Clonal Variation in Flowering Abundance of *Pinus koraiensis*

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In a seed orchard, unbalanced genetic contributions of clones were very important factors affecting seed quality and genetic flexibility of progenies. Generally, the superior clones had been selected to establish advanced generation seed orchard based on the progeny test. The flowering characteristics of clones have been relatively less considered and applied in a seed orchard management in Korea. Thus, this study was conducted to investigate the flowering characteristics of *P. koraiensis* clones and to supply information for advanced breeding.

MATERIALS AND METHODS

The clonal variation in flowering abundance was studied in *Pinus koraiensis* clone bank, established in 1983. It was located in mid Korea and consisted of 180 clones from mid and northern Korea. The flowering abundance was studied in 1991-2003 at annual, clonal and graft level. In 1996 and 2001, however, the flowering was very poor. Thus, the data of those years were excepted from genetic parameter estimation. The broad-sense heritability and genetic gain of male and female flowering was estimated. The clonal stability of male and female flowering was compared using clonal mean and coefficient of variation values of each clone. Additionally, the implications of the results to genetic improvement of *P. koraiensis* were discussed.

RESULTS AND DISCUSSION

The between-year variation was large in both female and male flowering. The average percentages of flowering graft of female and male were 54.3 % and 26.1%, respectively. The average number of flower per graft of female and male were 7 and 205, respectively. In both case, they were varied from graft to graft. The spearman rank correlation from year to year were usually positive and significant, and in general slightly higher in male than in female flowering. The proportion of clones that did not flower at all was larger when flowering was poor. The clonal variation of male flowering was larger than that of female flowering (Table 1).

The average broad-sense heritability values for female and male flowering were 0.32 and 0.44, respectively, but varied considerably from year to year (Table 2). The average of broad-sense heritability of female and male were relatively high. Thus, the flowering abundance of *P. koraiensis* might be under the strong genetic control, although the flowering was mainly affected by environmental conditions.

The genetic gain was estimated using average broad-sense heritability and selection differential of female and male flowering abundance. The genetic gain of female and male was 20.0% and 57.2% when the upper 30% clones were selected, respectively (Table 3). However, when the selelction intensity was increased to enhance the genetic gain, the genetic diversity was decreased. Thus, the more attention was required when the advanced selection breeding program was established.

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Table 1. The percentage of flowering grafts, clonal mean, minimum and maximum values for the number of flowers in different years.

Year	Female flower					Male flower				
	Flowering Graft (%)	Mean	Min.	Max.	CV(%)	Flowering Graft (%)	Mean	Min.	Max.	CV(%)
1991	39.7	2	0	45	202.3	20.9	51	0	2510	394.3
1992	55.8	4	0	53	167.2	30.8	27	0	1087	354.7
1993	70.7	8	0	83	141.1	41.3	46	0	3300	376.5
1994	73.0	6	0	46	126.2	42.7	77	0	1760	278.2
1995	52.6	3	0	34	150.4	32.4	47	0	3100	415.8
1997	54.4	4	0	45	162.5	5.7	10	0	502	488.6
1998	63.8	5	0	90	161.8	22.5	59	0	4000	443.5
1999	74.3	12	0	62	104.4	34.6	205	0	15000	525.8
2000	32.6	5	0	88	231.7	11.1	272	0	1500	472.9
2002	37.8	6	0	90	206.1	7.0	11	0	1000	642.1
2003	43.2	25	0	238	157.5	38.4	1700	0	30000	217.3
Average	54.3	7				26.1	205			

Table 2. The broad-sense heritability for the number of flowers in different years.

	’91	’92	’93	’94	’95	’97	’98	’99	’00	’02	’03	average
Female	0.38	0.40	0.58	0.35	0.42	0.45	0.32	0.45	0.05	0.07	0.00	0.32
Male	0.79	0.74	0.40	0.74	0.71	0.44	0.34	0.44	0.19	0.06	0.04	0.44

The clonal stability of flowering was compared with average number of flowering and CV value of each clone. Only considering seed production, a clone with large flowering abundance and high stability was ideal one. In female, the clones such as K16, K21, K23, K26 and K68 showed abundant flowering and high stability. In case of male, they were K96, K84, G11, K52 and K29 (Figure 1). However, the correlation coefficient between female and male flowering of clones was not high (r=0.43). Thus, different genetic contribution of female and male of a clone was also considered in a seed orchard management of *P. koraiensis*.

Table 3. Estimation of genetic gain for female and male flowering abundance.

	Parameter	Selection criteria				
		Upper 50% (90 clones)	Upper 40% (72 clones)	Upper 30% (54 clones)	Upper 20% (36 clones)	Upper 10% (18 clones)
Female	S	3	4	5	6	9
	ΔG	0.96	1.28	1.60	1.92	2.88
	%G	12.0	16.0	20.0	24.0	36.0
Male	S	320	428	563	759	1157
	ΔG	140.8	188.3	247.7	333.9	509.1
	%G	32.5	43.5	57.2	77.1	117.6

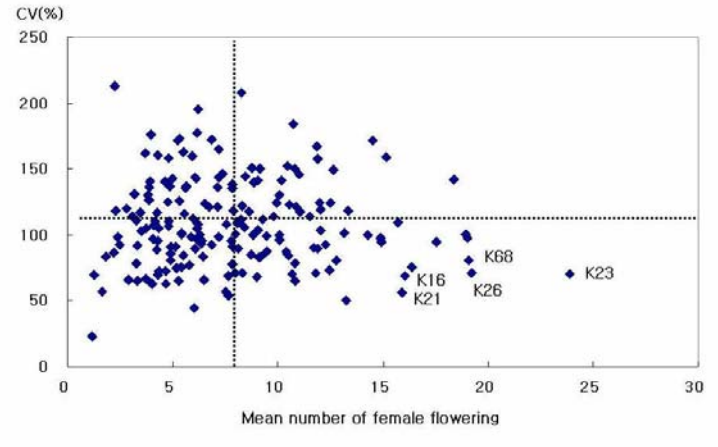

Figure 1. The biplot of mean number of female flowering and CV(%) of each clone

LITERATURE CITED

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