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The Variation of Winter Buds among 10 Selected Populations of *Kalopanax septemlobus* Koidz. in Korea

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ABSTRACT

The objective of this study was to understand the conservation of gene resources and provide information for mass selection of winter bud characters among the selected populations of *Kalopanax septemlobus* Koidz using analysis of variance(ANOVA) tests. The obtained results are shown below;

1. Ten populations of *K. septemlobus* were selected for the study of the variation of winter bud characters in Korea. The results of the analysis of variance(ANOVA) tests shows that there were statistically significant differences in all of the winter bud characters among those populations.

2. Correlation analysis shows that width between Height and DBH(Diameter at breast height) characters have negative relationship with all of the characters, as ABL(Apical branch length), ABW(Apical branch width), AWBL(Apical branch winter bud length), AWBW(Apical branch winter bud width), ABT(Apical branch No. of thorns), ABLB(Apical branch No. of lateral bud) and LBL(Lateral branch length), LBW(Lateral branch width), LBT(Lateral branch No. of thorns), LBLB(Lateral branch No. of lateral bud).

3. The result of principal component analysis(PCA) for winter buds showed that the first principal components(PC' s) to the fourth principal component explains about 78% of the total variation. The first principal component(PC) was correlated with AWBW, LWBW, and LBL and the ratio of ABL/ABW and LBL/LBW out of 16 winter bud characters. The second principal component correlated with ABL, ABW, ABLB, LWBL(Lateral branch winter bud length), and LBW and the ratio of AWBL/AWBW. The third principal component correlated with ABL, ABW, LWBL, LBL, and the ratio of LBL/LBW. The fourth principal component correlated with LBL and the ratio of LWBL/LWBW(Lateral branch winter bud width), LBL/LBW. Therefore, these characters were important to analysis of the variation for winter bud characters among selected populations of *K. septemlobus* in Korea.

4. Cluster analysis using the average linkage method based on 10 selected populations for the 16 winter bud characters of *K. septemlobus* in Korea showed a clustering into two groups by level of distance 1.1(Fig. 3). As can be seen in Fig. 3, Group I consisted of three areas(Mt. Sori, Mt. Balwang and Mt. Worak) and Group Ⅱ contisted of seven areas(Suwon, Mt.

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Chuwang, Mt. Kyeryong, Mt. Kaji, Mt. Jiri, Muan, and Mt. Halla). The result of cluster analysis for winter bud characters corresponded well with principal component analysis, as is shown in Fig. 2.

Key Words *: Kalopanax septemlobus*, Winter bud, Correlation analysis, Principal component analysis(PCA), Cluster analysis

I. INTRODUCTION

The genus *Kalopanax* comprises one species of deciduous, small to medium-sized tree that is native to China, Japan, Eastern Russia, and Korea. The Castor aralia(*K. septemlobus*) is a deciduous tree which when fully grown is up to 30m high with a DBH 1.8m. The bark color is gray and covered, when young, with prominent short and sharp prickles with a broad base. Leaves are palmate, long stalked, 10~30cm long as they are wide with 5 to 9 lobes. Lobes are acuminate and finely toothed. Lamina are shiny green and glabrous above while slightly pubescent when young beneath(Lee, 1993). In Korea, this species is widespread from mountains and fields throughout the country from 100m to 1,800m of sea level. But, this species is the most widespread at 700m on the north side of a slanting surface or rich woodland valley area(Lee, 2001). It is a valuable tree in China, Japan, and Korea. The wood may be suitable for furniture, instrument, construction, musical instrument wood, carving, and some interior uses. The dried bark and root have been used as a medicine in those countries for various ailments. Analysis of the nutrient content of leaves for castor-aralia showed plentiful levels of iron, zinc, magnesium, calcium, and beta-carotene, making it a potential food source of high nutritive value. Phytochemical investigations have allowed the isolation and characterization of saponin and phenolic compounds that are reported to show preventive activity against stress-induced changes(Lee *et al.* 1995; Porzel *et al.* 1992; Shao *et al.* 1989). Young leaves and shoots contain a unique odor. People eat this edible wild plant in the spring. It is valuable for development of both edible and medicinal uses, and in fact, there is a great demand for this. The breeding importance of the *K. septemlobus* must be maintained by not broadening the genetic base in Korea.

In general, there is the need for improvement of the characteristic forest form and the selection of quality individuals for management of genetic variation through analysis of genetic variation within a forest which contains a variety of genetic variations. That is, it is necessary to carry out research successively and continuously for a dominant group or mass selection, plus tree selection, and progeny testing from a natural group. To promote this research systematically, basic research is needed for understanding the level of variation of a selected group and individual variation among groups. In this study, a variation survey and analysis of winter bud characters of *K. septemlobus* in naturally distributed areas in Korea is needed to conserve gene resources and to provide basic information for breeding of *K. septemlobus*.

II. MATERIALS AND METHODS

The materials for a variation survey of winter bud characters of *K. septemlobus* are a selection of twenty specimen trees from each of the ten selected areas, where Mt. Sori(A), Mt. Balwang(B), Suwon(C), Mt. Worak(D), Mt. Chuwang(E), Mt. Kyeryong(F), Mt. Kaji(G), Mt, Jiri(H), Muan(I), and Mt. Halla(J)(Fig 1).

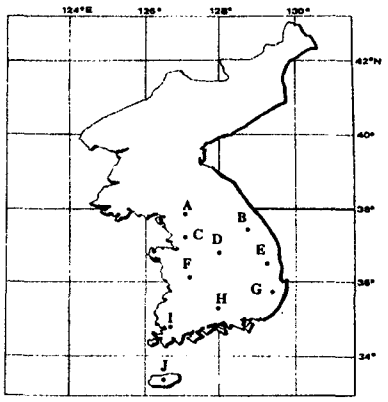

Fig. 1. Location of *K. septemlobus* natural populations by collected districts. A ; Mt. Sori, B ; Mt. Balwang, C ; Suwon, D ; Mt. Worak, E ; Mt. Chuwang, F ; Mt. Kyeryong, G ; Mt. Kaji, H ; Mt. Jiri, I ; Muan, J ; Mt. Halla

These specimens were selected by the Korean Forest Research Institute from 1996 to 2000 for the dominant single tree of *K. septemlobus*. For each specimen tree, the DBH and Height were measured and surveyed, as well as each branch' s Apical branch Length(ABL), Apical branch Width(ABW), Lateral branch Length(LBL), and Lateral branch Width(LBW) on four sides. Also, the Length of Winter Bud(AWBL, LWBL), the Width of Winter Bud(AWBW, LWBW), the Number of Thorns(ABT, LBT), and the Number of Lateral Buds(ABLB, LBLB) were surveyed each at the Apical and Lateral branch. To understand the shape of winter bud characters of *K. septemlobus* the ratio of ABL/ABW, LBL/LBW of apical branches was assessed and the ratio of AWBL/AWBW and LWBL/LWBW of each part were analyzed as well. The surveyed materials used the SAS program(SAS Institute, 1982) for group variation analysis among the selected groups. Correlation analysis and principal component analysis were hired and analyzed flexibility among groups after ANOVA testing.

III. RESULT AND DISCUSSION

1. The shape of winter bud characters

Table 1 and 2 shows that the survey results of the shape of winter bud characters, such as ABL, ABW, AWBL, AWBW, ABT, ABLB, LBL, LBW, LWBL, LWBW, LBT and LBLB within 10 selected populations of *K. septemlobus*. Table 1 show that the shape of winter bud characters of each group is different. For example, the average of the AWBL is 0.7cm, and the AWBW is 0.8cm while the average of the LWBL is 0.5cm and the LWBW is 0.6cm of the winter bud.

This means the apical branches are bigger than the lateral branches. The ratio of ABL/ABW and of LBL/LBW were 0.8 each. This indicated that the shape of the winter bud is round because the diameter is more wider than the length. Also, the Table 1 and 2 shows that the average ABL is 15.8cm, the ABW is 0.9cm, the ABT is 7.2EA, and the ABLB is 2.4EA, while the LBL is 4.3cm, the LBW is 0.7cm, the LBT is 1.7EA, and the LBLB is 0.7EA which indicated that the apical branches are more numerous and longer in characteristics than the lateral branches.

The apical branch characteristics among the groups are as follows; relatively the biggest groups are on Mt. Kyeryong; the groups of Mt. Halla are of a shorter

Table 1. Morphological characteristics of apical branch for *K. septemlobus* by studied districts.

District		HT (m)	DBH (cm)	Apical branch characteristics*							
				AWBL (cm)	AWBW (cm)	AWBL/ AWBW	ABL (cm)	ABW (cm)	ABL/ ABW	ABT (EA)	ABLB (EA)
Mt. Sori	Mean	10.9	22.9	0.6	0.6	1.0	7.1	0.7	10.4	3.8	1.7
	S.D	2.1	5.0	0.1	0.1	0.1	3.8	0.1	4.9	3.9	1.3
	C.V	19.2	21.9	19.2	16.8	12.6	54.1	18.0	46.9	103.7	75.5
Mt. Balwang	Mean	14.3	43.7	0.6	0.8	0.8	8.1	0.8	9.4	2.2	0.9
	S.D	4.1	21.3	0.1	0.1	0.1	4.8	0.1	4.9	3.4	1.2
	C.V	28.3	48.9	10.0	9.0	13.5	58.6	13.6	51.8	154.5	136.7
Suwon	Mean	11.2	41.5	0.6	0.9	0.7	16.7	0.9	18.6	9.8	2.5
	S.D	3.0	11.5	0.1	0.3	0.2	9.4	0.4	8.3	7.8	1.4
	C.V	26.4	27.7	16.0	29.4	21.7	56.5	42.2	44.6	79.5	57.4
Mt. Worak	Mean	13.3	28.1	0.6	0.7	0.9	8.3	0.8	11.1	3.8	1.2
	S.D	8.4	21.6	0.1	0.1	0.1	7.6	0.1	10.3	6.0	1.6
	C.V	63.2	76.9	11.2	17.4	9.4	91.8	17.6	92.6	158.0	129.1
Mt. Chuwang	Mean	9.0	23.1	0.8	1.0	0.8	20.3	1.0	20.5	6.0	3.6
	S.D	2.4	6.2	0.2	0.2	0.1	9.0	0.2	8.4	6.6	1.8
	C.V	26.8	26.9	20.6	17.1	15.4	44.1	19.8	41.1	110.9	51.2
Mt. Kyeryong	Mean	4.7	13.0	0.8	1.0	0.8	32.8	1.2	26.1	16.0	4.7
	S.D	0.7	3.6	0.6	0.2	0.1	14.3	0.2	10.9	13.7	2.5
	C.V	15.7	28.0	16.7	17.2	15.9	43.8	18.5	41.8	86.1	53.2
Mt. Kaji	Mean	5.8	21.5	0.7	0.9	0.8	18.1	0.9	20.3	13.9	3.1
	S.D	1.1	6.3	0.1	0.1	0.1	5.4	0.1	5.8	11.1	1.9
	C.V	18.7	29.3	15.3	11.3	10.0	30.1	11.6	28.3	79.6	60.8
Mt. Jiri	Mean	9.7	23.0	0.8	0.9	0.9	23.2	1.1	21.1	14.0	3.8
	S.D	2.8	6.7	0.1	0.1	0.1	8.1	0.2	6.4	11.2	1.9
	C.V	29.1	29.1	11.8	16.0	16.0	34.7	16.2	30.4	80.4	50.2
Muan	Mean	10.9	70.5	0.7	0.8	0.8	17.4	1.0	17.0	2.0	2.3
	S.D	2.6	27.5	0.1	0.1	0.1	10.5	0.2	10.4	4.5	1.4
	C.V	23.6	39.0	10.2	7.6	9.0	60.5	15.1	61.4	224.9	63.2
Mt. Halla	Mean	12.2	33.4	0.6	0.7	0.8	5.8	0.8	6.9	0.4	0.4
	S.D	1.8	2.9	0.1	0.1	0.1	3.3	0.1	3.8	1.1	0.7
	C.V	15.0	8.6	13.3	15.3	12.5	57.2	12.9	54.8	269.2	185.3
Total	Mean	10.2	32.1	0.7	0.8	0.8	15.8	0.9	16.1	7.2	2.4
	S.D	4.6	21.0	0.1	0.2	0.1	11.6	0.2	9.8	9.6	2.1
	C.V	44.6	65.4	20.0	22.8	16.6	73.4	26.5	60.7	133.2	87.1
F-Value		44.47**	82.24**	49.86**	51.52**	31.91**	64.44**	46.45**	39.12**	31.63**	43.27**

* ; Symbol of characteristics were referred to method and materials, ** ; Significant of 1% level.

Table 2. Morphological characteristics of lateral branch for *K. septemlobus* by studied districts.

District		Lateral branch characteristics*							
		LWBL (cm)	LWBW (cm)	LWBL/ LWBW	LBL (cm)	LBW (cm)	LBL/ LBW	LBT (EA)	LBLB (EA)
Mt. Sori	Mean	0.5	0.5	1.0	2.6	0.6	4.3	1.2	0.4
	S.D	0.2	0.2	0.1	2.9	0.2	4.7	2.4	0.9
	C.V	30.6	29.6	12.2	112.9	26.2	109.2	203.4	209.8
Mt. Balwang	Mean	0.5	0.5	0.8	2.1	0.7	3.0	0.0	0.1
	S.D	0.1	0.1	0.1	2.1	0.1	3.0	0.0	0.3
	C.V	15.9	17.2	14.3	100.9	11.4	98.0	0.0	350.9
Suwon	Mean	0.5	0.7	0.7	2.1	0.7	3.4	4.7	0.8
	S.D	0.1	0.2	0.1	3.1	0.1	5.2	5.7	1.0
	C.V	19.4	28.6	15.2	151.4	14.6	153.7	122.2	123.5
Mt. Worak	Mean	0.4	0.5	0.9	1.8	0.6	2.8	0.3	0.2
	S.D	0.1	0.1	0.1	2.8	0.1	3.9	0.8	0.4
	C.V	29.9	30.9	13.0	152.2	14.2	138.1	226.8	226.8
Mt. Chuwang	Mean	0.6	0.7	0.8	7.5	0.7	10.9	1.4	1.6
	S.D	0.1	0.2	0.1	6.3	0.1	8.3	2.1	1.2
	C.V	23.9	22.6	7.2	84.1	15.3	76.6	155.4	78.3
Mt. Kyeryong	Mean	0.6	0.8	0.8	6.5	0.8	6.9	3.5	0.9
	S.D	0.1	0.2	0.1	8.2	0.2	8.2	4.7	1.2
	C.V	24.0	26.5	10.2	126.3	20.9	118.5	135.1	132.4
Mt. Kaji	Mean	0.5	0.7	0.7	5.1	0.6	7.7	1.5	1.3
	S.D	0.1	0.1	0.04	4.4	0.1	5.9	1.7	1.3
	C.V	14.4	18.1	5.0	84.9	8.2	77.5	112.9	106.2
Mt. Jiri	Mean	0.6	0.6	0.9	6.6	0.7	8.8	2.4	0.9
	S.D	0.2	0.2	0.1	6.0	0.1	7.5	2.8	1.2
	C.V	36.9	28.3	13.9	91.1	11.5	85.7	119.1	130.1
Muan	Mean	0.5	0.6	0.9	6.4	0.7	8.9	1.4	0.6
	S.D	0.1	0.1	0.1	7.0	0.1	9.0	3.5	1.1
	C.V	11.7	17.4	14.4	108.7	13.3	101.1	246.3	181.6
Mt. Halla	Mean	0.3	0.4	0.8	1.7	0.7	2.6	0.0	0.0
	S.D	0.1	0.1	0.2	1.9	0.1	2.7	0.0	0.0
	C.V	20.4	19.8	19.5	111.6	15.4	103.8	0.0	0.0
Total	Mean	0.5	0.6	0.8	4.3	0.7	6.0	1.7	0.7
	S.D	0.1	0.2	0.1	5.5	0.1	7.1	3.5	1.1
	C.V	29.2	31.5	16.6	128.5	17.5	117.0	202.0	156.7
F-Value		24.03*	29.92*	25.00**	10.53**	11.52**	10.96**	11.11**	13.11**

* ; Symbol of characteristics were referred to method and materials, ** ; Significant of 1% level.

length, have a fewer number of thorns, and have a fewer number of lateral buds; the groups on Mt. Sori have an AWBW and ABW that are relatively smaller than other areas. The lateral branch characteristics among the groups are as follows; relatively the biggest groups are Mt. Kyeryong(LWBL, LWBW, and LBW); the groups of Mt. Chuwang have longer length and a greater number of lateral branch lateral buds; the groups of Mt. Halla are of a shorter length, have fewer numbers of thorns, and fewer numbers of lateral buds; and the LBW is shorter than other places at Mt. Sori and Mt. Worak relatively speakingly.

As a result, overall the groups of Mt. Kyeryong and Mt. Chuwang are larger than other groups and Mt. Halla are smaller than other groups when examining both apical and lateral branches. Based on these data, the ANOVA test was hired to find out differences among the different groups. ANOVA testing shows that there were statistically significant differences for all factors among the different groups.

2. Correlations between winter bud and growth characters

Tables 3 and 4 shows that the result of correlation analysis of growth characters, including DBH and Height and 16 different shape characters of *K. septemlobus*. The range of the correlation coefficient of apical branches is -0.54~0.91, and the correlation coefficient especially shows a positive relationship that is relatively high for apical branch winter bud length and width(0.62), apical branch length and width(0.70). Correlation analysis also shows that the characters of winter bud and numbers of thorns correlated as 0.40~0.42, and lateral branch number of lateral bud correlated as 0.55~0.64. In addition, correlation analysis is 0.36~0.66 for apical branch length and width with number of thorns, and 0.58~0.86 with lateral branch number of lateral buds and which indicated a relatively high positive relationship and is similar to the result at lateral branch.

On the contrary, correlation analysis shows that width between Height and DBH characters have a negative relationship with all characters(ABL, ABW, AWBL, AWBW, ABT, ABAB, LBL, LBW, LBT, LBLB). A similar result has been obtained from correlation analysis of the lateral branch. This proves a general tendency that with the larger growth of *K. septemlobus*, the size of the winter bud becomes smaller and the number of thorns decreases.

The range of correlation coefficient for the lateral

Table 3. Correlation coefficients between individual winter bud morphological characteristics and growth characteristics in the apical branch of selected trees.

Characteristics※	Apical branch							
	X1	X2	X3	X4	X5	X6	X7	X8
HT	-0.27**	-0.24**	0.02*	-0.30**	-0.30**	-0.21**	-0.29**	-0.26**
DBH	-0.20**	-0.07	-0.17**	-0.18**	-0.03*	-0.18**	-0.25**	-0.23**
AWBL(X1)		0.62**	0.27**	0.61**	0.57**	0.50**	0.40**	0.55**
AWBW(X2)			-0.54**	0.67**	0.63**	0.58**	0.42**	0.64**
AWBL/AWBW(X3)				-0.19**	-0.22**	-0.19**	-0.13**	-0.22**
ABL(X4)					0.70**	0.91**	0.66**	0.86**
ABW(X5)						0.40**	0.36**	0.58**
ABL/ABW(X6)							0.64**	0.81**
ABT(X7)								0.66**

※ ; Symbol of characters are the same as those of Table 1. ** ; Significant at 1% level, * ; Significant at 5% level.

Table 4. Correlation coefficients between individual winter bud morphological characteristics and growth characteristics in the lateral branch of selected trees.

Characteristics*	Lateral branch							
	X9	X10	X11	X12	X13	X14	X15	X16
HT	-0.22**	-0.28**	0.13**	-0.14**	-0.20**	-0.11*	-0.15**	-0.23**
DBH	-0.03*	-0.10*	0.14**	0.11*	0.03*	0.14**	-0.003	-0.08*
X1	0.63**	0.56**	0.01*	0.42**	0.39**	0.39**	0.12**	0.40**
X2	0.68**	0.85**	-0.34**	0.41**	0.50**	0.38**	0.45**	0.51**
X3	-0.23**	-0.44**	0.36**	-0.11*	-0.23**	-0.10*	-0.36**	-0.23**
X4	0.68**	0.72**	-0.17**	0.54**	0.47**	0.52**	0.54**	0.59**
X5	0.59**	0.62**	-0.13**	0.42**	0.53**	0.38**	0.47**	0.42**
X6	0.56**	0.62**	-0.17**	0.48**	0.30**	0.47**	0.44**	0.53**
X7	0.37**	0.42**	-0.15**	0.14**	0.14**	0.15**	0.62**	0.44**
ABLB(X8)	0.74**	0.75**	-0.11**	0.54**	0.42**	0.54**	0.53**	0.69**
LWBL(X9)		0.85**	0.13**	0.66**	0.62**	0.63**	0.44**	0.69**
LWBW(X10)			-0.39**	0.61**	0.57**	0.59**	0.56**	0.74**
LWBL/LWBW(X11)				-0.05	-0.01	-0.06	-0.25**	-0.19**
LBL(X12)					0.51**	0.98**	0.25**	0.67**
LBW(X13)						0.40**	0.31**	0.35**
LBL/LBW(X14)							0.24**	0.68**
LBT(X15)								0.61**

※ ; Symbol of characters are the same as those of Table 1. ** ; Significant at 1% level, * ; Significant at 5% level.

branch is -0.39~0.98. The correlation coefficient shows a positive relationship with relatively high lateral branch winter bud length and width(0.85), and lateral branch length and width(0.51). Correlation analysis also shows that the characters of winter bud and numbers of thorns correlated at 0.44~0.56, and lateral branch number of lateral buds correlated at 0.69~0.74. In addition, correlation analysis shows that lateral branch length and width with number of thorns is 0.25~0.31, and with lateral branch number of lateral buds is 0.35~0.67, which indicated a positive relationship with relatively high correlation and shows similar result for the lateral branch, as mentioned above.

The range of correlation for the apical branch and lateral branch with the characteristics of shape is -0.44~0.85, and for the apical branch winter bud length and lateral branch winter bud length and apical branch winter bud width and lateral branch winter bud width is 0.56~0.85 which indicated a high positive relationship among them. The range of correlation coefficient of the apical branch and lateral branch' s winter bud length and width is 0.59~0.72 which indicated a high positive relationship between them.

3. Principal component analysis

Table 5 shows that the result of principal component analysis(PCA) for 16 winter bud characters. The characteristics value of the first principal components is 5.667 where the first principal component explains 35% and the fourth principal component explains 78% of the total variation. The characteristics value of the fifth principal components was excluded because the value was less than one(0.95).

Table 6 shows the characteristics value of each

Table 5. Eigenvalue and its contribution rate obtained from principal component analysis.

Principle component	Eigenvalue	Difference	Proportion	Accumulated % of track
1	5.667	1.926	0.35	35.42
2	3.741	2.131	0.23	58.50
3	1.610	0.220	0.10	68.86
4	1.389	0.438	0.09	77.55
5	0.951	0.309	0.06	83.49
6	0.642	0.206	0.04	87.51
7	0.436	0.015	0.03	90.24
8	0.421	0.074	0.03	92.87
9	0.347	0.067	0.02	95.04
10	0.280	0.081	0.02	96.79
11	0.199	0.016	0.01	98.03
12	0.183	0.088	0.01	99.17
13	0.095	0.075	0.01	99.76
14	0.020	0.005	0.00	99.89
15	0.015	0.013	0.00	99.99
16	0.002	0.000	0.00	100.00

Table 6. Eigenvactor associating to eigenvalue obtained from principal component.

Characteristics※	Prin 1	Prin 2	Prin 3	Prin 4	Prin 5	Prin 6	Prin 7	Prin 8	Prin 9	Prin 10
AWBL	0.225	0.146	0.098	0.211	0.603	-0.197	-0.402	0.446	-0.234	0.099
AWBW	0.315	0.129	-0.019	-0.129	0.421	-0.214	0.388	-0.231	0.235	-0.041
AWBL/AWBW	-0.121	0.355	-0.140	0.227	0.130	0.420	0.294	-0.196	-0.666	0.097
ABL	-0.174	0.412	0.287	-0.108	0.061	0.117	0.079	0.104	0.207	0.024
ABW	-0.251	0.369	0.257	0.070	0.034	0.045	0.094	0.09	0.134	-0.052
ABL/ABW	0.362	-0.028	-0.007	-0.081	0.098	0.407	0.117	-0.005	0.220	0.042
ABT	0.239	0.068	-0.118	-0.527	-0.026	0.434	-0.169	0.332	0.013	0.298
ABLB	0.156	0.345	-0.216	0.053	0.006	0.141	-0.593	-0.597	0.190	-0.056
LWBL	-0.260	0.354	0.243	-0.056	-0.002	0.051	-0.021	0.112	0.215	-0.173
LWBW	0.361	0.156	0.015	-0.045	0.153	-0.203	0.300	0.139	-0.014	-0.138
LWBL/LWBW	0.060	0.148	0.580	0.352	-0.080	0.154	0.111	0.415	0.248	-0.466
LBL	0.312	0.075	0.288	0.354	-0.284	0.051	0.082	0.047	0.089	0.228
LBW	-0.314	0.337	-0.346	0.131	-0.134	-0.398	-0.009	0.055	0.147	0.570
LBL/LBW	0.319	0.059	0.255	0.364	-0.297	0.101	0.069	0.058	0.077	0.204
LBT	0.172	0.261	-0.229	-0.414	-0.317	-0.258	0.159	0.101	-0.224	0.030
LBLB	0.283	0.206	0.212	-0.091	-0.332	-0.207	-0.231	0.055	-0.328	-0.443

※ ; Symbol of characters are the same as those of Table 1.

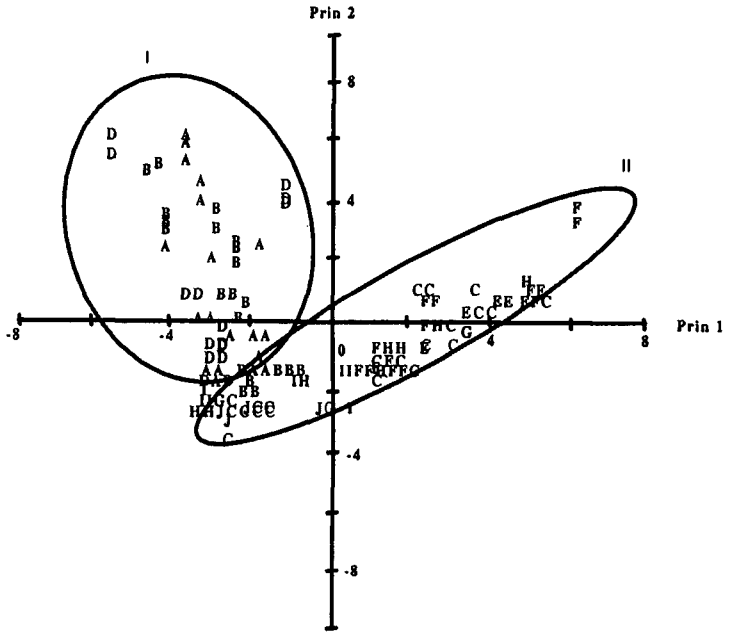

Fig. 2. Two dimensional view of position for 10 populations in a space determined by component I and component II.

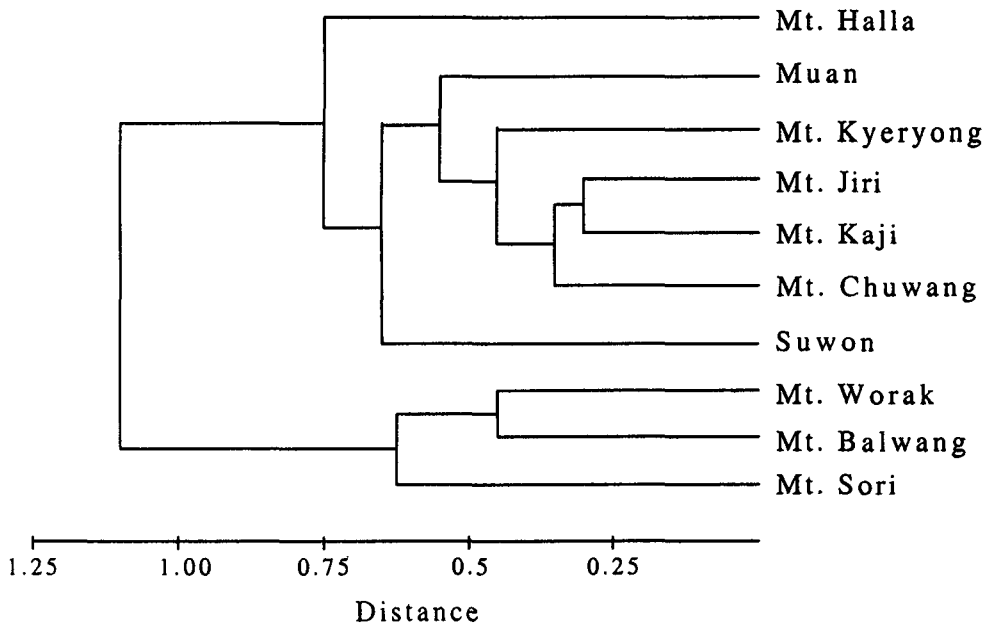

Fig. 3. Cluster dendrogram of studied districts based on winter bud morphological characteristics.

principal component. The first principal component(PC) was correlated with AWBW, LWBW, and LBL and the ratio of ABL/ABW and LBL/LBW out of 16 winter bud characters. The second principal components was correlated with ABL, ABW, ABLB, LWBL, and LBW and the ratio of AWBL/AWBW. The third principal components was correlated with ABL, ABW, LWBL, LBL, and the ratio of LBL/LBW. The fourth principal components was correlated with LBL and the ratio of LWBL/LWBW, LBL/LBW.

The results of each of data about the characteristics value of each principal component was plotted for each group on an action grid where the first principal components are on X axis and the second principal components are on Y axis(Fig. 2).

4. Cluster analysis

Cluster analysis using an average linkage method based on 10 selected populations for 16 winter bud characters of *K. septemlobus* in Korea showed a clustering into two groups by level of distance 1.1(Fig. 3). As can be seen in Fig. 3, Group I consisted of three areas(Mt. Sori, Mt. Balwang and Mt. Worak), and Group Ⅱ consisted of seven areas(Suwon, Mt. Chuwang, Mt. Kyeryong, Mt. Kaji, Mt. Jiri, Muan, and Mt. Halla). The result of cluster analysis for winter bud characters corresponded well with principal component analysis as can be seen in Fig. 2.

Further research is required through gene analysis such as, the RAPD method and corresponding enzyme analysis, for discovering the differences for the quantitative characteristic form and quantity of winter bud characters regarding environmental factors or genetic differences between the two groups.

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