# [033]マダケ林の生産組織に関する研究

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# STUDIES IN ORGANIZATION OF PHYLLOSTACYS BAMBUSOIDES STANDS

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## Résumé

With a view to studying how to establish the industrial organization of bamboo forests, making the most of the essentials of the industrial organization in agriculture and forestry and the characteristics of bamboo stands, the author first clarified the stand composition of bamboo forests with MA-DAKE (*P, Bambusoides* Sieb, et Zuce.) the main species produced in Japan; and then analyzed the working systems and the final ages to find out the working system and the final age fit to the Purpose; tried to give a theoretical basis to the organization of bamboo forests and the determination of cut; and studied into the properties and meaning of the rational and economical growingstock of a bamboo stand. And the following results were obtained.

The report will treat the findings in the order of 1) the characteristics of the stand composition of bamboo forests' 2) the kinds of working systems for bamboo stands and their relative merits, 3) the kinds of final ages and their characteristics, 4) the kinds of methods of regulation of cut and their characteristics, and 5) the normal state of bamboo stands.

1. Characteristics of Stand Composition of Bamboo Forests

A. Composition of Bamboo Stands above the Ground.

i. The crown composition is characterized by the single-stage multi-layer (rarely multi-stage multi-layer) vertical structure.

ii. The distribution of standing bamboos is characterized by the uneven-aged forest of irregular (linear) group formation, with standing bamboos ranging from 1-year bamboos to those reaching the final age.

iii. The diameter distribution of the standing bamboos bears a close resembrance to the diameter distribution of the uniform even-aged tree forests (i.e. normal curve type).

iv. As regards the length of stalk and the height below the branch, they are naturally affected not only by the site quality and the nature of soil, but also conspicuously by the crown density of the stand, the working system, the final age, etc. The influences of these factors are much more marked than on the tree forests, and it makes an important characteristic of the bamboo forest.

v. The distribution of the stem volume of bamboos resembles that of the uniform even-aged tree stands and appears to be apporoximately of the so-called normal curve type like the diameter distribution.

vi. As regards the age, so such relationship between the age of the bamboos and the shape of the standing bamboos can be seen in a completed bamboo

stand as in the case of the tree stand, but from the technical stand point and the view point of sustained yield, the age of the bamboos is a factor far more important than in the case of the tree stand and it can be said to make the basis for the analysis of the stand composition of bamboo forests.

vii. Such factors as the species, the diameter class and the utilization per cent are important not only as the value factors but also are of deep significance from the technical view point. However, as they depend on complicated elements, their evaluation is very difficult.

viii. The present stem volume of the stand is the result of the working carried out in the past and it can make the basis for the practical evaluation of the working in the past, and at the same time it is meaningful as a guide to the future working or its organization. This situation is the same as with the general tree stands.

ix. It has been made clear that the stand increment and the process of growth are quite different from those with tree stands and they make salient characteristics of the bamboo stand and they have come to be regarded as the most important stand composition factors in the working of bamboo stands and its organization, and it is now recognized that no satisfactory result would be obtainable in the management of bamboo forest, unless their substances are grasped securely.

B. Composition of Bamboo Stands under the Ground

The characteristics of the stand composition of bamboo stands above the ground were summarized in the foregoing, and those of the subterrenean portion of the bamboo stand are treated briefly in the following, which is hoped to be of some reference value.

Since the subterrenean portion of the bamboo stand is composed of subterrenean shoots, some factors relative to subterrenean shoots necessary for the management of bamboo forests are derived and made a reference information for the understanding of the subterrenean composition of the bamboo stand.

i. Shape and weight of subterrenean shoots

The subterrenean shoots are seldom circular and hollow. They have one bud to each knot and roots grow out of each knot. The diameter class of the subterrenean shoot is determined at the time of its birth and it does not grow afterwards. The subterrenean shoots in more fertile lands are somewhat longer, larger and heavier than those in less fertile lands.

ii. The vertical and horizontal composition of the subterrenean shoots varies by the geographical features and the nature of the the soil, and is affected sensitively by the locality.

iii. It may be recognized as one of the salient features that the diameter class and the age of the subterrenean shoot influence the diameter class and shape and quality of the bamboo stem.

iv. The vital power of the subterrenean shoot lasts from 7 to ten years in the case of MA-DAKE, but the sprouting power has its peak at about 3 years of age. It is a significant tendency that the better the soil, the shorter the duration of period of vital power, and vice versa.

v. Three modes of growth are observed with subterrenean shoots. The number of ramifications is greater with smaller bamboos and the direction of ramification is mostly slantwise with respect to the main shoot. The branch shoots run wavily and have a tendency to turn downward as they near the ground surface. The growth reaches its maximum in July and August and declines gradually.

2. Working Systems for Bamboo Stands

The classification of working systems for forests has been based on the characteristics and special features of the methods of working. However, since it is difficult to grasp and classify the characteristics of the whole process of production, the classification has usually been based on the most conspicuous characteristic easy to grasp, namely the features of the process of reproduction.

In the classification of the working systems for bamboo stands, therefore, a method similar to that for the tree forests is adopted. The regeneration of bamboo forests is by the rhizomatous natural regeneration, and since there are various cutting methods as the methods of reproduction, the working systems for bamboo forests are classified, as in the case of general tree forests, as follows based on the method of cutting as well as the shape, size and distribution of the cutting area, the speed of cutting, the length of reproducing period, the stand composition of the cutting area and its vicinity, etc.

Working Systems for Bamboo Stands

- Block Working
  - Clearcutting with Natural Regeneration by Self-sown Rhizome
    - Whole Stand Clearcutting
    - Spot Clearcutting
    - Clearcutting in Strips
      - Alternate Strips Method
      - Progressive Method
  - Natural Regeneration by Rhizome and Mother Bamboo Method
    - Scattered Method
      - Leaving 1-year Bamboos
      - Leaving 1-and 2-year Bamboos
      - Leaving 1-, 2-and 3-year Bamboos

Group Method
Leaving 1-year Bamboos
Leaving 1-and 2-year Bamboos
Leaving 1-, 2-and 3-year Bamboos
Strip Method
Alternate Strip Method
Leaving 1-year Bamboos
Leaving 1-and 2-year Bamboos
Progressive Method
Leaving 1-year Bamboos
Leaving 1-and 2-year Bamboos
Selective Cutting
Alternate Years Method
Whole Stand
Strip Method
Annual Working Method

The results of the test carried out for the purpose of comparing the working systems for bamboo stands with those for tree forests and finding the characteristics of the working systems for bamboo stands and the most suitable working system for the bamboo stand, are summarized in the following.

The annual selective working system is ideal for the bamboo stand from the view point of the physiology and ecology of the rhizomatous natural regeneration and it proved the highest in the quality and quantity of the bamboos produced. However, this working system is of necessity intensive technically and in the requirement of labor, and it seems next to impossible to adopt this method generally. On the other hand, in view of the fact that no practical difference was seen qualitatively and quantitatively in the reproduced bamboos between the cut area and the remaing area of the alternate strip clearcutting system and the alternate strip natural regeneration by rhizome and mother bamboo system and the alternate years selective cutting system showed good results in various factors, next to the annual selective cutting system, the alternate strips, alternate years selective cutting system, combining the long points of both these systems, is considered to be the next best method. In this system the intensiveness in the technical and labor requirments, which is the short point of the annual selective working system, is considerably alleviated and it is expected that this method will prove to give as good a production of bamboos as in the case of the annual selective working system, both quantitatively and

qualitatively. And in consideration of the characteristic tendency of the bamboo stand of the alternation of the high and the low sprouting power years, even better results could be expected if the working system is well harmonized with the alternation of sprouting power.

Even in case where the natural regenration by rhizome and mother bamboo methods leaving 1-and 2-year bamboos or leaving 1-year bamboos have to be adopted, it is expected that technically favorable results would be obtained in the yield, conservation, work done of cutting operation, etc., if a cutting system of the alternate strips type or the progressive strips type is adopted instead of a methed of cutting a wide area simultaneously, in the light of the results of the alternate strips clearcutting system and the alternate strips natural regeneration by rhizome and mother bamboo system.

3. Final Age

The problem of the necessity of the rotation (or the final age) which originated in the ideas of the control method and the continuous forest and was expanded and stressed by Eberbach and C. Wagner is considered with bamboo forests.

i. The function of the final age is to present a criterion for the formation and appraisal of a rational quantitative and qualitative composition of growing-stock.

ii. In view of the characteristics of the bamboo stand, the final age presents an essential measure for the computation of the rational growing-stock, increment (increment per cent) based on the age and the age grade distribution, and further for the determination of the average quantity of annual cutting. This is so also from the consideration of the vital age of subterrenean shoots in view of the characteristics of the natural regeneration of the subterrenean shoots which leads to the consideration of the silvical final age.

iii. There is an optimum time for the utilization of bamboo materials, which requires adequate maturity and proper cutting age, and it is a big characteristic of bamboo stands that they are best regulated by the final age.

iv. In view of the stand composition of the bamboo stand for which the time or the age can conveniently and properly be adopted as the criterion for the control and future planning of working, the final age is regarded as an essential and indispensable factor of the bamboo stand.

Next, some final ages, which are not important with general tree forests but should be considered with bamboo stands, will be treated for their evaluation as the final age for bamboo stands.

1) Silvical Final Age

Due to the characteristics of the natural regeneration by subterrenean shoots in the bamboo stand, the size and the quality of subterrenean shoots affect directly and sensitively the diameter class, number and quality of bamboo shoots or new bamboos, and therefore, it is essential to maintain the best condition of vitality and sprouting power of subterrenean shoots. The working system based on the final age most favorable for the enrichment of such subterrenean shoots could be considered to come under this category.

For MA-DAKE, the silvical final ages are likely to be as follows.

Medium diameter class stand (sitequality : medium)

(D=5cm—7cm) 4 years

2) Technical Final Age

In the bamboo stand, the diameter class and the form of the standing bamboos are determined at the time of sprouting and the later change is limited to the change in material quality. Therefore, the final age is often decided from the stand point of the utilization of bamboos as material, and since this naturally is different in content and substance from that of tree forests, the technical final age often agrees with the economically advantageous final age very well.

The fact that the composition of the stem differs by the species, age season, site of growth, etc., and it varies by the part even in one bamboo stem, should be given due consideration in the utilization of bamboos.

Judging from the relation between the specific gravity of the bamboo and its age, the most rational final age may be from 4 years to 5 years.

3) Final Age of Maximum Volume Production

This final age is determined so that the average volume increment of the stand may be the maximum. In the tree stand there are two cases, one where the volume production is limited to the yields of final cuttings and the other where the yields of thinning are included, but in the case of bamboo forests, as there is no yield to be considered as the yield of thinning, the age giving the maximum ratio of the growing-stock as against the final age becomes this final age.

This final age can readily and accurately be determined from the yield table for the stand, and it does not change or fluctuate if the treatment of the stand is held constant. However, it has the disadvantage of needing changes in case the volume increment or the process of growth of the stand changes.

iv. Budget Regulation

Various methods of budget regulation may be considered for bamboo forests, but in view of the stand composition and especially the growth characteristics of bamboo stands, various methods of organization by increment will make the principal line of the budget regulation, and methods like the organization by area may be adopted in some cases. And the control method, the increment per cent method, and the average increment by age method are counted as major methods of organization by increment, and the method of division into annual coupes as the organization by area.

1) Control Method of Budget Regulation

The increment in one working period is taken as the yield in the next working period. This working period is very short, generally about 5 years, and is determind to suit the growing conditions of the bamboo stand. This method is fundamentally a suggestion or an estimate proposed to the operator, who adjusts it to suit the actual conditions in the process of his working. The operator adjusts the given yield estimate aiming at the future formation of an ideal growing-stock quantitatively and qualitatively, based on his studies in the past trend of growing-stock quantitatively by the increment per cent or the recovery rate and qualitatively by the diameter distribution by ages or the conditions of diameter shift, and also based on the silvicultrural consideration of the present conditions of the stand such as the sprouting of new bamboos or silvical conditions of the standing bamboos.

However, this method seems to be difficult of general application, because it involves such practical difficulties as 1) the determination of increment takes a long time and is very expensive, 2) the measuring technique is difficult, 3) the yields are given as a mere suggestion and can be changed widely by the judgement of the operator.

2) Increment Per Cent Method of Budget Regulation

This is the method of computing the yields from the increment per cent and the existing growing-stock. The increment per cent is determined by the survey of the stand conditions and the measurement of volume increment and other elements with suitable sample plots established in the bamboo stand. This method has wide application as a substitute for the direct increment method or as a method of an approximate nature.

3) Average Increment by Age Method of Budget Regulation

In this method the summation of the average increment by ages for each stand is taken directly as the yields, and it is a very simple method of budget regulation. However, as this method is nothing but a pure yield appraisal, leaving no room for yield adjustment and having no designation

of cutting spots, this method relies heavily upon the technique and judgement of the operator, and, therefore, is difficult in the application in practice.

4) Division into Annual Coupes Method of Budget Regulation

The entire forest area is divided into the same number of coupes as the number of years of rotation and one coupe is cut for yields each year through the cutting cycle. This method is classified into 1) the simple coupe method and 2) the proportional coupe method, and 1) was used originally in the primitive selection forest.

This method has at present practically no possibility of application, because it has many disadvantages both economically and technically. The merit of this method lies in its common sense simplicity, but at the same time its all-controlling fixedness or rigidity makes its general application hopeless in the present day.

v. Normal Condition

Generally, the so-called normal forest is not the ultimate standard of management, but the significance of the concept will be recognized for ever as a step to or the ideal basis of the ultimate.

The basic type of the normal conditions of sustained volume yields of bamboo forests is the working system where the bamboo reaching the final age are cut each year in the bamboo forest where all age grades of bamboos up to the final age are growing intermixedly all over the entire forest. Such a simple type is practicable in a small area, but the scope of working becomes extensive year after year in case of a wide area, and various difficulties arise in the practice of this type of working, and consequently the yields decrease and the working system would become next to impracticable. Therefore, it is the general practice to divide the entire forest into several divisions, one of which is cut selectively each year so that one division may be worked once in 2 or 3 years in turn.

The normal conditions in the working of bamboo forests are as follows.

1. Normal Age-gradation

This resembles the normal age-gradation in the high forest system by clearcutting which is not laid fallow, and it is not necessary to resort to such a measure as to use the breastheight diameter (D.B.H.) instead of the age when judging whether the age-gradation is normal or not in the selection forest. In actual cases, however, it is almost improbable that the site quality is the same all over the entire forest. Therefore, in the actual practice, the so-called normal forest is supposed, and there are considered two ways of achieving it; (1) the reduced area method (2) the method of dividing the entire forest by the site

quality and carrying out the sustained working system by each site grade.

2. Normal Stand Distribution

In the general tree forest, the distribution of the selective cutting plots is made originally so as to be resistant to various outside damages and the regeneration is made independently of the other selective cutting plots. Therefore, the 2nd and the 3rd conditions of the normal stand distribution in the clearcutting system do not come into question in this case, and the stand distribution is called normal if only the distribution is made so that the hauling of the felled trees in each cutting plot may be made advantageously without trouble. In the case of bamboo forests, however, the bamboo stand involves many intrinsic morphological weak points against wind and snow, and consequently it is necessary that more conditions be considered than for the conditions of the normal stand distribution of the high forest system by clearcutting of the general tree forest.

3. Normal Growing-stock

The growing-sock varies by the seasons of the year, being the largest just before cutting and the smallest right after cutting. It differs from and is in contrast to that of the tree forest in the following points.

1) The normal growing-stock of the bamboo stand is close to the growing-stock of the so-called "financial normal forest" aiming at a sustained maximum economic effect.

2) The working of bamboo forest is characterized by complexity in that it is based not only on the age-gradation and stand distribution mainly but also on the suitable size of growing-stock and the optimum increment per cent.

3) In the working of bamboo forests, although it is considerably difficult, it is possible to prepare the yield table or the increment table on which to base the computation or th eforecast, as in the case of the high forest system by clear-cutting.

4. Normal Increment

The normal increment is equal to the normal quantity of cutting, as seen from the relation between the increment and the yields or the so-called "recovery rate curve" in a near stable stand.

Now that the normal yield is the yield from cutting carried out without disturbing the normal conditions of the normal forest, especially without lowering the normal conditions, it can be said that mission of the normal forest lies in allowing or supplying such a normal yield. Therefore, the normal yield is equal to the normal increment.

The essentials for the organization and reasonable and rational management of the bamboo forest are summarized in the following.

It must be expected that a reasonable and rational management of a bamboo

forest would be, realized if the natural and social economic conditions such as the size of management, habitat, capital investment, available labor, market conditions,etc. are considered, and in as much as the production of bamboo materials is the intermediate purpose, the present conditions of the given bamboo stand, which are the criterion of the result of the past working or the result of natural productivity and which can become suggestions for the future working and organization, are throughly analyzed, and especially close observation is made of the sprouting power in the sprouting period and the process of growth new bamboos, and the standard stand is supposed in the given forest fromt he normal conditions of the bamboo forest and the final age (silvical, technical or maximum average volume production, for example) matching the leading principle for the development of rational working and management of bamboo forest through the habitat and the size of management, shape and quality and quantity of bamboos, the will and technique and capital power of the operator, is adopted, and the harvesting is based on the estimation by the increment rate formula of the yield from the entire forest and the yield from each stand by the control method of budget regulation.

It is added for reference that in a fairly large completed MA-DAKE forest of medium site quality, the final age of 5 years is considered adequate for the maximum quality and quantity of new sprouting bamboos and for the best use of artistic qualitiea of the bamboo, and as for the method of working, as there is the tendency of alternation of high and low sprouting power years and there is some difficulty in carrying out the annual selective cutting in a bamboo forest of fairly large scale, the alternate years selective cutting system is considered to be the practically most advantageous working system at present from the view point of transportation of cut bamboos and the conservation and protection of bamboo forests, and in their budget regulation, the approximate quantity of the yields from the entire forest is obtained by the increment per cent method or the annual average increment method, and the conservation consideration is given to each stand by the control method of budget regulation, and based on the recovery rate that shows the correlation between the cutting quantity and the increment very well (for example, if the final age is 5 years, about 20% of annual cutting quantity of the growing-stock does not appear to change the stand conditions very much) and the old, dead and irregular bamboos in the stand are cut, then a reasonable and rational yield matching the purpose will be ahieved year after year.