J. Univ. Kuwait (Sci.) **8**, 1981

Dry matter production of *Pinus halepensis* Mill. var. *brutia* (Ten.) Henry (Syn. *P. brutia* Ten.) at Bakrajo, Sulaimaniyah, Iraq

V. K. SHARMA AND B. K. MAULOOD

Department of Biology, College of Science, University of Sulaimaniyah, Iraq

ABSTRACT

A 24-year-old *Pinus halepensis* var. *brutia* plantation was studied for standing crop biomass by average tree technique. The stand has a density of 908 trees/ha covering 5·67% basal area. Total above-ground biomass is 38·51 tons/ha. Vertical profile of biomass gives the stand a pyramidal shape. Biomass relationships of different plant parts with bole diameter at different heights have been established. There is a positive correlation between bole diameter and bark thickness.

INTRODUCTION

Forests constitute one of the major terrestrial ecosystems of the world. The primary productivity of different forest types varies widely. It depends on the magnitude of primary synthesis, energy dissipation rate via respiration and formation of new tissues, availability and utilisation of mineral and water from the soil and the genetic set-up of the primary producers (Misra 1970).

In the analysis of an ecosystem, biomass is basic data, hence different techniques are employed in studying dry matter production as accurately as possible in aquatic and terrestrial systems (Misra 1968). After the classical work of Boysen-Jensen (1932) extensive data on dry matter production in various forest types of different climatic zones have been collected. Art & Marks (1971) provided a summary table of biomass in forest ecosystems of the world. Singh (1976) compared biomass of different plantations of the world. No data are available for biomass and primary productivity of forest ecosystems in Kurdistan, and the present work was done to study biomass production in a 24-year-old *Pinus halepensis* var. *brutia* plantation at Bakrajo Research Farm.

SITE DESCRIPTION, CLIMATE AND SOIL

Bakrajo Research Farm lies between latitudes 35° 31′ and 35° 33′N and longitudes 45° 21′ and 45° 23′ E, at 700–760 m above sea level. Out of the 375 ha total area, 95% is under cultivation and agricultural experiments (Khan *et al.* 1979). There is an east–west belt of different forest plantations, mainly of *Pinus* and *Cupressus*.

Climatic data for 5 years (1973–8) (Fig. 1) were obtained from the Meteorological Office, Sulaimaniyah. Zohary (1950) described the climate of the country as

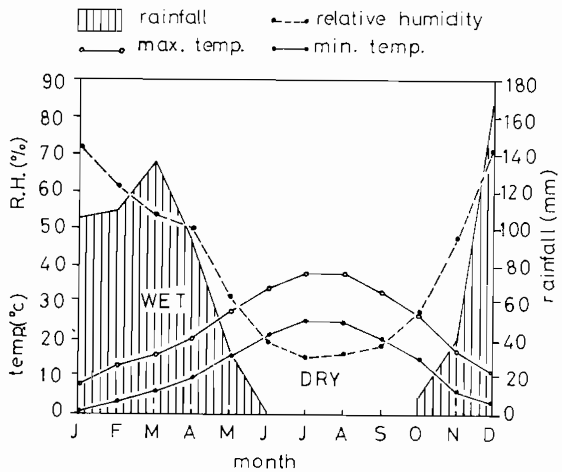

Fig. 1. Ombrothermic and relative humidity diagram of Sulaimaniyah (1973–8).

intermediate between the typical central Asian (Irano-Turanian) and Saharo-Sindian climates. The year can be divided into dry hot summer (mean max. temp. 30·4°C in July), snowy and wet winter (mean min. temp. 2·4°C in January) and short spring, with total annual rainfall of about 700 mm (Fig. 1). On the basis of rainfall only, this climate can be classified as sub-humid (Maulood & Hinton 1978; Sharma *et al.* 1980).

Soils of Bakrajo have recently been studied by Khan *et al.* (1979). Soil of the forest stand is silty clay, dark brown in colour (10 YR 4/3) and alkaline (pH 7·5–7·8).

MATERIALS AND METHODS

Total density of the stand was assessed by the count quadrat method. Each tree of the studied quadrats was marked at breast height (1·3 m) and numbered. An average tree of 49·8 cm girth at breast height (gbh) was felled in May 1979 for biomass studies. The tree was divided into 1 m logs with a chain-saw and fresh weight of different plant parts was estimated in the field by a field balance. Samples of bole, branches and leaves of every stratum were kept at 105°C for 48 hr for dry weight estimation.

RESULTS

Stand structure

Physical characteristics of the 24-year-old *Pinus halepensis* var. *brutia* stand are given in Table 1. The stand has total density of 908·3 trees/ha, average tree diameter at breast height (dbh) is 15·8 cm, average height is 7·45 m, basal coverage of trees 5·67% and canopy coverage 90·8%.

Above-ground biomass

Above-ground biomass for an average tree of the forest stand is 42·42 kg to which bole contributes 52·1% followed by branches (26·4%) and leaves (21·5%). Total above-ground biomass on area basis is 38·51 tons ha; bole, branches and leaves contribute 20·06, 10·19 and 8·25 tons/ha, respectively (Table 2).

Table 1. Stand structure of *Pinus halepensis* var. *brutia* plantation at Bakrajo (physical characteristics)

Density (trees/ha)	908·3
Mean gbh (cm)	49·8
Mean dbh (cm)	15·8
Average height (m)	7·4
Bark thickness at dbh (cm)	1·0
Canopy diameter (m)	3·6
Canopy depth (m)	6·0
Age (year)	24
No. of annual rings	23
Basal coverage (%)	5·67
Canopy coverage (%)	90·8

Table 2. Above-ground biomass of *Pinus brutia* plantation

	Oven dry weight	
Plant part	kg/tree	tons/ha
Bole	22·10	20·06
Branches	11·23	10·19
Leaves	9·09	8·25
Total	42·42	38·50

Productive structure

Vertical distribution of biomass of average tree is presented in Fig. 2. It is evident from the data that a greater amount of organic matter accumulates in the lower strata. In the second and third strata biomass increases due to higher dry content of the branches and leaves found in these strata. Dry matter content decreases considerably in the upper strata. This eventually gives a pyramidal shape to the productive structure of the stem. Fig. 2 also shows that bole decreases gradually from the lower to the upper parts. Branches attain their maximum in the third and fourth strata and decrease

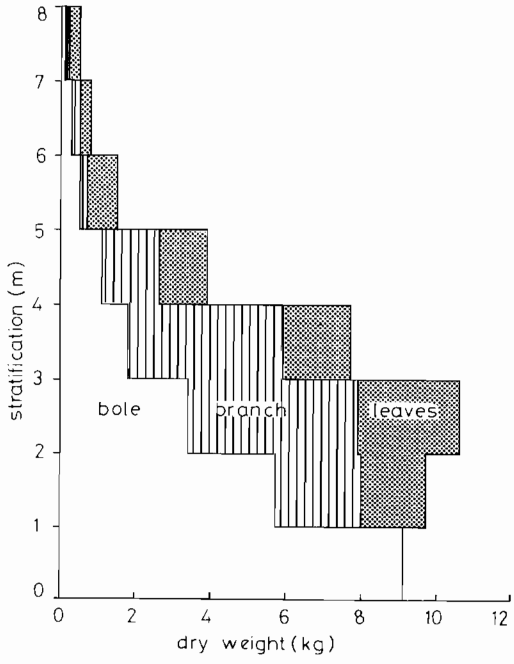

Fig. 2. Vertical distribution of biomass of average tree of *Pinus halepensis* plantation.

considerably in the upper strata. Leaves attain their maximum in the third stratum and their minimum in the top stratum. Branches and leaves are absent in the bottom stratum.

Bole diameter and dry weight relationship

Bole diameter and dry weight of different plant parts at different stratifications are closely related (Fig. 3). With increasing height, bole diameter decreases, which has

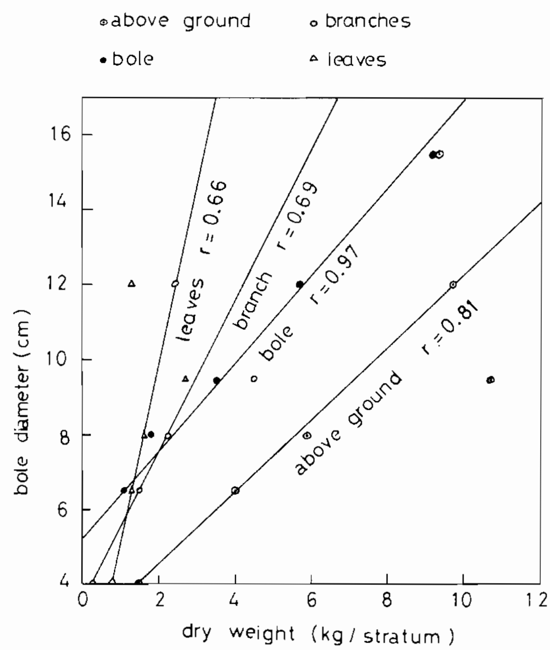

Fig. 3. Bole diameter relationship with plant parts biomass at different strata. Regression equations:

Bole diameter *vs.*	bole (kg/stratum)	$Y=0{\cdot}824X-4$
	branches (kg/stratum)	$Y=0{\cdot}481X-1{\cdot}668$
	leaves (kg/stratum)	$Y=0{\cdot}228X-0{\cdot}686$
	bole + branches + leaves (kg/stratum)	$Y=0{\cdot}985X-2{\cdot}274$.

positive correlation with the weight of bole, branches and leaves and the sum of bole, branches and leaves at different strata. From the regression equations (Fig. 3), given a known bole diameter, dry matter of the component plant parts at different heights can be estimated.

Bole diameter and bark thickness relationship

Bark thickness in the 24-year-old plantation varies from 0·01 to 2 cm. It is evident from Fig. 4 that there is a close correlation between bole diameter and bark thickness ($r=0{\cdot}91$).

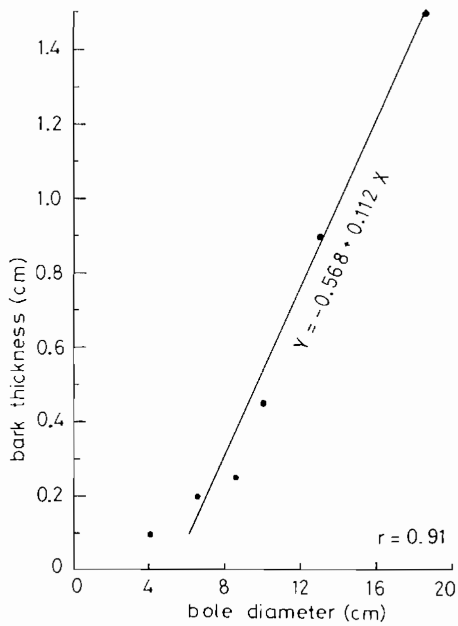

Fig. 4. Bole diameter relationship with bark thickness in *Pinus halepensis* plantation.

DISCUSSION

Measurement of dry matter production of green plants is a prerequisite for the understanding and management of resource ecosystem. During the last two decades, there has been an increasing interest among ecologists to collect data on biomass and primary productivity of terrestrial and aquatic communities throughout the world (Sharma 1971).

Green plants are the principal harvesters of the sun's energy and hence are the primary producers within the biosphere. Solar energy is captured by the green plant; a fraction of this energy is used up in metabolic activities including the synthesis of energy-rich organic compounds. It is necessary to obtain quantitative measurements of standing crop biomass and productivity potentials of the primary producers in different climatic zones of the world (Leith 1971). Determination of dry matter production in forests is a difficult problem. Several sampling techniques have been developed to measure the structure and function of woodland ecosystems. Ogawa *et al.* (1965), Kira *et al.* (1967) and Kira & Shidei (1967) preferred felling of a sample area to estimate the biomass. Satoo (1974) and Satoo *et al.* (1974) used regression techniques for biomass determination. Singh (1976) harvested selected (sample) trees and from their measurements calculated total biomass of the known area. Ovington & Pearsall (1956) and Swank & Schreuder (1974) used the average tree sampling technique to determine biomass. To minimise destruction and labour, average tree technique has been used in the present study. This technique may give slight underestimation of the actual production as suggested by Swank & Schreuder (1974). Biomass of the examined stand is less than that of *Pinus radiata* plantations in Australia (Ovington *et al.* 1967), oak-pine forest of the U.S. (Whittaker & Woodwell 1969), and that of

Eucalyptus tereticornis plantations in central India (5–9 years old) which have two to six times the biomass of the present woodland (Singh 1976).

The shape of the vertical profile of biomass is pyramidal. Maximum organic matter accumulates near the ground and minimum occurs at the top of the tree. With the advancement of age, lateral growth dominates apical growth. Thus the branches and leaves in the middle strata increase and change the structural profile of the wood. Total biomass as well as that of fractional plant parts of every stratum are highly correlated with the bole diameter (except the first stratum where the branches and leaves are absent). Bark thickness is significantly correlated with the bole diameter.

ACKNOWLEDGEMENTS

The authors are thankful to the Dean, Agriculture College, for permission for harvesting and for providing labour facilities, to the Dean, Science College and Head of the Biology Department for laboratory facilities. Thanks are due to Dr S.A. Tewfik, Department of Horticulture, and Mr Hassar S. Al-Dosky, Department of Biology, for their help during sampling. We are also grateful to Dr G.C.P. Hinton for going through the manuscript.

REFERENCES

Art, H. W. & Marks, P.L. 1971. A summary table of biomass and net annual primary production in forest ecosystems of the world. XVth IUFRO Congress, University of Florida, U.S.A. pp. 3–34.

Boysen-Jensen, P. 1932. Die Stoffproduktion der Pflanzen. Fischer, Jena, 108 pp.

Khan, M.M., Hussain, M.S. & Shali, K.G. 1979. Soils of Bakrajow Research Farm. Zanco **5**(2): 1–27.

Kira, T., Ogawa, H., Yoda, K. & Ogino, K. 1967. Comparative ecological studies on three main types of forest vegetation in Thailand. IV. Dry matter production with special reference to the Khao Chong rainforest. Nature and Life in S.E. Asia **5:** 149–74.

Kira, T. & Shidei, T. 1967. Primary production and turnover of organic matter in different forest ecosystems of the western Pacific. Jap. J. Ecol. **17**(2): 70–87.

Lieth, H. 1971. Environmental control of primary productivity. Proc. Symp. Trop. Ecol. emphasizing organic productivity. (INTECOL, INSA and ISTE).

Maulood, B.K. & Hinton, G.C.F. 1978. An ecological study on Serchinar water chemical and physical aspects. Zanco **4**(3): 93–117.

Misra, R. 1968. Ecology workbook. Oxford and IBH, New Delhi.

Misra, R. 1970. Plant productivity studies in India. Proc. 57th Session of Indian Science Congress **1:** 1.

Ogawa, H., Yoda, K., Ogino, K. & Kira, T. 1965. Comparative ecological studies on three main types of forest vegetation in Thailand. II. Plant biomass. Nature and Life in S.E. Asia **4:** 49–80.

Ovington, J.D., Forest, W.G. & Armstrong, J.S. 1967. Tree biomass estimation. Symp. Primary Production and Mineral Cycling in Natural Ecosystems. AAAS and Ecol. Soc. Amer. 4–31.

Ovington, J.D. & Pearsall, W.H. 1956. Production ecology. II. Estimate of average production by trees. Oikos **7:** 282–5.

Satoo, T. 1974. Primary production relations in a plantation of *Larix leptolepis* in Hokkaido: Materials for the studies of growth in forest stands. Bull. Tokyo Univ. For. **66:** 119–26.

Satoo, T., Negisi, K. & Yagi, K. 1974. Primary production relations in plantation of *Thujopsis dolobrata* in the Noto Peninsula: Materials for the studies of growth in forest stands. Bull. Tokyo Univ. For. **66:** 139–51.

Sharma, V.K. 1971. Ecology of *Shorea robusta* Gaertn. and *Buchanania lanzan* Spreng. at Varanasi forest. Ph.D. Thesis, Banares Hindu University, Varanasi, India.

Sharma, V.K., Maulood, B.K. & Hinton, G.C.F. 1980. Ecology of Azmer hills. Vegetation in relation to soil characteristics and topography. Zanco. **6**(3): (in press).

Singh, R.P. 1976 Studies of annual net production, mineral standing state and energy accumulation pattern of *Eucalyptus tereticornis* Smith in western Uttar Pradesh. Ph.D. Thesis, Meerut University, Meerut, India.

Swank, W.T. & Schreuder, H.T. 1974. Comparison of three methods of estimating surface area and biomass for a forest of young eastern white pine. For. Sci. **20:** 91–100.

Whittaker, R.H. & Woodwell, G.M. 1969. Structure, production and diversity of the oak-pine forest at Brookhaven, New York. J. Ecol. **57:** 155–74.

Zohary, M. 1950. The flora of Iraq and its phytogeographical subdivision. Dept. Agric. Iraq Bull. **31:** 1–201.

(Received 25 May 1980)

حول انتاج المادة الجافة في نبات الصنوبر الحلبي
في بكراجو ، السليمانية ، العراق

ف . ك . شارما و ب . ك . مولود
قسم علوم الحياة ، كلية العلوم بجامعة السليمانية ، العراق

خلاصة

تمت دراسة غابة مزروعة بنبات الصنوبر الحلبي عمرها أربع وعشرون سنة ، واستخدمت طريقة الشجرة المتوسطة لقياس الكتلة الحية . وقد بلغت كثافة الاشجار ٩٠٨ شجرة في الهكتار ، وكانت مساحتها القاعدية ٥,٦٧٪ ، والكتلة الحية الهوائية ٣٨,٥١ طنا في الهكتار . وتبدو الغابة هرمية في قطاعها الرأسي . وقد تمت دراسة العلاقة بين الكتلة الحية لاجزاء النبات قطر جذع الشجرة ، كما وجد أن هناك علاقة موجبة بين قطر الجذع وسمك القلف .