Journal of Hydroscience and Hydraulic Engineering
Vol. 14, No. 2, November, 1996, 89-96

ON THE GROWTH RATE OF *S.GILGIANA* ON RESERVOIR MARGIN WHICH APPEARS IN AIR ONLY IN SUMMER SEASON

By

Masayuki Nagao

Research Associate, Department of Environmental Physics and Engineering, Tokyo Institute of Technology, Yokohama, Japan

Katsuhide Yokoyama

Postgraduate Student, Department of Environmental Physics and Engineering, Tokyo Institute of Technology, Yokohama, Japan

and

Tadaharu Ishikawa

Professor, Department of Environmental Physics and Engineering, Tokyo Institute of Technology, Yokohama, Japan

SYNOPSIS

Because the water stage is seasonally varying in a reservoir for flood control, an unsightly non-vegetated band appears along the margin, which diminishes the value of a reservoir for resort use. In this paper, some basic data are presented for vegetating the bands with *S.Gilgiana* which is persevering to submergence. Its growth rate under the condition of flood control reservoir is estimated by a field survey in Kamafusa reservoir. The result shows that the estimated growth rate is about the half of its value under an ordinary growth condition. A consideration is made by referring to the seasonal variation of the water stage and the characteristics of seasonal growth of *S.Gilgiana.*

INTRODUCTION

Dam reservoirs are not only a tool for the control of river flow but also the new environment formed around their margins can be used as recreational area. In fact, dam construction work has actually combined with projects for the development of health resorts. Flood control dams are, however, at a disadvantage for the latter purpose: In summer(flood season), because the water stage must be lowered to keep a volume available for flood water storage, bare slope appears around the water's edge. This spoils the landscape and diminishes the value of the reservoir as a health resort.

If the bare slope is vegetated with plants which can survive in water until next summer, the margin of the reservoir can be covered with greenery as soon as after the water stage is lowered. Considering this, the Ministry of Construction currently conducting field experiments to test the durability of plants under submerged condition(Niwa (2)).

Needless to say, the scenery will be different depending on whether grass or trees are planted. A grass cover is usually "thin" because it re-grows each year. A band of grass several meters high on the slope between the water surface and surrounding forest will result in a curious artificial landscape. On the other hand, Tree cover is "thick", and makes the landscape around the reservoir rich and natural. However, most kinds of trees cannot survive being submerged for several months.

Some kinds of willows are fairly resistant to submergence because they usually inhabit riversides where flooding occurs frequently. Actually, small colonies of willows can also be observed along the margin of flood control reservoirs. Therefore, they can be used to vegetate the bare slopes around reservoirs.

In this study, the growth rate of *S.Gilgiana* (a kind of willow) around the margin of Kamafusa Reservoir which are subjected to frequent inundation is studied in a field experiment. The correlations were investigated among tree's age, height and period of submergence were investigated. The results are compared with a growth curve for normally growing trees presented in existing literature. The difference is considered to be the effect of seasonal submergence on the growth rate.

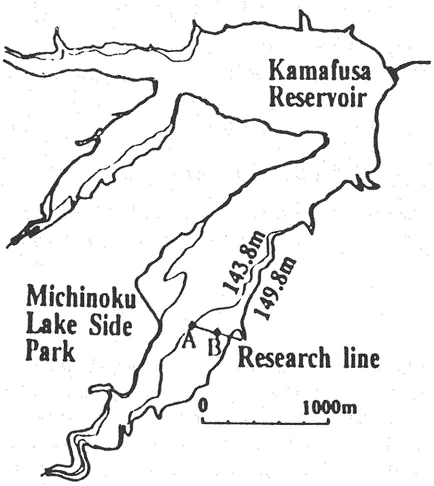

Fig.1 Plane view of Kamafusa reservoir

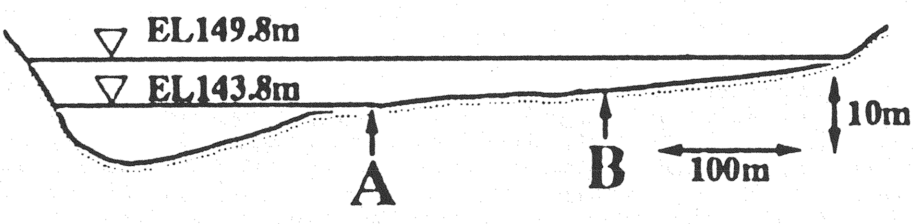

Fig.2 Cross section of research line

DERIVATION

Site Condition

Fig. 1 shows a plane view of Kamafusa reservoir where the field experiment was carried out in August 1993. Kamafusa reservoir is located on the upper reaches of the Natori river in Miyagi prefecture. The high water level of the reservoir(H_n) is 149.80m above sea level, and the normal water level in flood season (H_f) is 143.80m. The thick line in Fig. 1 corresponds to H_n and the thin line to H_f.

Measurements were made on trees which stand along the line A-B in Fig. 1. Fig. 2 shows the cross section of the reservoir along this line. The average slope between Point-A and Point-B is about 1.6%. When the water level is lowered from H_n to H_f, ground 400m wide appears above the water. The ground is covered with cocklebur(annual plant) and reeds(perennial plant) in late summer, with small colonies of *S.Gilgiana* scattered among them.

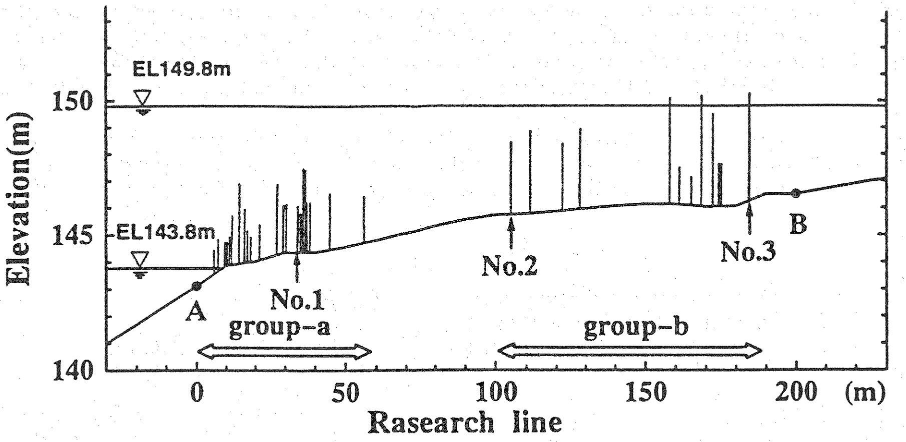

Fig.3 Distribuution and height of trees

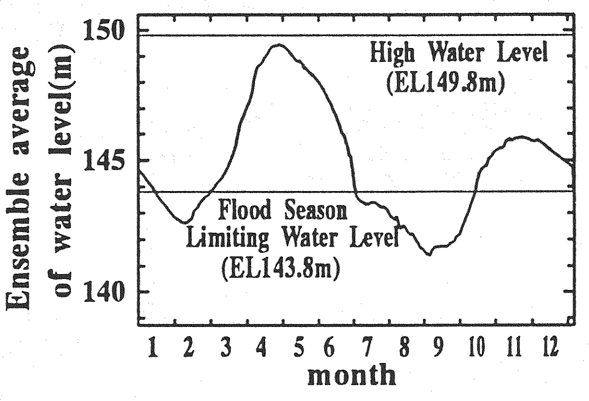

Fig.4 Variation of water level(average from 1984 to 1993)

Measurements

34 of *S.Gilgiana* were selected from along the line A-B for measurement. Their location, height, crown width and number of branches along the main trunk were measured by using a tapeline and transit. Their age can be estimated from the number of branches as discussed later. Three of the *S.Gilgiana* were dissected in detail: They were cut at each branching point. The number of annual rings, thickness of each annual ring and length of branch between every two cut-off points were

measured. The Growth history can be estimated from this data.

RESULTS AND DISCUSSION

Period of Submergence

Fig. 3 shows the location and height of the measured *S.Gilgiana*. They grow between the H_n(E.L. 149.8m) and the H_f(E.L. 143.8m). Fig. 4 shows the seasonal variation of the water surface level obtained by averaging data from the last 10 years. From the figures, it can be seen that all the *S.Gilgiana* studied are completely covered by water in the spring. However, because the water surface level has two peaks, some trees experience partial submergence twice a year while others do only once. This fact could effect their growth. Therefore, the measured *S.Gilgiana* are classified into two groups as shown in Fig. 3. Trees of group-a stand on ground lower than E.L. 145.80m, which is the second peak of the water surface level, and group-b trees stand above this level.

Assuming that *S.Gilgiana* can grow only when the tree appears completely above the water surface, the number of days when the water surface stays below the tree roots is an useful index for tree growth. It

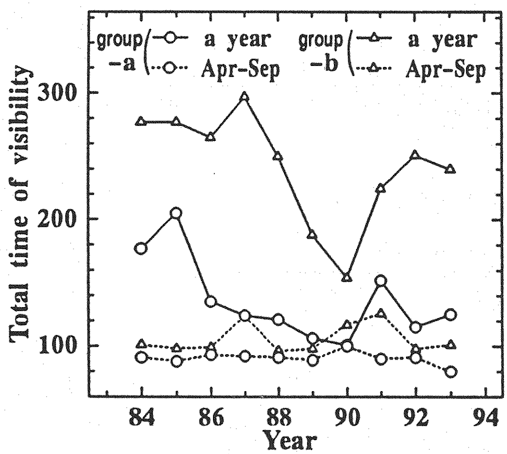

Fig.5 Number of days in which trees were visible

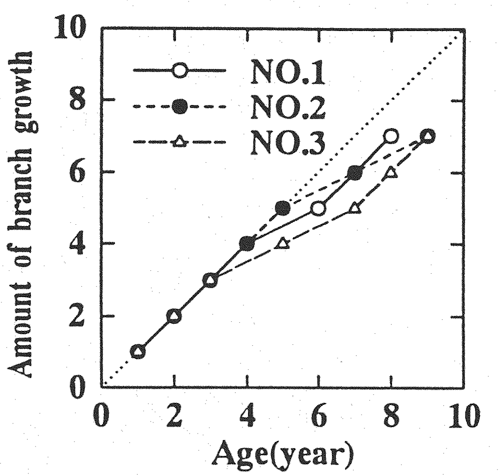

Fig.6 Age vs amount of branch growth

is called "appearance days" herein. Fig. 5 shows the "appearance days in a year(D_e)" and "appearance days during the growing season(D_g)" (from April to September). The averaged values of D_e for group-a and group-b are 137 and 243, respectively, while D_g are 100 and 106. It must be noted that the values of D_g are close to each other, but D_e are very different.

Annual growth rate

(a)Growth rate estimating from aspect

We could determine the age of tree by counting the number of annual rings. But we could not cut the same *S.Gilgiana* in order to observe growth rate in the future. Therefore we estimated the age of *S.Gilgiana* by means of the method below. Because *S.Gilgiana* grows its branch from another one which grew last year, we could think that the number of branches may correspond to the age of tree (Nakada (1)). In order to check this idea, we plotted the number of branch against the age (Fig. 6). It has some errors, but it seems that its gradient is about 1, so we could estimate the age from the number of branches.

The height of *S.Gilgiana* is a most convenient index of growth rate. Fig. 7-1 shows the relationship between the age and the height. But there are many different shapes of tree; some extend their branch not vertically but horizontally. In consideration of this, in order to estimate their growth rate, we calculated projective area which is made by the height times the width , measured from pictures. Fig. 7-2 shows the result.

From Fig. 7-1, there aren't so many difference between group-a and group-b in matter of growth rate. And we see that Fig. 7-2 does not show a difference in the growth rate, either. We draw two parabolic curve by using a least-squares estimation. These curves show that growth rate of group-b is a little greater than that of group-a.

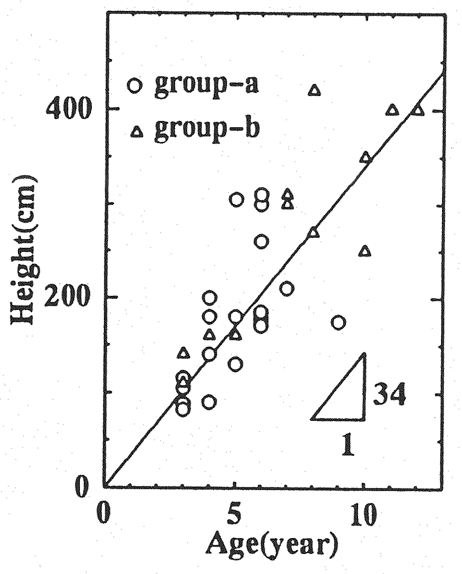

Fig.7-1 Relation between age and height

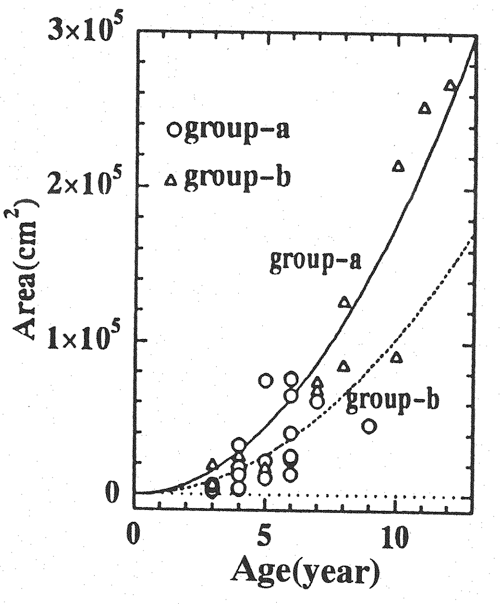

Fig.7-2 Relation between age and area

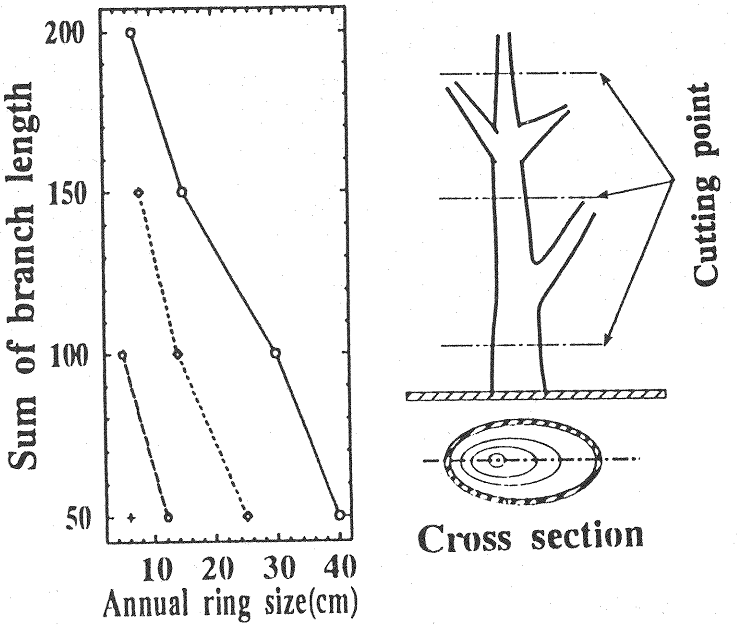

Fig.8 How to estimate the length of branch from annual ring

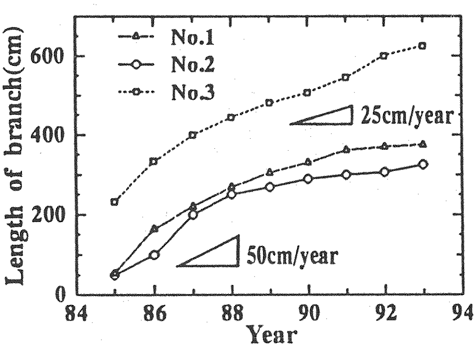

Fig.9-1 Annual growth rate (Kamafusa Reservoir)

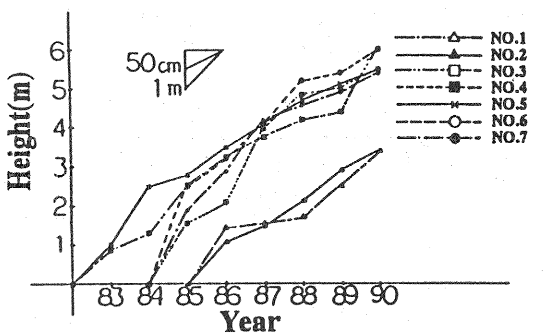

Fig.9-2 Annual growth rate (Yoshida River)

To sum up, although D_e of group-b is about two times as large as group-a, there is not so much difference of growth rate between them. On the other hand, as Fig. 5 showed above, the difference of D_g between group-a and group-b is only about 6 days. Therefore the reason why growth rate is the same between group-a and group-b is because that during the period when *S.Gilgiana* is growing up, both groups are submerged for a similar length of time.

(c) Growth rate estimating from the annual ring

The left side of Fig. 8 shows the vertical cross section of tree. The right side of Fig. 8 explains how to create this graph; at first we cut tree at branch, second measure the annual rings at cross section and then plot the sum of branch length versus the width of the annual ring. We could estimate *S.Gilgiana*'s past shape by using Fig. 8. For the longest branch we cut off, we estimate the relationship between the age and growth rate by the above method.

Fig. 9-1 shows the result. No. 1 is a member of group-a. No. 2 and No. 3 are members of group-b. Annual growth rate is about 50cm from 0 to 3 years old. For a tree older than 4 years, the annual growth rate is about 30cm. In Fig. 7-1, annual growth rate calculated from tree shape is about 34cm. This value is almost the same that is estimated from Fig. 9-1.

Comparing with ordinary *S.Gilgiana*

Takahashi (3) et al. studied the growth rate of *S.Gilgiana* at Yoshida river, which is a branch of Naruse river and is located at Miyagi prefecture. *S.Gilgiana* at growing on the river side are some times submerged in water but this does not occur very often. Therefore we compare our study with Takahashi's. Fig. 9-2 shows Takahashi's results. The annual growth rate at the river side is about 100cm from 0 to 3 years old. For above four years old, the rate is about 50cm. In comparing this with in Fig. 9-1, it seems that Kamafusa reservoir's submerged *S.Gilgiana* has growth rate half that of river side *S.Gilgiana*.

Nakada (1) et al. reported that ordinary *S.Gilgiana* flies their seeds at April, then starts extending their new branch and until middle of June grows up at about a half of annual growth amount. But *S.Gilgiana* at the Kamafuasa reservoir is submerged in water in the important growing period, from April to June. Therefore they start growing up in the middle of June when the water level is going down.

If we define the period in which *S.Gilgiana* can grow up as from April to September, at Kamafusa reservoir, they have only about a half of that period. Therefore the reason why the growth rate of *S.Gilgiana* at Kamafusa reservoir is less than that of the river side is not because of a difference in the capability of growing but due to a difference in the growing period.

CONCLUSION

The growth rate of *S.Gilgiana* at the reservoir which has a flood control function is about half that of an ordinary one. This difference corresponds days in which *S.Gilgiana* has not been submerged in water. Therefore even if they have been submerged for a long term, their capability for growing is not changed. This means that, when we plant trees at the lake side of the reservoir, it is very useful to plant *S.Gilgiana*. And, by appropriate water level control after the building of the reservoir are completed, we could encourage the growth rate.

ACKNOWLEDGMENT

This study is financially supported by a grant-in-aid, Ministry of Education, Science and Culture(Representative is Professor Shunsuke Ikeda, Tokyo Institute of Technology). And we are extremely thankful to the control office of Kamafusa reservoir, Tohoku Construction Bureau, Ministry of Construction.

REFERENCES

1. Nakada, N., K. Takahashi, and T. Ishikawa : A case study about *S.Gilgiana*'s branching in a river load, Proceeding of Annual Conference of JSCE Tohoku, pp.440-441, 1992(in Japanese).
2. Niwa, K : Protector for reservoir function(Part 3, Environment Protection), Dam Engineering, No.65, pp.20-29, 1992(in Japanese).
3. Takahashi, K., T. Ishikawa : A study about *S.Gilgiana*'s growth rate in a river load, Proceeding of Annual Conference of JSCE(part 2), pp.482-483, 1991(in Japanese).

APPENDIX-NOTATION

The following symbols are used in this paper:

D_e = number of days when *S.Gilgiana*'s root could emerge upper the water during one year;

D_g = number of days when *S.Gilgiana*'s root could emerge upper the water during from April to September;

H_f = normal level at Kamafusa reservoir in flood season that is defined as E.L. 143.80m; and

H_n = normal level at Kamafusa reservoir in non-flood season that is defined as E.L. 149.80m.

(Received January 30, 1995; revised September 13, 1996)