EFFECT OF ELEVATION ON HEIGHT AND DIAMETER GROWTH FOR THREE BROADLEAF SPECIES

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ABSTRACT

A study of three broadleaf species growing on hills of Chittagong University campus showed that height and diameter growth diminish as one moves up the hill. The rate of diminution can be predicted by using separate logarithmic functions developed for each species. Some recommendations are made on species selection and future management considerations.

সারসংক্ষেপ

চট্টগ্রাম বিশ্ববিদ্যালয় ক্যাম্পাসের পাহাড়গুলোতে বর্ধনশীল তিনটি বৃহৎ–পত্র প্রজাতির গাছের উপর পরিচালিত এক সমীক্ষায় দেখা গেছে যে যতই পাহাড়ের উপরে যাওয়া হয়, ততই গাছের উচ্চতা ও ব্যাস–এর বৃদ্ধি কমে যায়। এই হ্রাসের হারকে প্রজাতি তিনটির জন্য পৃথকভাবে উদ্ভাবিত লগারিদমিক ফাংশান দ্বারা নির্ধারণ করা যেতে পারে। এর আলোকে প্রজাতি নির্বাচন এবং ভবিষ্যৎ ব্যবস্থাপনা বিবেচনার জন্য কিছু সুপারিশমালা পেশ করা হলো।

INTRODUCTION

In 1989, the Institute of Forestry, Chittagong University initiated an afforestation programme for hilly areas at the University campus (approx. 91°'50 E and 22°'30 N). The planted area ranges from 14m to 87m above mean sea level, (Gafur *et al.* 1979) and is only about 20km north of the Bay of Bengal. In the surrounding area, there are extensive hilly areas of almost identical formation which are under a future afforestation programme by Bangladesh Government. The main species planted were garjan *(Dipterocarpus turbinatus)*, chapalish *(Artocarpus chaplasha)* and minjiri *(Cassia siamea)* which are typical reforestation species in Bangladesh. One-year old seedlings were planted at a spacing of 2m x 2m. Rows were runnig up to the tops of the hills. Each hill was planted with only one of the species. According to Soil Survey Staff (1979), the soil's of the Chittagong University area are inceptisols, i. e. well drained and moderately textured sandy loams.

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In 1989, it was observed that there was an unusually rapid decrease in height and diameter growth up the hills for all three species planted. Therefore, detailed measurements were made for sample trees representing all positions on the slopes, with the following objectives :

- to establish whether or not the apparent decrease in dbh and height growth with position up the hills was significant for each of the planted species.

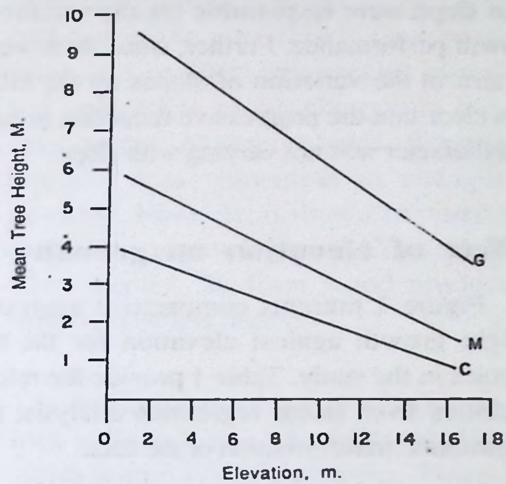
- to develop models for predicting the decrease in dbh and height at any position on the slope when the slope and elevation of the point are given.

All the trees in the selected rows were measured for :

- total height to the nearest 0.1 m, using a graduated telescopic pole
- diameter at breast height to the nearest 1 cm, using a diameter tape and
- topographic position, i. e. horizontal and vertical distance from the base tree.

Data from all rows were pooled together, and trees were classified according to their positions in the topography. Various regression models were tested to predict relative height and diameter reductions with rising position on the topography.

The mean slope was obtained for each row from tree measurements made at base, middle and top portion of the hills. This was useful in testing whether or not the slope is a contributory factor in the reduction in diameter and height. Aspect was not considered because the hills are quite low and all aspects are almost equally illuminated.



M = *Cassia siamea* (Mingiri)
$h = 6.01 - 0.26\,x$ ($r = -0.703$)
G = *Dipterocarpus turbinatus* (Garjan)
$h = 10.17 - 0.50\,x$ ($r = -0.711$)
C = *Artocarpus chaplasha* (Chapalish)
$h = 3.99 - 0.18\,x$ ($r = -0.565$)

Figure - 1. Effect of elevation on height.

RESULTS AND DISCUSSION

Effect of slope on growth

Overall terrain slopes ranged from 35% to 62% with a standard deviation of 8%. It was found that there was no relationship between the terrain slope and the growth performance for any of the three species studied. Further analysis of the effects of slope was done by considering the microsite condition of the tree. The maximum and minimum slopes for individual tree were 84% and 35% respectively. Again the results showed that the effects of slope were not significant.

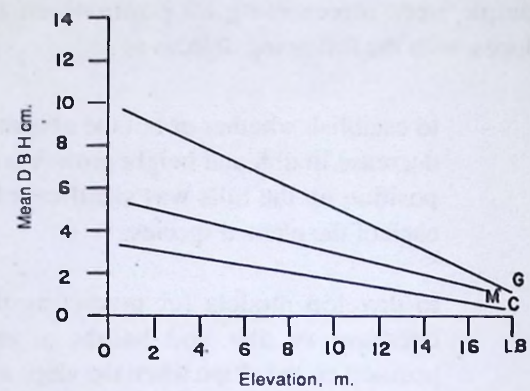
These results confirmed that factors other than slope were responsible for the variation in growth performance. Further, since there was no pattern in the variation of slopes up the hills, it was clear that the progressive reduction in height and diameter was not varying with slope.

Effect of elevation on growth

Figure 1 presents comparative analysis of height growth against elevation for the three species in the study. Table 1 provide the relevant statistics from linear regression analysis, after logarithmic transformation of the data.

It is clear that height growth varied up the hills in a predictable way for each of the species. The use of simple linear regression models is effective in predicting height with changing elevation. However, if other factors such as soil and water conditions had been incorporated, a multiple linear regression model would have been more appropriate. It is expected that the logarithmic models will perform better as the trees grow bigger. At the present stage, there seems to be no significant difference in the predictive power of the linear and the logrithmic models.

Figure 2 and Table 2 present a comparative analysis of diameter growth against elevation. Again, linear regressions provided the best fits. The limitations pointed out above are also applicable here. The logarithmic models are likely to be superior with further development of the crop. Differences in the performances of the three species are presumably attributable to inherent genetic variations. It is apparent that *Artocarpus chaplasha* was less vulnerable to increase in elevation than the other species. This may be due to the fact that it was generally younger, so the effects had not started showing well enough; otherwise it may be due to genetic variation (see recommendation 3).



G = *Dipterocarpus urbinatus* (Garjan)
d = 10.10 - 0.509 x (r = -0.722)
C = *Artocarpus chaplasha* (Chapalish)
d = 3.46 - 0.169 x (r = -0.479)
M = *Cassia siamea* (Mingiri)
d = 5.57 - 0.268 x (r = -0.617)

Figure - 2. Effect of elevation on diameter.

CONCLUSIONS

Height and diameter at different elevations for the three species in the study could be estimated using the models :

i) Log h = Log a + b log x
where, h = height of the tree (m)
x = elevation above a common benchmark (m)
a, b = regression constant and coefficient respectively.

ii) Log d = Log a+ b log x
where, d = diameter at breast height (m)
x, a and b = as explained under (i) above.

The results should be used cautiously, because from knowledge of growth factors it is unlikely that the relationship would remain the same for the life time of the crops. New models must be sought when other growth factors have been assessed and at a later stage of crop development. Expansion of the study over a wide geographical area may yield results which could be incorporated into growth models.

RECOMENDATIONS

1. From field observation, it is speculated that the main cause of reduction in dbh and height growth is due to rapid dropping of the water table as one moves up the hill, caused by the large fraction of sand in the soil. Other contributing factors may include leaching of nutrients resulting in the shortage of critical nutrients up the slopes. Future research work should be directed at soil analysis at different positions on the slopes.

2. This assessment was made at a very early stage of development of the species under considerations. It is not certain that the relationships developed would hold true for older crops. Follow up studies are needed. Establishment of permanent sample plots is recommended.

3. It is highly unlikely that there would be immediate practical measures to overcome the problem in the near future. One possible solution is to select tree species which are less susceptible to the changes in the soil environment. As demonstrated, chapalish is probably less vulnerable to changes in elevation. However, it should be noted that chapalish was growing much slower than the other species. So from wood production point of view it is inferior.

4. The rapid change in site conditions up the hills will result in a very high variation in yields within very small areas. There is a need to conduct a country wide study covering all the hilly areas currently earmarked for afforestation to predict the total effect of the phenomenon on yield.

5. Some research work is needed on weeding and other silviculture techniques which may boost the growth of the species on poor sites on the hills.

Table 1. Effect of Log_{10} elevation on Log_{10} height

Species	n	Max ht. (m)	Min. ht (m)	Regr. const	Regr. coef.	Se of b	Corr. coef
Garjan	54	15.6	1.2	1.01	-0.371	0.05	-0.718
Chapalish	54	5.9	0.3	1.76	-0.545	0.11	-0.554
Minjiri	57	7.5	1.2	0.84	-0.403	0.06	-0.660

All regression coefficients were significant at p 0.05

Table 2. Effect of Log_{10} elevation on Log_{10} dbh

Species	n	Max ht. (m)	Min. ht (m)	Regr. const	Regr. coef.	Se of b	Corr. coef
Garjan	54	15.1	1.0	1.01	-0.402	0.06	-0.675
Chapalish	54	5.9	1.0	0.63	-0.496	0.12	-0.514
Minjiri	57	8.4	1.0	0.80	-0.479	0.09	-0.597

All regression coefficients were significant at p 0.05

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