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Study of the regular pattern of geography variation and selection of *Phyllostachys heterocycla* cv. *pubescens* provenances

CHEN CUN-JI *, LIANG YI-CHI and QIU ER-FA

Forestry College of Fujian Agricultural and Forestry University, Nanjing 353001, China

Abstract—Mother bamboos from 16 *Phyll. pub.* provenances in 8 provinces in the spring of 1995 were selected for a provenances trial in Jian'ou city and Hua'an country. Over 5 years, according to the observation of more than 70 indexes, including bamboo shoot growth of different provenances the structure of spring shoot nutrition and physiological indexes, and using mathematical genetics theories and skills, the results show that there are obvious geographical variations of *Phyll. pub.* provenances. The numbers of spring shoots in the south are greater than in the north, but the reverse is true for the diameter and height. According to the synthetic evaluation, the provenances of Wuyi Mountain Jian'ou Shaxian in Fujian and Shangrao city in Jianxi are better than others, and there is significant genetic improvement.

Key words: Phyllostachys pubescens; provenances trial; regular pattern of geography variation; provenances selection.

1. INTRODUCTION

Species variation is an essential component in the development and evolut of living creatures. The genetic phenomenon exists generally, and it is hered that has stabilized and preserved living beings. Through more than 100 ye examination of provenances has been regarded as important by countries all o the world, and has confirmed that most tree species exhibit geographic variati which shows that there are genetic variations among different provenances. This played a very important role in selecting fine provenances and gaining signific genetic strength [1–3]. For example, Professor Yu Xin-tuo of Fujian Forest Colle launched a provenances trial of *Pinus mossoniana* in the Sanming city of Fuj

*Chen Cun-Ji is the director of Fujian Forestry and Agriculture University in China, and is enga in forestry research specializing in bamboo. E-mail: lcxshx0175@hotmail.com

Table 1.
Geographical location of *Phyllostachy heterocycla* cv. *Pubescens*

No.	Provenance	Latitude (°)	Longitude (°)	Elevation (m)	No.	Provenance	Latitude (°)	Longitude (°)	Elevation (m)
1	*Jurong Jiangsu*	31.9	119.14	280	9	*Lechang Guangdong*	25.2	113.40	600
2	*Yixing Jiangsu*	31.3	119.79	340	10	*Conghua Guangdong*	23.5	113.60	100
3	*Huoshan Anhui*	31.4	116.29	320	11	*Wuyi Fujian*	27.9	118.03	430
4	*Wuhan Hubei*	30.5	114.32	230	12	*Songxi Fujian*	27.6	118.78	400
5	*Zhuzhou Hunan*	28.0	113.18	200	13	*Jianou Fujian*	27.1	118.33	280
6	*Juxian Zhejiang*	28.9	118.88	280	14	*Shaxian Fujian*	26.4	117.83	250
7	*Jiujiang Jiangxi*	29.7	115.90	300	15	*Huaan Fujian*	25.0	117.54	280
8	*Shangrao Jiangxi*	28.5	117.99	370	16	*Longhai Fujian*	24.4	117.64	170

shape, and the standard plant hole was $1.2 \times 0.6 \times 0.5\ m^3$, around which there was a ditch dug, 0.7 m thick that was cleaned once every year, to prevent the rhizome from extending between groups. After afforestation, tending measures should assist with the blocks, including enlarging the plant hole and getting rid of grasses twice and fertilizing once every year.

3. INVESTIGATION AND ANALYSIS OF DATA

3.1. Investigation of the growth properties

3.1.1. The investigation of underground rhizome. The diameter of the new rhizome, the length, the amounts of rhizome bud, and branch rhizome, the amount of rhizome node with 1 m, and rhizome area were investigated from three bamboo specimens of every provenance.

3.1.2. Observation of phenological period of spring shoots. This investigation included bamboo shooting period, amount, and the height and diameter of the spring shoot, and so on from 1996 to 1999.

3.1.3. Investigation of the new bamboo. During 4 years from 1996 to 1999, the height, diameter, the number of bamboo shoots and branches, the height of the culm under the lowest branch, and the number of new bamboo plants were recorded, and, taking into account the respective heights and diameters, the fresh weight of bamboo could be calculated.

3.1.4. The biomass investigation of new bamboo branches and leaves. Two or three average growth bamboos were selected from every provenance as judged by the height and diameter. In the middle of each a branch was selected to investigate the amount of leaves, and the weight of leaves and branches in the last ten-day period of May and December, the mid part of July and November, and the first ten-day period of October.

3.1.5. Differentiation of provenance bands. The region above 30° North latitude belongs to the North band, that under 25° to the south band, and that in between 25° and 30° to the middle band.

3.2. Disease and pest investigation

The disease and pest of new bamboo in 1995 and 1996 and of mother bamboo from different provenances were investigated. From 30 bamboos the leaves were drawn, respectively from the upper, middle and lower parts of the individual bamboo. These leaves were ranked as follows: generally non-harmful square, harmful square less than one-fourth, between one-fourth and one half, between one half and three-fourth, and more than three-fourth. These data were recorded statistically.

4. RESULTS AND ANALYSIS

4.1. Trend surface analysis of geographic variation in diameter of new bamboo

Trend surface analysis is a statistical method of fitting a mathematical surface, which was calculated to fit trends in changes in data with respect to different regions; that is, the mathematical surface was the trend surface (please see the note at the end).

The results of trend surface analysis of diameter of new bamboo of different *Phyll. het.* cv. *pub.* provenances showed (Fig. 1) that the character of new bamboo diameter by one-time fitting of geographic variation changed gradually from northwest to southeast. (A one time fitting means that the one-time trend surface is shown by the one-time mathematic equation of trend face fitting; a two-time fitting is shown by the two-time mathematic equation.) A two-time trend surface showed a 'U' shape that changed from north to south, and a three-time or four-time trend surface presented two relatively independent geographical groups, which were a northeast group and a southwest group: in those groups the diameter changed gradually from the centre to the surround, and was thicker in the northeast than in the southwest.

4.2. Estimation of the genetic parameter

Heredity, repeatability and hereditary toner were the important genetic parameters of quantity characteristics, and which help to acquire the genetic reference, to definite the methods of selection, to evaluate the selection effect and to draw up an important plan and breeding scheme. In the past years [7, 8], there were no reports of the genetic parameter of *Phyll. het.* character, which was studied with duplicated data in this paper.

Heredity refers to the ability of a parental generation to pass genetic characteristics to the next generation in biology, and reflects the quality of the parental generation. But there is no heredity between the original plant and the offspring plant in the case of vegetative propagation, only the relation of the original and the clone plant that inherits all the genetic properties of the original plant. It is not appropriate to express the genetic transmission ability between the original and the clone by heredity, but suitable to express it by the repeatability.

Repeatability refers to the degree of persistence stabilization of the characteristics of each separate plant with identical genotype in different time or different place. As we all know, the growth of different individuals with identical genotypes varies with the different effects of vegetative propagation except for the effects of soil and so on in different environments. Repeatability is applied in quantity heredity to measure the degree of the effects of environment on different clones.

The diameter, height, length of rhizome, numbers of root buds and indexes of whole disease and worm had higher repeating ability, $R_C = 0.64–0.86$, $R_I = 0.39–0.67$. The repeating ability of diameter was fairly stable, which was 0.7156, 0.7347, and 0.7171, respectively, in 1997, 1998, and in 1999. Economic character,

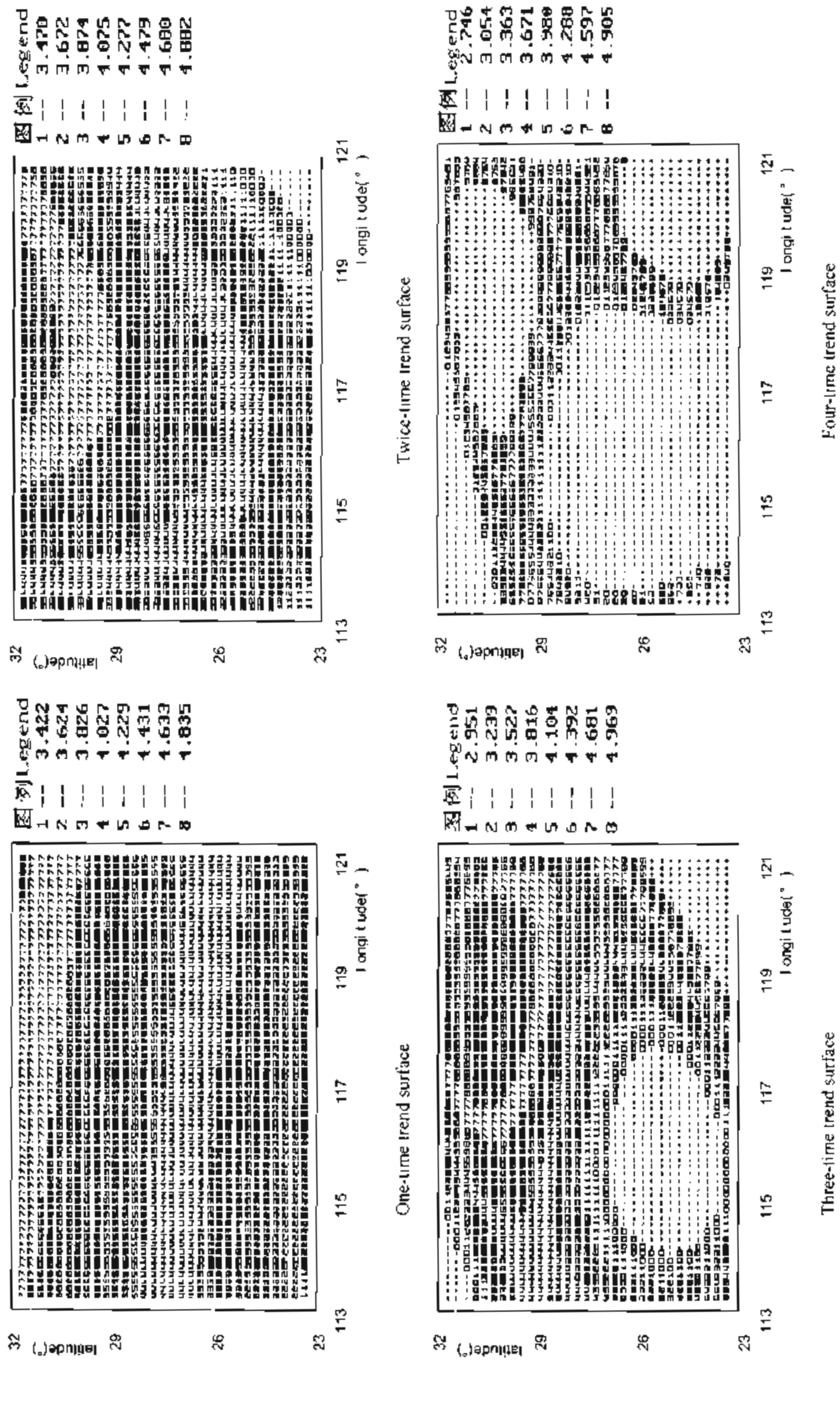

Figure 1. Trendface of mew bamboo's DBH of different provenances fitted from 1 to 4 time; unit: cm; top is North.

based on the weight of bamboo and bamboo shoot, had mid-repeating ability. But the height under the lowest branch and the numbers of branches had lower repeating ability (Table 2). Hence, selecting the finest clone to enlarge propagation is the main way of improving the output in a unit area.

4.3. Synthetic evaluation and selection of multi-properties

4.3.1. Selection of fine provenance of shoot-producing bamboo. According to shoot output and quality, the provenances of the shoot-producing bamboo were selected by cluster analysis. When $\lambda = 1.00$, 16 *Phyll. het.* cv. *pub.* provenances were classified into 5 classes, as follows: ① 7, 11, 13, 14; ② 1, 2, 9; ③ 3, 6, 5, 8, 12; ④ 4, 10, 16; ⑤ 15. Among these, the first class including Jian'ou, Wuyi Mountain, and Shaxian in Fujian and Jiujiang in Jiangxi were the best (Fig. 2).

4.3.2. Selection of the fine provenance of culm-producing bamboo. There were three characteristics (the weight of the individual bamboo, the whole weight, and average amount of new bamboo) that could reflect the output. The growth character including height, height of under branch, the number of branches, and diameter reflected the quality and output. Those characters were important indices to select the finest culm-producing bamboo. The method of multi-principle components of hereditary indexes was adopted to select better culm-producing *Phyll. het.* cv. *pub.* provenances (Table 3–Table 7). According to the value of the principal components evaluated synthetically, 16 provenances were classified into 4 classes, as follows: ① 1, 2, 3, 4; ② 5, 6, 7, 8, 9, 10; ③ 11, 12, 13, 14; ④ 15, 16. Among these, the first class including Jian'ou, Wuyi Mountain, and Shaxian in Fujian and Huoshan Mountain in Anhui were better than others (Table 8), and whose genetic improvement of average diameter was 12.07%, and of weight was 19.59%.

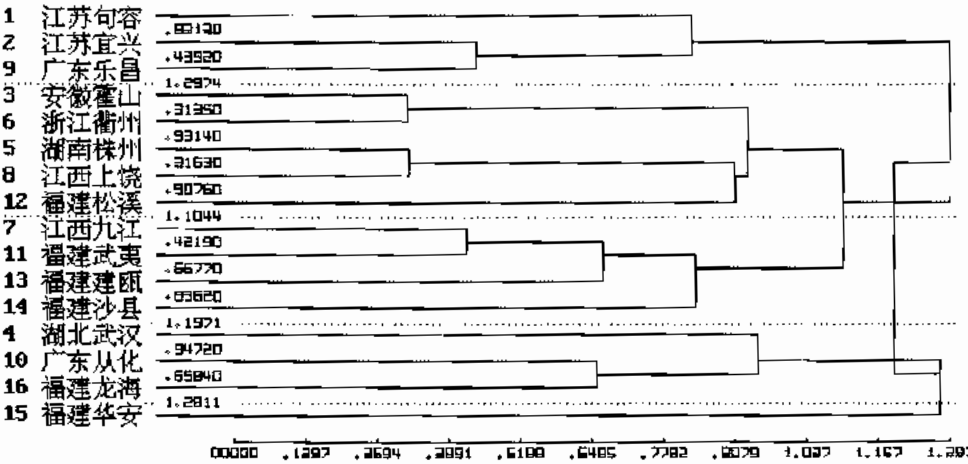

Figure 2. Synthetic cluster analysis of shoot output and quality.

Table 2.
The genetic parameters of *Phyllostachy pubescens* provenances

Characters	Genetic variance	Environmental variance	Phenotypic variance	Repeating ability of the clones	Repeating ability of the individual
Numbers of average bamboo shoot in 3 years	0.048058	0.505329	0.553387	0.2220	0.0868
Numbers of average new bamboo in 3 years	0.020152	0.216843	0.236995	0.2180	0.0850
Weight per area in 3 years	1533.833	14476.77	16010.6	0.2412	0.0958
Numbers of whole bamboo shoots in 3 years	11.250000	73.38333	84.63333	0.3150	0.1329
Numbers of whole new bamboo in 4 years	12.823610	47.6125	60.43611	0.4469	0.2122
Numbers of whole new bamboo in 5 years	22.197180	23.3181	45.51528	0.7406	0.4877
Whole weight per area in 1996	21.295170	94.67816	115.9733	0.4029	1.1836
Individual weight in 1996	0.018629	0.069211	0.087840	0.4467	0.2121
Numbers of new bamboo in 1996	1.246286	1.349629	2.595914	0.7348	0.4801
Diameter in 1997	0.302273	0.360384	0.662658	0.7156	0.4562
Numbers of bamboo shoots in 1998	4.445988	13.80507	18.25106	0.4914	0.2436
Whole weight per area in 1998	857.4256	4913.207	5770.633	0.3436	1.1486
Individual weight in 1998	0.605929	0.653522	1.259451	0.7356	0.4811
Height in 1998	0.287749	0.297285	0.585034	0.7438	0.4918
Diameter in 1998	0.315095	0.344886	0.659980	0.7327	0.4774
Numbers of new bamboo in 1998	1.303402	7.893930	9.197331	0.3313	0.1417
Whole weight per area in 1999	29.01676	4774.808	4803.825	0.0179	0.0604
Individual weight in 1999	0.941367	1.597452	2.538819	0.6387	0.3708
Height of the culm under the lowest branch in 1999	0.016279	0.182746	0.199025	0.2109	0.0818
Numbers of branch in 1999	0.648441	7.503637	8.152078	0.2059	0.0795
Height in 1999	0.122266	1.055420	1.177686	0.2579	0.1038
Diameter in 1999	0.337298	0.399178	0.736476	0.7171	0.4580

Table 2.
(Continued)

Characters	Genetic variance	Environmental variance	Phenotypic variance	Repeating ability of the clones	Repeating ability of the individual
Length of root in 1999	246.2942	120.8132	367.1074	0.8595	0.6709
Numbers of root buds in 1999	1.867945	2.926946	4.794892	0.6569	0.3896
Root thick in 1999	0.047538	0.206482	0.254020	0.4085	0.1871
Fuliginous disease	60.19866	254.4981	314.6967	0.4151	0.1913
Acarid of leaf	18.66281	114.755	133.4178	0.3279	0.1399
Indexes of whole disease and worm	68.4554	113.5634	182.0188	0.6439	0.3761
Average bamboo shoot weight	9.942769	63.95542	73.89819	0.3181	0.1345

Table 3.
Correlation coefficient matrix of phenotypic and genetic parameters

Character	Diameter	Weight	Numbers of new bamboo
Diameter	0.487915	0.939280	−0.256434
Weight	0.999883	0.361957	−0.235087
Numbers of new bamboo	−0.684725	−0.585377	0.241533

Table 4.
Genetic variance and covariance matrix

Character	Diameter	Weight	Numbers of new bamboo
Diameter	0.39674	0.63815	−1.17636
Weight	0.63815	0.98682	−1.58608
Numbers of new bamboo	−1.17636	−1.58608	7.43943

Table 5.
Phenotypic variance and covariance matrix

Character	Diameter	Weight	Numbers of new bamboo
Diameter	0.81314	1.39852	−1.28334
Weight	1.39852	2.72635	−2.15428
Numbers of new bamboo	−1.28334	−2.15428	30.80089

Table 6.
The economic weight vectors

Diameter	Weight	Numbers of new bamboo
0.6206513	0.6011384	0.5034131

Table 7.
The genetic improvement matrix of each character

Diameter	Weight	Numbers of new bamboo
0.90765	1.46161	−3.67932

Table 8.
Integrated evaluation of good provenances election for timber-used of *Phyllostachys heterocycla* cv. *Pubescens*

Order	provenance	Diameter (cm)	Value of standard gene type	Effective value of gene type	Hereditary toner (%)	Weight (kg)	Value of standard gene type	Effective value of gene type	Hereditary toner (%)
1	*Jianou Fujian*	6.0933	17.47	1.87	17.79	7.1022	11.85	2.45	32.82
2	*Shaxian Fujian*	5.7233	16.89	1.29	12.21	5.7409	10.48	1.08	14.46
3	*Wuyi Fujian*	5.7400	16.91	1.31	12.46	6.1642	10.91	1.51	20.17
4	*Huoshan Anhui*	5.3000	16.22	0.61	5.83	5.4781	10.21	0.81	10.91
5	*Songxi Fujian*	5.5933	16.68	1.08	10.25	5.6336	10.37	0.97	13.01
6	*Jurong Jiangsu*	5.0933	15.89	0.29	2.71	5.0562	9.79	0.39	5.22
7	*Juxian Zhejiang*	5.3000	16.22	0.61	5.83	4.7787	9.51	0.11	1.48
8	*Jiujiang Jiangxi*	5.3500	16.29	0.69	6.58	5.6311	10.37	0.97	12.98
9	*Yixing Jiangsu*	4.5967	15.10	−0.50	−4.78	4.1642	8.89	−0.51	−6.81
10	*Zhuzhou Hunan*	4.5867	15.08	−0.52	−4.93	4.0175	8.74	−0.66	−8.79
11	*Shangrao Jiangxi*	4.7733	15.38	−0.22	−2.11	4.4013	9.13	−0.27	−3.61
12	*Longhai Fujian*	4.3300	14.68	−0.93	−8.80	3.4926	8.22	−1.18	−15.87
13	*Wuhan Hubei*	4.3767	14.75	−0.85	−8.09	3.4131	8.14	−1.26	−16.94
14	*ConghuaGuangdong*	4.4700	14.90	−0.70	−6.69	4.1832	8.91	−0.49	−6.56
15	*Huaan Fujian*	3.8000	13.83	−1.77	−16.79	2.6551	7.37	−2.03	−27.17
16	*LechangGuangdong*	3.4900	13.34	−2.26	−21.46	2.7933	7.51	−1.89	−25.31
Average value of the first class		5.7141	16.87	1.27	12.07	6.1214	10.86	1.46	19.59
Average value of the second class		5.0866	15.88	0.27	2.61	4.8802	9.61	0.21	2.85
Average value of the third class		4.4875	14.93	−0.68	−6.42	3.8725	8.60	−0.80	−10.75
Average value of the fourth class		3.8000	13.83	−1.77	−16.79	2.6551	7.37	−2.03	−27.17

Table 8.
(Continued)

Order	Number of new bamboos	Value of standard gene type	Effective value of gene type	Hereditary improvement (%)	Value of principal components	Indexes of hereditary selection	Synthetic evaluation
1	13.58	9.94	0.02	0.21	8.1301	9.00	high-yield
2	10.62	8.85	−1.07	−10.50	7.7279	8.62	high-yield
3	12.84	9.67	−0.25	−2.47	7.6414	9.44	high-yield
4	8.40	8.04	−1.88	−18.52	7.6235	7.68	high-yield
5	13.83	10.03	0.11	1.11	7.2349	8.76	mean-yield
6	10.37	8.76	−1.16	−11.39	7.1073	9.85	mean-yield
7	10.62	8.85	−1.07	−10.50	7.1011	8.61	mean-yield
8	15.32	10.57	0.66	6.47	6.9119	7.91	mean-yield
9	8.39	8.04	−1.88	−18.53	6.6907	5.61	mean-yield
10	8.15	7.95	−1.97	−19.42	6.6574	6.66	mean-yield
11	16.79	11.12	1.20	11.81	5.9177	9.56	low-yield
12	14.32	10.21	0.29	2.89	5.5848	9.51	low-yield
13	16.79	11.12	1.20	11.81	5.2976	9.61	low-yield
14	21.49	12.84	2.92	28.76	5.1043	10.18	low-yield
15	17.78	11.48	1.56	15.38	4.5395	6.58	lowest-yield
16	17.09	11.23	1.31	12.88	4.4802	7.76	lowest-yield
Average value of the first class	11.36	9.12	−0.79	−7.82	7.7807		
Average value of the second class	11.11	9.03	−0.88	−8.71	6.9506		
Average value of the third class	17.35	11.32	1.40	13.82	5.4761		
Average value of the fourth class	17.78	11.48	1.56	15.38	4.5395		

Table 9.
Synthetical evaluation of multi-characteristics from 16 provenances

Class	Evaluation	Number of provenance
I	Excellent	11, 14, 13
II	Good	8
III	Middle	12, 7, 1, 2, 3
IV	Poor	5, 6, 4
V	Poorer	16, 10, 9, 15

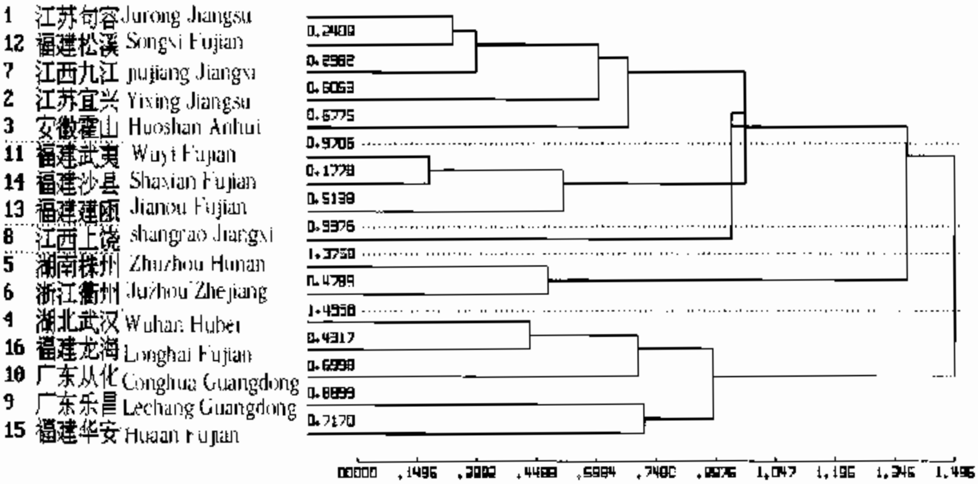

Figure 3. The cluster analysis figure of multi-properties.

4.3.3. Selection of fine culm and shoot-producing bamboo. The shoot output and quality, the bamboo wood output, the growth properties of bamboo and the resistance character were analyzed by synthetic cluster analysis to select the best culm and shoot-producing bamboo provenances [9]. We could see from Fig. 3 and Table 9 that the results had 5 classes among which the first and second classes were better than others. It was the provenances of Jian'ou, Wuyi Mountain, and Shaxian in Fujian and Jiujiang in Jiangxi, and the genetic toners were significant. Strong resistance was important in selecting the fine provenances. From Table 10 it is shown that four selected provenances were superior to others in resistance, and the average value of selected provenances was lower than that of the colony, by 24.93%–63.37% than the average value. The superior character of the shoot is shown in Table 11. The average weight of bamboo shoot in 3 years and the individual shoot weight in selected provenances was higher than that of the colony by 17.21%–16.42%. The properties of bamboo substances and growth of selected provenances bamboo was superior to the others (Table 12). There was a higher content of aminophenol in selected provenances bamboo shoot; especially, the average value of 8 aminophenols necessary to human nutrition in selected

Table 10.
The effecting of selected fastness

Character	Average value of selected choiceness provenances	Average value of colony	Toner (%)
Acarid of leaf	11.83	19.17	−38.28
Noctuid of bamboo shoot	2.64	3.52	−24.93
Coccid	1.68	4.58	−63.37
Fuliginous disease	16.63	22.70	−26.73

Table 11.
The effecting of selected shoot

Character	Average value of selected choiceness provenances	Average value of colony	Toner (%)
Average weight of bamboo shoot in 3 years	25.75	21.97	17.21
Shoot weight each one	1.56	1.34	16.42

Table 12.
The characteristics of selected material

Character	Average value of selected choiceness provenances	Average value of colony	Toner (%)
Height	7.63	7.27	5.00
Diameter	5.58	4.91	13.65
Numbers of scourge buds	5.13	4.99	2.81
Scourge thick	2.44	2.31	5.63
Scourge length	0.86	0.80	7.50
Weight each one	5.85	4.67	25.27
Whole weight in 4 years	74.12	61.37	20.78
Average numbers of new bamboo	4.54	4.56	−4.49

provenances was higher than that of the colony by 15.07 % (Table 13). Also, higher protein, deoxidised sugar, and general sugar content is shown in Table 14.

5. CONCLUSION AND DISCUSSION

(1) This paper was the first to develop a trial of *Phyll. het.* cv. *pub.* provenances internationally, and to report on the geographical variation of different provenances. The results showed that the numbers of bamboo shoots in the south was higher, and that the diameter and height of new bamboo in the north were higher than others.

(2) It was shown that different provenances had obvious geographical variation trend by trend face analysis.

Table 13.
The characteristics of selected aminophenols

Character	Average value of selected choiceness provenances	Average value of colony	Toner (%)
Aspartic	5.7500	5.5631	3.36
Threonine※	2.0550	1.7000	20.88
Serine	2.2575	1.9738	14.38
Glutamic acid	4.5625	4.2650	6.98
Glycin	1.9475	1.9781	−1.55
Alanine※	1.4475	1.3625	6.24
Cystine△	8.7375	7.0444	24.04
Valine※	3.7725	3.0719	22.81
Methionine	0.7350	0.6775	8.49
Isoleucine※	1.8375	1.4988	22.60
Leucine※	3.0075	2.5519	17.85
Tyrosine△	5.0900	4.3269	17.64
Phenylalanine※	2.0575	1.9325	6.47
Lysine※	2.0225	1.8056	12.01
Histidine※	1.1975	1.0131	18.20
Arginine	2.1450	1.6563	29.51
Proline	1.7525	1.4744	18.86

Table 14.
The nutritional content of selected provenance

Character	Average value of selected choiceness provenances	Average value of colony	Toner (%)
Protein	2.2675	2.2637	0.17
Amylum	1.1050	1.1359	−2.72
Deoxidize sugar	1.0800	1.0705	0.89
General sugar	2.1350	2.1287	0.29
Coarse-fibre	0.6025	0.6158	−2.15

(3) Four superior provenances were selected according to the character of the weight of per shoot. There were Jian'ou, Wuyi Mountain, and Shaxian in Fujian and Jiujiang in Jiangxi. Average hereditary toner was 11.5%.

(4) Cluster analysis was adopted to analyze shoot output and nutrient contents from different provenances. The result showed that 16 provenances were classified into 5 classes, and the first class, including the provenances of Jian'ou, Wuyi Mountain, and Shaxian in Fujian and Jiujiang in Jiangxi, was better than others.

(5) By synthetic analysis of several properties that included shoot output and quality and bamboo wood output, the growth properties and resistance were assessed. The result showed that 16 provenances were classified into 5 classes, and Jian'ou, Wuyi Mountain, and Shaxian in Fujian and Shangrao in Jianxi produced a superior provenance of the culm and shoot-producing bamboo.

(6) Four provenances of culm and shoot-producing bamboo were selected according to the initial stage result of the provenances trial, which was distributed in the south of Wuyi Moutain.

(7) This study collected 16 provenances from 8 provinces, and every provenance came from just onc forest depot of one city. It needs further investigation to determine whether one provenance of one city can stand for one *Phyll. het.* cv. *pub.* clone in this area [10, 11].

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EDITOR'S NOTE ABOUT TREND SURFACE ANALYSIS

Trend surface analyse is a statistical method, which presupposes that each observation 'z' on a location 'i' is being influenced by (1) a large scale process called 'trend' or 't' which generates the total pattern of variation in the region, (2) a local process 'l', (3) random fluctuations and errors 'e'. The result is:

$$z_i = t_i + l_i + e_i.$$

Normally the local process and the errors are taken together:

$$z_i = t_i + e_i.$$

The trend 't' can have any mathematical form, but it is usual to fit a polynomial function related to the local coordinates (x, y), similarly as with standard regression.

The result might look like:

$$\begin{aligned} t_i &= f(x_i, y_i) \\ &= \alpha_{00} + \alpha_{10}x_i + \alpha_{01}y_i + \alpha_{20}x_i^2 \\ &\quad + \alpha_{11}x_i y_i + \alpha_{02}y_i^2 + \cdots + \alpha_{0q}y_i^q. \end{aligned}$$

Most authors try to describe the data with a combination of linear, quadratic and cubic functions.

The author has used the next equations for the four maps; x and y are the coordinates. Evidently the calculation has been performed with proper accuracy; for the convenience of the reader the result is shown here with three decimals only.

Times of fitting	Trend equation	Goodness of fit	Value of F
One time	$-2.4 + 0.029x + 0.12y$	25.85	4.880
Two times	$-665 + 12x - 0.055x^2$ $-2.3y + 0.024xy$ $-0.0068y^2$	29.30	2.693
Three times	$62000 - 1400x + 10x^2$ $-0.023x^3 - 819y + 14xy$ $-0.069x^2y - 0.52y^2$ $+0.03xy^2 - 0.036y^3$	52.27	4.380
Four times	$625000 + 40000x - 749x^2$ $+5.5x^3 - 0.014x^4$ $-65000y + 1580xy$ $-13x^2y + 0.037x^3y$ $+169y^2 - 2.4xy^2$ $-0.0043x^2y^2 - 0.73y^3$ $+0.041xy^3 - 0.038y^4$	64.16	4.923