of variance of provenance differences of damage score in trial 22.

Effect	DF	MS	F-value	P-value	Bonferroni sequential tablewide correction
Provenance	10	2.4	2.4	0.04	n.s.
Block	4	5.8	5.6	0.002	
Error	27	1.0			

Figure 16. Damage score in the *Acacia nilotica* provenance trial at Dagar Kotli, Pakistan (Trial no. 22 in the arid zone series). Values presented are least square means with 95 % confidence limits. The units are points on the damage score scale, where 0 is a healthy tree and 3 a severely damaged tree. The confidence intervals have different length because the analysis was performed with a weighted model (see text).

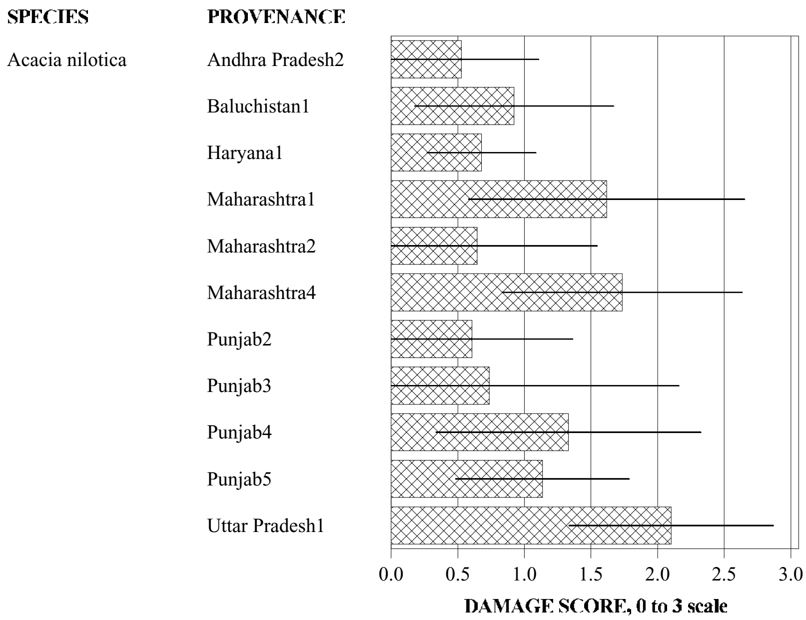
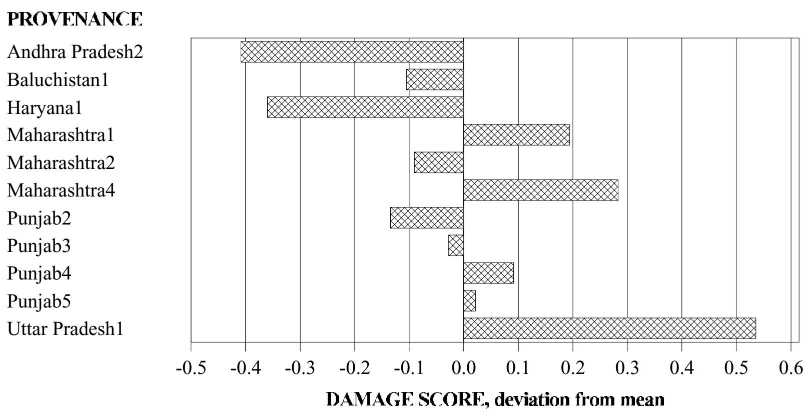


Figure 17. Best linear unbiased predictors (BLUPs) for damage score in the *A. nilotica* provenance trial at Dagar Kotli, Pakistan (Trial no. 22 in the arid zone series). Values are presented as deviations from the mean value. Units are points on the damage score scale.



4.10 Multivariate analysis

The multivariate analysis included all nine variables analysed in the univariate analyses. Since there were plots where no trees had survived, 5 observations were not included in the analysis. Unfortunately, the analysis cannot account for the variance inhomogeneity observed when the variables were analysed separately. This may influence the results of the analysis.

The first canonical variate was at the border of significance, whereas all the other canonical variates were far from significance (Table 10). The first canonical variate accounted for only 47 % of the variation, leaving a very large proportion of the variation unexplained. The large unexplained variation indicates that the model fit the data poorly, perhaps due to variance inhomogeneity. The significance of the differences between provenances were dependent on the type of test applied (P-value for Wilk's lambda=0.05, P-value for Pillai's trace=0.14).

The plot of scores for the two first canonical variates is given in Fig. 18. Apart from the scores, the mean values for the provenances are given together with their approximate 95 % confidence regions. In the diagram, provenances that are far apart are interpreted as being different, and if the confidence regions do not overlap, it is likely that the two provenances have different properties. However, since the second canonical variate was not significant, differences along the can2 axis should not be interpreted.

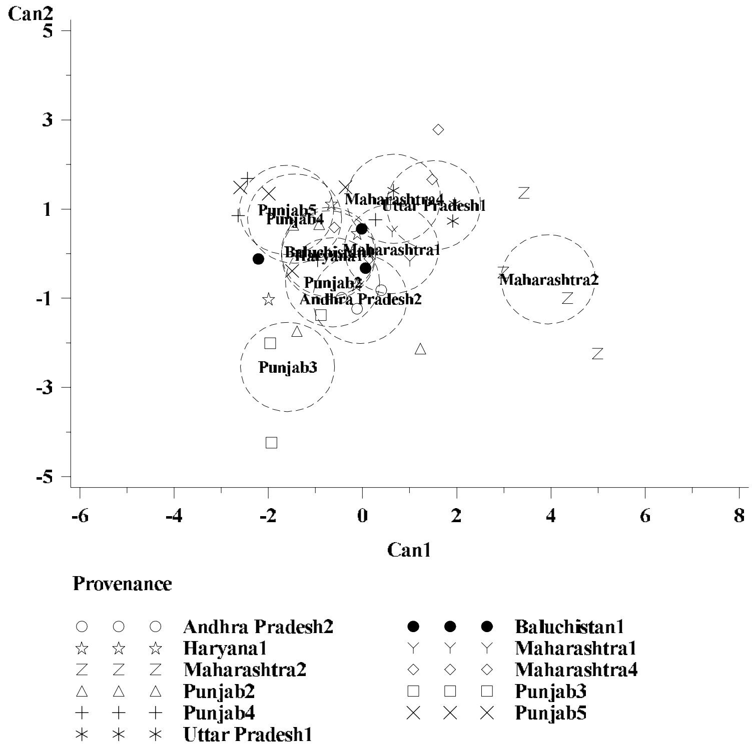
It appears that the only provenance diverging noteworthy from the others was Maharashtra2, of the subspecies *indica* var. *vediana*. However, it would be questionable to conclude on the basis of this that the variety is generally behaving different from the other varieties included. There were no signs of differences between the subspecies *indica* var. *jaquemontii* and *indica* var. *cupressiformis*, and the provenances from Pakistan did not separate from those from India.

Table 10. Results from the canonical variate analyses for the first two canonical variates in trial 22.

Canonical variate no.	**1**	**2**
Proportion of variation accounted for	0.47	0.21
Significance, P-value	0.05	0.39

	Raw canonical coefficients		**Standardised canonical coefficients**		**Canonical directions**	
Canonical variate no.	**1**	**2**	**1**	**2**	**1**	**2**
Survival	6.3	4.1	1.6	1.0	0.50	-0.34
Height	-0.99	0.35	-2.8	1.0	-5.0	-14.0
Crown area	0.25	0.098	1.9	0.7	26.0	-66.4
Number of stems	0.75	-0.68	0.5	-0.5	4.3	0.04
Basal area of the mean tree	0.20	0.16	18.5	14.9	158.3	-745.9
Total basal area	-1.1	-3.5	-8.0	-26.8	6.8	-34.2
Dry weight of the mean tree	-0.40	-0.41	-16.7	-7.0	69.3	-338.5
Total dry weight	0.23	0.80	7.5	25.7	31.7	-136.2
Damage score	1.6	0.90	1.3	0.8	1.3	9.7

Figure 18. Score plot of the first and the second canonical variate from the canonical variate analysis for the provenances in the *A. nilotica* provenance trial at Dagar Kotli, Pakistan (Trial no. 22 in the arid zone series). All variables from the univariate analyses were included. Each provenance is marked at the mean value and surrounded by a 95 % confidence region.



5. Discussion and conclusions

Productivity

The production of the two fastest growing provenances was impressive, reaching 6.5 t ha^{-1} y^{-1}. This is the second largest production in the whole series of arid zone trials, outgrown only by a trial in Mettupalayam in India (trial no. 18). Considering that precipitation at Dagar Kotli was the smallest in the series, the high production becomes even more conspicuous. The large productivity could indicate that there is easy access to ground water. Trials with other *Acacia* species and *Prosopis cineraria* at the same site had lower growth rates, albeit still high when the rainfall is taken into account (trials no. 21 and 23).

Even though the average production for the trial is high, there is a large variation within the trial. It would be natural to ascribe this to soil variation, as there are sand dunes in some parts. However, the level of the plots did not explain this variation, being non-significant for all variables.

Provenance differences

In terms of biomass production, Maharasthra2 and Haryana1 seemed to be the best provenances in the trial. Maharashtra2 had a better survival and a larger crown area, but Haryana1 had the fastest height growth – reflecting the different growth habits of subsp. *indica* var. *vediana* respectively subsp. *indica* var. *cupressiformis*. The latter has the more erect and narrow crown. Of the provenances from Pakistan, Punjab2 seemed to be the best producer of biomass. It appeared that there was a larger scatter between the provenances from India, always representing the best and the poorest provenances. There was less variation between the provenances from Pakistan, always being intermediate.

If it is possible to get seed from the same sources again, it seems that Maharasthra2 and Haryana1 are promising choices. However, both provenances originate in areas with high precipitation compared to Dagar Kotli, and it may be reasonable to evaluate the long-tem performance of the provenances before planting on a large scale is initiated. When there are no tested seed sources available, it seems that provenances from Pakistan should be chosen. They may not have the fastest growth, but seem to represent a safe choice.

Even though the three provenances from Maharashtra were collected at the same site, they were remarkably different. The subspecies *indica* var. *vediana* (represented by Maharashtra2) had a significantly better performance than the subspecies *indica* var. *jaquemontii* and *indica* var. *cupressiformis* (represented by Maharashtra1 and Maharashtra4). This demonstrates clearly that subspecies *indica* var. *vediana* represent a different genetic unit than the two other subspecies.

6. References

Afifi, A.A. and V. Clark. 1996 Computer-aided multivariate analysis. Chapman & Hall, London, 3rd ed., 455 pp.

Brenan, J.P.M. 1983. Manual on taxonomy of *Acacia* species. Food and Agriculture Organisation of the United Nations, Rome, 47 pp.

Chatfield, C. and A.J. Collins. 1980. Introduction to multivariate analysis. Chapman and Hall, London.

DFSC 1994. Preliminary assessment report – Trial no. 22. *Acacia nilotica* provenance trial, Dagar Kotli, Pakistan. Joint assessment, August 1991 and April/May 1992 by PFI, FAO and DFSC. Danida Forest Seed Centre.

Draper, N. and H. Smith. 1981. Applied regression analysis, second edition. John Wiley & Sons, New York, 709 pp.

Fagg, C.W. and A. Greaves. 1990. *Acacia nilotica*. Annotated bibliography no. F42. CAB International, 77 pp.

Graudal *et al.* 2003. Introduction to the Evaluation of an International Series of Field Trials of Arid and Semi-arid Zone Arboreal Species. Danida Forest Seed Centre, Humlebaek, Denmark.

Graudal, L. *et al.* (in prep.). Biomass regressions for some species of *Acacia* and *Prosopis*.

Holm, S. 1979. A simple sequentially rejective multiple test procedure. Scandinavian Journal of Statistics 6: 65-70.

Hussain, R.W. (no date): Performance of tree seedlots of different genetic resources in arid areas of Pakistan. Pakistan Forest Institute, Peshawar, 23 pp.

Kjaer, E.D. and H.R. Siegismund. 1996. Allozyme diversity in two Tanzanian and two Nicaraguan landraces of teak (*Tectona grandis* L.). Forest Genetics 3: 45-52.

Littell, R.C., G.A. Milliken, W.W. Stroup and R.D. Wolfinger. 1996. SAS® System for mixed models. SAS Institute Inc., Cary, NC, 633 pp.

Ross, J.H. 1979. A conspectus of the African *Acacia* species. Memoirs of the Botanical Survey of South Africa, 44, 155 pp.

Ræbild, A., C.P. Hansen and E.D. Kjaer. 2002. Statistical analysis of species and provenance trials. Guidelines and Technical notes no. 63. Danida Forest Seed Centre, Humlebaek, Denmark

SAS 1988a SAS® Procedures Guide, Release 6.03 Edition. SAS Institute Inc., Cary, NC, 441 pp.

SAS 1988b. SAS/STAT® Users Guide, Release 6.03 Edition. SAS Institute Inc., Cary, NC, 1028 pp.

SAS 1991. SAS® System for Statistical Graphics, First Edition. SAS Institute Inc., Cary, NC, 697 pp.

Skovgaard, I.M. and P. Brockhoff. 1998. Multivariate analysis and variance components. Lecture notes, Dept. of Mathematics and Physics, The Royal Veterinary and Agricultural University, Copenhagen, 41 pp.

Snedecor, G.W. and W.G. Cochran. 1980. Statistical methods. Iowa State University Press, 7th ed., 507 pp.

White, T.L. and G.R. Hodge. 1989. Predicting breeding values with applications in forest tree improvement. Kluwer Academic Publishers, Dordrecht, 367 pp.

Annex 1. Description of the trial site

Name of site:	Dagar Kotli Latitude: 31°33'N Longitude: 71°07'E Altitude: 200 m
Meteorological stations:	Dagar Kotli (Establishment Report 1984, Sheikh 1986) Mankera (9 km (Sheikh 1986)) D.I. Khan (31°49'N, 70°55'E, 172 m (FAO 1987))
Rainfall:	Mean (period): 100 mm (Mankera - 15 years, 1970-1985) Yearly registrations: 1981: 377 mm (Dagar Kotli, Sheikh 1986) 1982: 117.8 mm (Dagar Kotli, Sheikh 1986) 1982/83: 164.7 mm (Dagar Kotli)
Rainy season:	July-August Type: All year round (FAO 1987) Length (days): 0 (FAO 1987)
Dry months/year:	No. of dry months (< 50 mm): 10-11 (1982/83, Dagar Kotli) No. of dry periods: 1
Temperature:	Annual mean: 24.6 (FAO 1987) Coldest month: 4.4 (min. monthly temp., Establishment Report 1984) Hottest month: 42.8 (max. monthly temp., Establishment Report 1984) Occurrence of frost: 10 days/year (Establishment Report 1984).
Wind:	Prevailing directions: Summer: S; spring and fall: E, SE; winter: N (Sheikh 1986). Speed (at 2 m in m/s): 1.2 (FAO 1987).
Topography:	Flat
Soil:	(Establishment Report 1984 and Sheikh 1986): Type: Moderately calcerous, fine brown sand with fine kanker, clayey loam, no stones, alkaline, sand dunes occurring. Depth: deep, well drained (sand dunes shallow).
Climatic/agroecological zone:	Arid zone, Thal Desert
Koeppen classification:	BWh

Annex 2. Provenances of *Acacia nilotica* tested in the trial

The plot numbers refer to the seedlots in the map of the trial, see Annex 3.

Provenance	Seedlot numbers			Provenance information							
	DFSC	Country of origin	Plot	Subspecies	Seed Collection Site	Country of origin	Latitude	Longitude	Altitude (m)	Rainfall (mm)	No. of mother trees
Andra Pradesh2	1080/82		4	*indica* var. *jaquemontii*	Anantapur	India	14 41 N	77 37 E	350	562	
Baluchistan1		DKotli2	11		Gadani, Sind	Pakistan	25 06 N	66 43 E	25	200	
Haryana1	1081/82		5	*indica* var. *cupressiformis*	Nornaul Singhana Road, Bhiwani (Hissar)	India	28 03 N	76 07 E	250	714	4
Maharash-tra1	1070/82		2	*indica* var. *jaquemontii*	Pune	India	18 32 N	73 51 E	559	715	25
Maharash-tra2	1071/82		3	*indica* var. *vediana*	Pune	India	18 32 N	73 51 E	559	715	25
Maharash-tra4	1082/82		6	*indica* var. *cupressiformis*	Pune	India	18 32 N	73 51 E	559	714	25
Punjab2	1168/83		10		Patoki	Pakistan	31 05 N	73 30 E	200	350	25
Punjab3	1169/83		9		Fazal Abad Rice Mill, D.I.Khan	Pakistan	31 15 N	70 45 E	330	300	25
Punjab4	1170/83		8		Dargai-Jehangira	Pakistan	33 50 N	72 20 E	500	750	25
Punjab5	1171/83		7		Muzaffar Garh	Pakistan	30 05 N	71 10 E	170	200	25
Uttar Pradesh1	1069/82		1	*indica* var. *jaquemontii*	Bawain Forest Block, Eta-wah (Mainpuri)	India	26 45 N	79 00 E	157	762	26

Annex 3. Layout of the trial

Layout of blocks and plots in the field The numbers correspond to the seedlots given in annex 2:

y											
5	11	3	9	10	BLOCK 5						
4	8	5	3	10	7	2	1	9	4	6	BLOCK 1
3	4	10	5	7	11	9	6	8	1	2	BLOCK 2
2	10	3	8	5	4	7	11	6	2	1	BLOCK 3
1	7	2	11	1	8	6	5	4	9	3	BLOCK 4
	1	2	3	4	5	6	7	8	9	10	x

Individual tree positions in each plot:

y						
6	*	*	*	*	*	*
5	*	+	+	+	+	*
4	*	+	+	+	+	*
3	*	+	+	+	+	*
2	*	+	+	+	+	*
1	*	*	*	*	*	*
	1	2	3	4	5	6 x

*: plot border trees

+: plot core trees

Annex 4. Plot data set

Provenance	Block	Plot	Plotx	Ploty	Level	Survival	Height	Crown area	Number of stems	Basal area of the mean tree	Total basal area	Dry weight of the mean tree	Total dry weight	Damage score
					m	proportion	m	m^2 tree^{-1}	no. tree^{-1}	cm^2 tree^{-1}	m^2 ha^{-1}	kg tree^{-1}	t ha^{-1}	0-3 scale
Punjab2	1	10	4	4	31	0.88	6.7	7.2	1.36	127	12.3	43	42	0.07
Punjab3	1	9	8	4	26	0.13	0.6	0.0		0	0.0	0	0	3.00
Punjab4	1	8	1	4	0	0.94	4.1	3.8	1.42	57	5.9	17	17	0.53
Punjab5	1	7	5	4	18	0.38	3.1	3.3	2.25	36	1.5	9	4	1.00
Haryana1	1	5	2	4	21	0.88	5.8	7.9	1.08	122	11.9	43	42	0.57
Maharashtra4	1	6	10	4	20	0.13	2.9	5.1	4.50	41	0.6	10	1	2.00
Andhra Pradesh2	1	4	9	4	22	0.00	0.0		0.00					
Maharashtra1	1	2	6	4	16	0.44	0.7	0.0		0	0.0	0	0	3.00
Uttar Pradesh1	1	1	7	4	20	0.13	0.5	0.0	0.00	0	0.0	0		3.00
Maharashtra2	1	3	3	4	24	0.88	5.5	17.0	2.15	161	15.6	63	61	0.21
Baluchistan1	2	11	5	3	20	0.50	7.0	3.1	1.38	123	6.8	41	23	0.13
Punjab2	2	10	2	3	17	0.94	8.9	14.2	1.60	206	21.4	80	84	0.00
Punjab3	2	9	6	3	18	0.63	4.8	2.7	1.40	103	7.2	34	24	0.00
Punjab4	2	8	8	3	29	0.63	4.1	5.3	1.00	72	5.0	23	16	1.00
Punjab5	2	7	4	3	22	0.94	10.3	13.7	1.40	257	26.7	111	116	0.20
Haryana1	2	5	3	3	17	0.75	12.3	21.5	1.42	271	22.6	114	95	0.00
Maharashtra4	2	6	7	3	18	0.56	3.6	4.0	2.00	57	3.6	17	11	0.67
Andhra Pradesh2	2	4	1	3	18	0.69	4.7	6.0	2.27	79	6.1	26	20	0.00
Maharashtra1	2	2	10	3	30	0.50	2.0	2.0	2.50	22	1.2	5	3	1.50
Uttar Pradesh1	2	1	9	3	23	0.63	2.0	1.8	2.17	23	1.6	6	4	2.00
Baluchistan1	3	11	7	2	20	0.69	6.6	10.7	1.60	138	10.6	51	39	0.64
Punjab2	3	10	1	2	23	0.67	4.8	5.6	1.50	88	6.1	29	20	0.50
Punjab4	3	8	3	2	20	0.81	11.6	14.5	1.38	263	23.7	110	99	0.00
Punjab5	3	7	6	2	20	0.69	5.3	6.5	1.82	97	7.4	33	25	0.00
Haryana1	3	5	4	2	23	0.94	10.3	11.0	1.27	228	23.8	91	95	0.00
Maharashtra4	3	6	8	2	23	0.50	5.1	10.1	1.75	106	5.9	36	20	0.00
Andhra Pradesh2	3	4	5	2	19	0.63	5.4	9.2	1.50	149	10.3	53	37	0.00
Maharashtra1	3	2	9	2	23	0.25	6.8	21.9	2.25	234	6.5	99	28	0.00
Uttar Pradesh1	3	1	10	2	25	0.31	5.2	12.1	2.80	151	5.2	54	19	0.20
Maharashtra2	3	3	2	2	21	1.00	6.8	17.4	3.23	186	16.8	72	65	0.00

Provenance	Block	Plot	Plotx	Ploty	Level	Survival	Height	Crown area	Number of stems	Basal area of the mean tree	Total basal area	Dry weight of the mean tree	Total dry weight	Damage score
					m	proportion	m	m^2 tree^{-1}	no. tree^{-1}	cm^2 tree^{-1}	m^2 ha^{-1}	kg tree^{-1}	t ha^{-1}	0-3 scale
Baluchistan1	4	11	3	1	19	0.88	5.2	9.3	1.50	82	7.9	27	26	0.43
Punjab3	4	9	9	1	26	0.19	7.3	32.6	1.33	308	6.4	149	31	0.00
Punjab4	4	8	5	1	22	0.25	1.4	0.7	1.00	7	0.2	2	0	2.25
Punjab5	4	7	1	1	23	0.31	2.2	1.4	1.50	12	0.4	3	1	1.80
Haryana1	4	5	7	1	26	0.31	3.0	7.0	2.80	51	1.8	14	5	0.60
Maharashtra4	4	6	6	1	22	0.69	1.2	0.9	1.75	6	0.5	1	1	2.73
Andhra Pradesh2	4	4	8	1	28	0.50	3.0	5.6	3.13	49	2.7	13	7	0.00
Maharashtra1	4	2	2	1	20	0.44	2.7	7.9	2.50	57	2.8	18	9	0.43
Uttar Pradesh1	4	1	4	1	22	0.75	2.7	2.9	1.83	30	2.5	9	7	1.67
Maharashtra2	4	3	10	1	32	0.44	5.4	26.1	2.43	322	15.6	144	70	0.00
Baluchistan1	5	11	1	5	15	0.00	0.0		0.00					
Punjab2	5	10	4	5	15	0.19	2.0	0.7	1.00	16	0.3	4	1	2.00
Punjab3	5	9	3	5	13	0.25	1.7	0.4	3.00	8	0.2	2	0	0.75
Maharashtra2	5	3	2	5	17	0.56	1.4	1.0	1.80	15	0.9	3	2	3.00