J. Univ. Kuwait (Sci.) **4**, 1977

Statistical relationship between biomass and growth parameters in a 10-year-old *Eucalyptus tereticornis* Smith stand

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ABSTRACT

The purpose of this investigation is to establish certain statistical relationships between total and component plant parts biomass with different growth parameters (independent variables). Out of six independent variables, diameter square and height, diameter at breast height, and diameter at first branching yield high positive significant correlations with the biomass of component plant parts (dependent variables). Although all the growth parameters show positive correlations with the component plant parts biomass, the above-mentioned parameters have high positive relationships with the same. Diameter at first branching, an independent variable, shows very close relationship with the leaf area and leaf biomass. Component plant parts have a direct bearing on each other and show positive significant correlations.

INTRODUCTION

A lot of work has been done by ecologists on biomass and productivity studies of the temperate, evergreen, subtropical and tropical rain forests of the world (Ovington 1962; Kira *et al.* 1967; Whittaker 1963; Singh 1976; Sharma 1971; Sharma & Singh 1975; Singh & Sharma 1976). A summary table of biomass and net primary productivity in forest ecosystems of the world has been given by Art & Marks (1971). Biomass data of five different-aged plantations (5–9 years old) of *Eucalyptus tereticornis*, a hybrid variety, have been given by Singh & Sharma (1975).

In this investigation an attempt has been made to develop linear and allometric relationships between biomass of component plant parts and a number of growth parameters. With the help of these relationships, statistical equations may be developed for biomass estimation, and repeated felling of trees, which is a herculean task, can be avoided (Ovington 1962). Among independent variables, diameter at breast height (dbh), diameter at ground level (dgl), diameter at first branching (dfb), tree height (H), diameter square and height (d^2h) and diameter cube and height (d^3h) have been taken into consideration. Bole, branches, leaves, root, bole + branches, bole + branches + leaves (above ground), bole + branches + root (non-photosynthetic), leaf area, and total biomass are considered as dependent variables.

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MATERIALS AND METHODS

A 10-year-old stand of *Eucalyptus* was grown in rows by the Forest Department of Meerut Forest Division, Uttar Pradesh, along the main Ganga canal side in Muzaffarnagar district, to consider its suitability for the paper-pulp and paper industry and for checking soil erosion; the area occupied by the stand was 20 ha. The trees are conical in shape, having more branches and leaves in the middle strata. The stand was studied by the quadrat method. A quadrat of 10 m^2 area was used and 50 quadrats were randomly set up in the stand. All the trees in each quadrat were then numbered and measured in centimetres at a height of 1·3 m above ground level with the help of measuring tape. All the trees of the 50 quadrats were grouped into three girth classes (A, B, C) on the basis of dbh, since there was great variation in the girth of the trees. Girth class A, B and C varied between 30–40, 41–60 and 61–90 cm respectively.

Fifteen trees of average diameter were harvested for each girth class by selective harvest technique (Ovington 1962; Newbould 1967). Thus only 45 trees were harvested from the stand because the clear-felling of the stand was not permitted by the Forest Department of Uttar Pradesh. Biomass of the representative trees was estimated in the month of November 1973. Just after felling the representative tree, the following parameters were recorded: (a) dbh, (d) dgl, (c) dfb, (d) H.

The sample tree was then cut into 1 m pieces from the base, to calculate the biomass at different strata. Leaves and branches were collected at each stratification separately for their biomass estimation in each stratum and weighed in the field. One hundred leaves from all the strata of each sampled tree were randomly collected for the measurement of leaf area. Leaf area was calculated by planimeter method. Immediately after felling, the fresh weights of the above-ground parts of the sampled trees were determined with the help of a spring balance. The root system of the sampled trees of each girth class was dug out in 1 m^3 depth area and weighed. Uniform samples (1 kg) of the bole, branches, leaves and roots were sealed in polythene bags and brought to the laboratory, where they were placed in an oven at 85°C for 48 h for dry-weight determination.

RESULTS

1. *Linear relationships between independent and dependent variables*

Among different independent variables, d^2h shows high positive significant correlation with the biomass of bole, branches, bole+branches, above-ground and non-photosynthetic as well as with total biomass. Leaf area and leaf biomass are highly correlated with dfb. Root biomass has a direct bearing on dbh (Table 1). It is evident from Table 1 that no single curve form or independent variable consistantly produced the most reliable fit for all the components.

2. *Allometric relationships between independent and dependent variables*

In cases of allometric relationships dbh has an upper hand and shows high significant positive correlation with the biomass of bole, root, bole+branch, above-ground, non-photosynthetic and with the total biomass. Branch and leaf biomass and leaf area yield significant correlations with dfb (Table 2).

Thus, it becomes clear from Tables 1 and 2 that the biomass of different plant parts

Table 1. Linear correlation coefficients (r) between biomass of different plant parts and growth parameters in *Eucalyptus tereticornis* stand

Dependent variables	Independent variables					
	dbh	dgl	dfb	H	d^2h	d^3h
Bole	0·92	0·91	0·83	0·84	0·96	0·96
Branch	0·85	0·82	0·86	0·69	0·92	0·90
Leaves	0·80	0·74	0·85	0·72	0·78	0·75
Root	0·94	0·92	0·89	0·83	0·92	0·90
Bole + branches	0·92	0·91	0·85	0·82	0·97	0·96
Above-ground	0·93	0·92	0·87	0·83	0·98	0·96
Non-photosynthetic	0·93	0·92	0·86	0·83	0·97	0·96
Leaf area	0·72	0·66	0·78	0·66	0·70	0·67
Total biomass	0·94	0·92	0·88	0·84	0·99	0·98

has a high relationship with different growth parameters. With the help of these parameters we may develop regression equations, through which we can estimate the biomass of different plant parts without harvesting the crops.

3. *Relationship of total biomass with fractional plant parts*

The biomass of bole, branch, root, non-photosynthetic and above-ground parts has a very close correlation with the total biomass, whereas photosynthetic or leaf biomass has no significant bearing on the standing crop (Table 3). Among all the tree components, biomass of bole and non-photosynthetic parts has a very high relationship (r = 0·99) with the total dry weight.

4. *Relationships between dependent variables*

Bole biomass shows very close correlation with the biomass of non-photosynthetic and

Table 2. Allometric correlation coefficients (r) between biomass of different plant parts and growth parameters in *Eucalyptus tereticornis* stand

Dependent variables	Independent variables					
	dbh	dgl	dfb	H	d^2h	d^3h
$\log_e$ bole	0·98	0·95	0·90	0·92	0·97	0·96
$\log_e$ branch	0·93	0·89	0·94	0·83	0·92	0·92
$\log_e$ leaves	0·89	0·85	0·90	0·84	0·89	0·89
$\log_e$ root	0·95	0·94	0·90	0·85	0·94	0·94
$\log_e$ bole + branch	0·98	0·97	0·92	0·92	0·98	0·98
$\log_e$ above ground	0·98	0·97	0·93	0·92	0·98	0·97
$\log_e$ non-photosynthetic	0·98	0·97	0·93	0·92	0·98	0·97
$\log_e$ leaf area	0·85	0·81	0·87	0·84	0·86	0·85
$\log_e$ total biomass	0·98	0·97	0·93	0·92	0·98	0·98

Table 3. Correlation coefficients between biomass of component plant parts and total biomass in *Eucalyptus tereticornis* stand

Variables	Correlation coefficients (r)
Total biomass V/S:	
Bole	0·99
Branch	0·93
Leaves	0·74
Root	0·92
Above-ground	0·91
Non-photosynthetic	0·99

Table 4. Correlation coefficients between biomass of component plant parts in *Eucalyptus tereticornis* stand

Component plant parts	Bole	Branches	Leaves	Root	Above-ground	Non-photosynthetic
Bole	1·00	0·89	0·66	0·89	0·99	0·99
Branches	0·89	1·00	0·77	0·84	0·94	0·93
Leaves	0·66	0·77	1·00	0·77	0·73	0·71
Root	0·89	0·84	0·77	1·00	0·91	0·92
Above-ground	0·99	0·94	0·73	0·91	0·99	0·99
Non-photosynthetic	0·99	0·93	0·71	0·92	0·99	0·99

above-ground parts. Branches and root biomass has the same correlation while leaves show less significant correlation (Table 4). Branches and root biomass also shows positive correlation with non-photosynthetic and above-ground parts biomass. Bole and leaf biomass has the same significant correlation with branches and roots. Roots and branches are also highly correlated with each other. Leaf dry weight also shows high significant correlation with branches and roots followed by bole, above-ground and non-photosynthetic biomass in descending order (Table 4). Above-ground and non-photosynthetic plant parts are highly correlated with bole, branches, root and leaves in decreasing order (Table 4).

DISCUSSION

Based on the harvesting of the trees, several techniques have been developed during recent years by Woodwell & Whittaker (1968) and Attiwill & Ovington (1968). Clear-felling of an entire area at specified time intervals has been done by Ogawa *et al.* (1965) and Kira & Shidei (1967), in productivity studies of woodlands. This technique requires a tremendous amount of labour and also becomes impracticable when replicated plots have to be harvested at different times during a season. To reduce the amount of sampling and the labour involved in the above-mentioned technique, selective harvesting of the trees has been suggested by Ovington (1956, 1965), Baskerville (1965a, b), Sharma (1971) and Singh (1976). Thus, the selective harvesting technique has been used in the present study.

No single independent variable has a direct bearing on the biomass of different tree components. Among numerous independent variables tested, d^2h, dbh and dfh proved better. In most of the cases such as bole, branch, root and total biomass, d^2h shows high positive correlations. Diameter at first branching (dfb) yields highly significant positive correlations with the biomass of leaves and leaf area. Kira & Shidei (1967) have observed the highly positive significant correlation between the biomass of component plant parts and d^2h in *Cryptomeria* plantations, where the conical shape of the plant is more or less similar to that of *Eucalyptus* tree. In 5–9 year-old plantations of *E. tereticornis*, Singh & Sharma (1975) observed that dfb proved better for the leaf biomass and leaf area.

In allometric form, the logarithm of dbh is highly correlated with the logarithm of biomass of different plant parts. Results are very similar to the observations of Baskerville (1965a, b), Weetman & Harland (1964) and Crow (1971). In linear as well as in allometric form dfb yields high correlations with the leaf biomass and leaf area in *Eucalyptus* plantations because leaves remain attached to branches and maximum branching occurs in middle strata, hence the leaf biomass and leaf area have a direct relationship with dfb. Total biomass of plants is highly correlated with the biomass of component plant parts and results may be compared with the trees of natural dry deciduous forests (Sharma 1971) and with Dhawara and sal plantations (Pandeya, Pandit & Sharma 1970; Pandeya, Sharma & Pandit 1970). Component plant parts have a very close correlation with each other and results may be compared with the plantations of *Tectona grandis* and *Shorea robusta* (Faruqi 1972) in Gorakhpur (U.P.) forest.

ACKNOWLEDGEMENT

The authors are grateful to the authorities of the Forest Department of Uttar Pradesh for their help in the harvesting of trees.

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(*Received* 18 *March* 1976)

العلاقة بين الوزن الحى وأبعاد النماء
في مجتمع من أشجار الكافور عمره عشر سنوات

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خلاصة

الغرض من هذه الدراسة هو ايجاد العلاقة بين الوزن الحى الكلى للنبات ، والوزن الحـى لاجزاء النبات من جهة ، وأبعاد النماء المختلفة من جهة أخرى .

وتشير النتائج الى أن هناك علاقة موجبة بين الوزن الحى لاجزاء النبات ، وبين جميع أبعاد النماء التى درست ، وبصفة خاصة : قطر الشجرة في مستوى التفرغ الاول (أدنى الفروع الى الارض) ، وقطر الشجرة في مستوى صدر الانسان (على ارتفاع ١٣٠ سم فوق سطح الارض) ، وحاصل ضرب مربع قطر الشجرة في ارتفاعها ، كذلك ظهر أن هناك علاقة وثيقة بين قطر الشجرة في مستوى التفرع الاول ، ومساحة سطح الورقة ، والوزن الحى للورقة .

ان أجزاء النبات لها دلالات مباشرة وترتبط ببعضها بعلاقات موجبة هامة .

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