Jiangxi	24	26.74	18.56	14.63	11.85	9.44	7.40	5.34	3.50	1.82	0.72
Jiangsu	28	26.88	18.94	15.08	12.23	9.58	7.26	5.05	2.98	1.48	0.52
Zhejiang	14	27.74	18.27	13.94	11.51	9.51	7.27	5.24	3.63	2.03	0.86
Kuizhou	14	26.99	19.16	15.01	12.05	9.39	7.18	5.21	3.04	1.58	0.39
Tot.or Ave.	80	27.01	18.75	14.73	11.96	9.49	7.29	5.20	3.25	1.70	0.62

Structural Model of Fresh Weight of Culms

As indicateed in Table 5-6, the section at a same relative height of culms have similar percent of the total weight (Fig.5-5).

The relationship between relative height (H_x) and relative weight(W%) can be obtained by least square fitting,

$W_{\%}= 27H_x - 2.5H_x^2 + 0.08H_x^3$------- (5-31)

According to(5-31), the relative weight or actual weight of culm sections at any relative

Relation of Breast-height Diameter to Total Height and Clear Length of Culms

1. Breast height diameter and total height of culms

A, In order to determine the correlation of breast-height diameter(D) and total length(H)of culms, data collected from Damaoshan, Shimen and Yixing are fitted by least square into

$H = a+bD$, $H = aD^b$, and

$H = a+bD+cD^2$,

Damaoshan (575culmshm)

H=2.4574+1.1665D-------------- (5—32)

H=2.775D0.7179---------------- (5—33)

$H = 0.2002+1.7694D-0.038D^2$---- (5—34)

Shimen (53 culms):

H = 3.9042+0.9662D------------ (5—35)

$H = 2.469D^{0.7416}$------------------(4-36)

$H = 1.3109+1.4551D-0.0218D^2$-----(4-37)

Yixing (300 culms):

H= 2.4574 + 1.1665D------------ (5—38)

$H = 2.289D^{0.7905}$ --------------- (5—39)

$H = 0.2002+1.7694D-0.038D^2$----- (5—40)

Table 5-7a Relation of annual mean temperature and rainfall to culm height($H=aD^b$)

Locations		Chaoping	Zhungyi	Huankeng	Zhanshui	Chishui	Funxing	Damaoshan	Shimen	Yuchiashan	Tianmushan	Yixing	Xieshui	Kyoto*
An. m.tem.		19.97	19.20	17.75	16.50	18.10	17.40	17.60	15.98	15.60	14.40	15.60	15.80	16.31
An.ppt.mm		2142	1484	1880	1350	1322	1844	1800	1512	1615	1800	1320	970	1537
R/t		107.3	77.3	105.9	81.8	73.0	106.0	102.3	94.6	103.5	125.0	84.6	61.4	94.2
Expt.	a	3.035	2.519	3.109	2.291	2.524	3.042	2.775	2.469	2.975	3.109	2.289	1.892	2.250
	b	.7659	.7398	.6766	.8071	.7824	.6648	.7179	.7416	.6900	.6648	.7905	.8469	.7753
	r	0.994	0.915	0.969	0.998	0.950	0.877	0.982	0.976	0.963	0.976	0.990	0.993	0.986
Theor.	a	3.215	2.490	2.962	2.317	2.287	2.763	2.870	2.541	2.696	3.040	2.287	1.806	2.566
	b	.7154	.8012	.7194	.7933	.8135	.7386	.7297	.7517	.7263	.6648	.7803	.8467	.7529
	r	0.927	0.868	0.848	0.981	0.871	0.440	0.890	0.899	0.935	0.996	0.976	0.922	0.936

Table 5-7b Relation of annual mean temperature and clear length

Locations		Chaoping	Zhungyi	Huankeng	Zhanshui	Chishui	Funxing	Damaoshan	Shimen	Yuchiahan	Tianmuhan	Yixing	Xieshui	Kyoto*
Expt.	a_0'	-1.10	-1.00	0.000	-1.50	-1.12	-0.50	+0.50	-4.36	+0.62	-1.00	-1.11	-0.95	-
	b_0'	1.11	0.80	0.70	0.85	0.80	0.70	0.67	1.00	0.59	0.68	0.67	0.60	-
Theor.	a_t'	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
	b_t'	1.003	.7979	.8281	.6781	.7219	.8054	.8049	.6905	.6951	.6820	.6473	5945	.7057

Table 5-7c Relation of annual mean temperature and rainfall to weight of branches and leaves ($W_{bl}=c1+d_1D$)

Locations		Chaoping	Zhungyi	Huankeng	Zhanshui	Chishui	Funxing	Damaoshan	Shimen	Yuchiahan	Tianmuhan	Yixing	Xieshui	Kyoto*
Expt.	c_0'	-1.10	-1.80	2.000	-1.87	-1.14	-1.80	-1.60	-1.53	-	-2.40	-1.38	-1.30	-
	d_0'	0.94	0.73	0.85	0.78	0.65	0.74	0.72	0.83	-	0.98	0.86	0.62	-
	c_t'	-1.60	-1.60	-1.60	-1.60	-1.60	-1.60	-1.60	-1.60	-1.60	-1.60	-1.60	-1.60	-1.60
	d_t'	.9319	.7156	.8743	.7077	.6815	.8674	.8461	.7690	.8140	.9230	.7100	.6120	7723

Table 4-7d Relation of annual mean temperature and rainfall to weight of culms($W=cD^d$)

Locations		Chaoping	Zhungyi	Huankeng	Zhanshui	Chishui	Funxing	Damaoshan	Shimen	Yuchiashan	Tianmushan	Yixing	Xieshui	Kyoto*
Expt.	a_0	.1538	.1513	.1849	.1386	1008	.1594	.1566	.0959	.1467	.1614	.1527	.1000	.0906
	b_0	0.94	0.73	0.85	0.6	0.74	0.72	0.83	-		0.98	0.86	0.62	-
	r_0	.9319	.7156	.8743	.7077	.6815	.8674	.8461	.7690	.8140	.9230	.7100	.6120	.7723
Theor.	a_t	.1545	.1258	.1486	.1242	.1197	.1488	.1450	.1346	.1420	.1589	.1250	.1045	.1351
	b_t	2.2165	2.2772	2.2318	2.2864	2.2915	2.2336	2.2394	2.2629	2.2485	2.2150	2.2839	2.3262	2.2619
	r_t	0.946	0.957	0.983	0.979	0.991	0.974	0.950	0.971	0.856	0.978	0.982	0.999	0.939

Table 4-7e Relation of annual mean temperature and rainfall to weight of culms ($W=eD^f \cdot H$)

Locations		Chaoping	Zhungyi	Huankeng	Zhanshui	Chishui	Funxing	Damaoshan	Shimen	Yuchiashan	Tianmushan	Yixing	Xieshui	Kyoto*
Expt	e	.050	0600	.059	0605	.039	.052	.056	0388	0493	0519	0667	0528	.040

.	0	7		5		9	4	4						3
	f_0	1.4970	1.5034	1.4615	1.4571	1.5853	1.5212	1.4564	1.6222	1.5624	1.5431	1.3857	1.4841	
Theor.	e_t	.0482	.0505	.0502	.0519	.0523	.0506	.0518	.0524	.0527	.0536	.0531	.0535	.0520
	f_t	1.5038	1.4760	1.5124	1.4931	1.4780	1.5169	1.5120	1.5134	1.5222	1.5527	1.5055	1.4812	1.5090

note: * From Ueda,K."Studies on the Physiology of Bamboo".

Then, we calculate their standard deviation(δ).The quadric curve is the best with least error and height correlation, the power function the next, and the straight line the last. But for practical purpose, the power function equation is desirable, because it has only two parameters and resultsin much less error than the straight line, though slightly greater than the quadric curve.

According to H = aD b, we calculate a, b of regression equation for breast-height diameter and total height of culms from 13 locations and their correlation coefficient(r) as listed in Table 5-7. B. Climatic factors and height of culms

In Table 5-7, a_0 and b_0 vary with annual mean temperature(t) and precipitation(R). Their relationship is

$$a_0 = 0.1t + 0.0216\frac{R}{t} - 1.1 \quad \text{-----} \ (5\text{—}41)$$

$$b_0 = 1.0223 - 0.00286\frac{R}{t} \quad \text{-------} \ (5\text{—}42)$$

Then from

$H = a_0 D b_0$, we obtain

$$H = [0.1t + (0.0216\frac{R}{t}) - 1.1]\ D^{(1.0223-0.00286\frac{R}{t})} \quad \text{--------} \ (5\text{—}43)$$

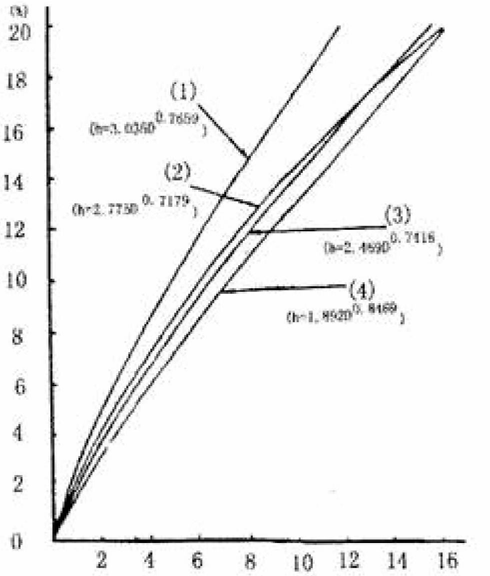

Fig.5-6 Breast-height diameter and heightof culms

(1,Chaoping 2,Damaoshan 3,shimen 4,Xiashui)

In the annual mean temperature and rainfall of an area are given to formulus(5-42),at and b_t can be calculated(Table 5-7) and the correlation coefficient(r) obtained shows that formulus(5-43) is feasible.

C. Stand density and height of culms stand density(N) influences the culm height(H). Their relationship is

$H = 0.8459N^{0.1745}D^{0.78}$ -------- (5—44)

Apparently, a denser stand always promotes height growth of culms,and a lower stand density results in a smaller height of culms.

Table 5-7 shows that the density of bamboo stands in 12 locations (except Kyoto,japan) is about 200 culms per mu, i.e. N=200 culms/mu,which can be recognized as a standard, the stand density parameter

K_N = 1, and be calculated,

$K_N = (0.8459N^{0.1745}D^{0.78}) / (0.8459 \times 2$

$000.1745D^{0.78}) = 0.3967N^{0.1745}$ -- (5—45)

D.Breast height diameter and total height of culms in different climate and different stand density. In studying the relationship between breast height diameter and total height of culms, it is necessary to consider the influence from the climatic conditions(t,R).Such a influennce can be expressed in a mathematical model by(5-43)×(5-45),

$$H = 0.3967N^{0.1745}\left(0.1t+0.0216\frac{R}{t}-1.1\right)$$

$$D^{\left(1.0223-0.00286\frac{R}{t}\right)}H = \left(3967t+857\frac{R}{t}-43637\right)$$

$$10^{-5}N^{0.1745}D^{\left(10223-28.6\frac{R}{t}\right)}10^{-4}\text{------}(5\text{-}46)$$

2. Breast height diameter and clear length of culms

A. The correlation of breast height diameter and clear length of culms is straight line(Fig.5-8)

$H_{cl}=a'+b'D$-------------(5-47)

Based on the data collected from 12 locations, a'and b'can calculated and listed in Table 5-7.

B. Climatic factors and clear length of culms From Table 5-7, a' values, except -4.36 for Shimen, are about -1, is related to the annual mean temperature and precipition,b'=0.66Rt2.Giving a' and b' values to (5-47) we obtain

$H_{cl}=(0.667Rt^2 10^{-6}+0.433)D-1$--(5-48)

According to (5-48),a'and b'of these location are iven. Results obtained from such an equation only slightly different as compared with the actual values.

C. Stand density and clear length of culms In an area,the denser stand,the longer clear length of culms.Their relation is

$H_{cl} = 0.0398N^{0.4668}$-----------(4-49)

As seen in Table 5-7,the stand density of 12 districts is about 200 culms per mu.We take N=200 culms/mu as a standard stand,i.e $K_N = 1$, and calculate K_N as follows,

$K_N = (0.0398N^{0.4668}D)/(0.0398\times200D^{0.4668} = 0.0843N^{0.4668}$ --------------(5-50)

D. Brestheight diameter and clear length of culms in different climate and different stand density. The mathematical model for brest-height diameter and clear length of culms can be constructed in relation to the climation conditions:

$H_{cl} = 0.0843N^{0.4668}(0.667Rt^2 10^{-6}+ 0.433)D-1 = (562Rt^2 10^{-10}+365\times10^{-4})N^{0.4668}D-1$---(5-51) As expressed in (5-51),the greater stand density,the larger brest-height diaameter and the longer is the clear length of culms. This fact indicates that with fair increase in the density of bamboo stands, not only the culm production increases,but the qulity of culms is greatly improved.

Reation of Brest height Diameter to Fresh Weight of Culms and Branch leaves

1. Breast-height diameter and culm weight

A.The fresh weight of culms is corrlated to the brest-height, that is the greater the diameter, the heavier the weight(Fig.5-7).

According to equations of $W = a+bD$, $w = cD^d$ and $W = a+bD = cD^2$, we calculate the data collected from damaoshan, Shimen and Yixing as follows. Daimaoshan(575 culms):

$W = 5.1193D-25.809$----------(5-52)

$W = 0.1566D^{2.1743}$ ------------(5-53)

$W = 0.2706D^2-0.369D^{-0.1282}$---(5-54)

Shimen(53 culms)

$W = 6.2079D-37.957$----------（5-55）

$W = 0.0959D^{2.3638}$ -------------(5-56)

$W = 0.4468D^2-3.7074D+14.4193$--(5-57)

Yixing(300 culms)

$W = 3.8493D-15.6926$----------(5-58)

$W = 0.1527D^{2.1756}$ -------------(5-59)

$W = 0.2825D^2-0.6312D+1.0815$---(5-60)

The standard deviations obtained show that the quadric curve is the best with the least error,the power function the next,and the straight line the last.But for practical purpose,W=cDd is desirable.It has only two parameters and results in much less error than the straight line,though slightly greater than the quadric curve.

According to $W=cD^d$,we caculate c,d for breast-height diameter and total weight of culms from 13 locations and correlation coefficient(r) as listed in Table 5-7 and Appendix

B. As indicated in Table 5-8, the parameter c increases with increase in annual mean temperature (t) and rainfall index(R/t). Their relationship is

$$c = 0.0163+0.00208t+0.000901\frac{R}{t}$$

$= (163 + 20.8t + 9.01\frac{R}{t})10^{-4}$ -- (5—61)

But the parameter d decreases with increase in annual mean temperature (t) and rainfall index($\frac{R}{t}$).Their relationship is:

$d = 2.53055 - 0.005648t - 0.001874\frac{R}{t}$

$= (253005 - 564.8t - 187.4\frac{R}{t})10^{-5}$--(5-62)

From (5-61) and (5-62),the relation of culm weight (w) to annual mean temperature (t)rainfall index(R/t) can obtained.

$$W = (163 + 20.8t + 9.01\frac{R}{t})10^{-4}D^{(253055 - 564.8t - 187.4\frac{R}{t})10^{-5}}$$ ------------------------(5-63)

Accordingly on the basis of t and R/t,ct, dt,and r can be calculated and listed in Table 4-7.As indicated in r values, the difference is not significant.Consequently (5-63)is feasible to calculate the relation of breast-height diameter to culm weight in connection with the climaticfactors(t,R).

2.Brest height diameter and fresh weight of branches and leaves

A.In general,weight of branches is relatively stable, but the weight of leaves varies considerably with season and leaf age.Thus the weight of branches and leavesappears to change greatly in accordance with seasons,leaf age and on or off year. Apparently the weight of branches and leaves increases with increase in brest height diameter of culms. Their relationship is expressed by Wbl= c′+ d′Dand c′,b′ can be calculated and listed in Table 5-7.

B.Climatic factors and branch leaf weight of culms As indicated in Table 5-7c′ is about -1.6 in average,d′ is related to t and R and can be written as follows

$d' = 0.188X10^{-5}R^2\frac{1}{t} + 0.5$---------(5-65)

If c′,d′ values given to (5-64), the relation of branch leaf weight to annual mean temperature and rainfall index(R/t) can be obtained.

$W_{bl} = (0.188X10^{-5}R^2\frac{1}{t} + 0.5)D - 1.6$---(5-66)

C.Stand density and branch

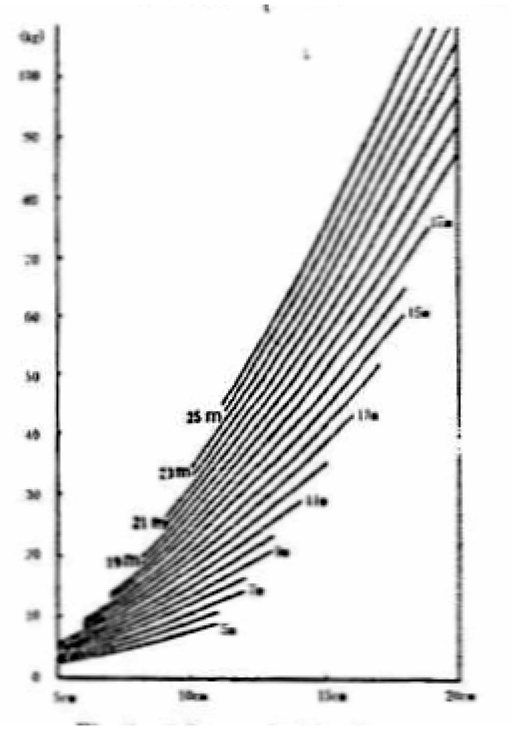

Fig.5-7 Brest-height diameter and weight of culms
(1.Damaoshan 2.Zhaoping 3.Xiashu)

leaf weight Generally, the greater stand density, the smaller branch- leaf weight of individual culms.

Their relationship is

$W_{bl} = 2.5998N^{-0.4}03D^{1.25}$ ----(5-67)

In Table 5-7,the stand density in 12 locations is about 200 culms per mu.We use N=200 culms/mu as a standard density to calculate K_N,

$K_N = (2.5998N^{-0.4030}D^{1.25}) / (2.5998X200 - 0.4030D^{1.25})$

$= 6.759N^{-0.4030}$----- (5—68)

D. Under different climatic conditions a mathematical model can be constructed to express the relationship between brest height diameter and branch leaf weight in different stand density

$W_{bl} = 6.759N^{-0.4030}(0.188X10^{-5}R^2\frac{1}{t} + 0.5)$

D-1.6

$W_{bl} = (1.2707X10^{-5}R^2\frac{1}{t} + 3.3795)$

$N^{-0.4030}D - 1.6$------------------(5-69)

3.Breast height diameter,height and weight of culms

The weight of culms always increases with increase in their breast height diameter and height. If culms are same in diameter at breast height,their weight increases proportionally with their height.In the case of same height,however, the increase of culm weight is not proportional to the breast height diameter, but follows a power function curve.Thus,their relationship can be expressed by

$W = eD^fH$----------------------(5-70)

From $W=cD^d$ and $W=cD^b$, e,f can be calculated.

$\because$ W=eDfH, $W=cD^d$,$H=aD^b$

$\therefore$ $W = eD^fH=cD^d$,

$eD^f \times aD^b=cD^d$ $eD^f=cD^d/aD^b=cD^{(d-b)}/a$

$\therefore$ e=c/a, f=d-c

$\because a = 0.1t+0.0216\frac{R}{t}-1.1$;

$b = 1.0223-0.00286\frac{R}{t}$;

$c = 0.0163+0.00208t+0.000901\frac{R}{t}$;

$d=2.53055-0.005648t-0.0001874\frac{R}{t}$

$\therefore$ $e = (0.0163+0.00208t\ R^2\frac{1}{t}+0.5)+0.000901\frac{R}{t})$

$/(0.1t+0.0216\frac{R}{t}-1.1) = (2t+\frac{R}{t}+8)/$

$(100t+20\frac{R}{t}-920$-------------(5-71)

$f= (2.53055-0.005648t-0.001874\frac{R}{t})$

$-(1.0223-0.00286\frac{R}{t})$

$=(150825-564.8t+98.6\frac{R}{t})10^{-5}$--(5-72)

Giving e,f values to $W=eD^fH$,we obtain the relation of culm weight to breast-height diameter (D) and height(H) with reference to annual mean temperature (t) and rainfall index(R/t):

$W =$ [$(2t+\frac{R}{t}+8)/(100t+20\frac{R}{t}-920)$]

$HD^{(150825-564.8t+98.6\frac{R}{t})10-5}$-----------(4-73)

Accordingly giving t and $\frac{R}{t}$ of different districts to (5-73),e,f of their theoretical regression equation can be calculated and listed as in Table 5-7. From the standard deviation and standard error between the theoretical value and actual value, the difference is not significent generally.Thus,the (5-73) is feasible to express the relation of culm weight to breast-height diameter and height in connection with the influence of annual mean temperature and precipitation.

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Appendix:

Reation of Brest-height diameter to Fresh Weight on Types I of Bamboo stand

Brest-height diameter(cm)		5	6	7	8	9	10	11	12	13	14	15
	0.0	4.3	6.6	9.54	13.0	17.2	22.1	27.7	34.0	41.1	49.0	57.8

Fresh Weight (kg)		1	6		8	7	6	6	6	9	9	0
	0.2	4.71	7.16	10.19	13.86	18.20	23.23	28.96	35.49	42.72	50.76	59.61
	0.4	5.17	7.72	10.88	14.68	19.14	24.31	30.21	36.85	44.27	52.48	61.49
	0.6	5.47	8.30	11.58	15.52	20.23	25.43	31.48	38.27	45.84	54.23	63.39
	0.8	6.11	8.91	12.31	16.39	21.13	26.58	32.78	39.72	47.46	56.01	65.37

Reation of Brest-height diameter to Fresh Weight on Types II，III of Bamboo stand

Brest-height diameter(cm)		5	6	7	8	9	10	11	12	13	14	15
Fresh Weight (kg)	0.0	5.12	7.62	10.65	14.24	18.40	23.13	28.47	34.46	40.93	48.10	55.89
	0.2	5.58	8.18	11.32	15.02	19.30	24.00	29.60	35.66	42.33	49.61	57.50
	0.4	6.06	8.77	12.02	15.84	20.22	25.20	30.76	36.94	43.72	51.15	59.17
	0.6	6.56	9.37	12.72	16.66	21.17	26.26	31.96	38.25	45.15	52.71	60.86
	0.8	7.07	10.00	13.48	17.52	22.14	27.35	33.17	39.58	46.62	54.29	62.59

（This text source: 《Journal of Nanjing Technological College of Forest Products》,1981,No.1)