Effect of parent selection and crosses of *Pyrus ussuriensis* on the early-bearing ability of F1 progenies

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Abstract. In order to investigate the effect of combinations of different pear varieties and their descendants and other cultivated pear varieties on the early fruiting of F1 generation, the individual plant Numbers of F1 generation of 17 hybrid combinations were investigated. The results showed that: 17 combinations of 1175 hybrid seedlings, 15 combinations of fruit age in 6–8 years, 8 years of birth there are two combinations of Hanxiangli × Jinxianshui, Dacili × Eli1 did not blossom. Among the flowering combinations, there were differences among different maternal combinations. The flowering plant rate of the combination with Dacili as the parent was the highest, which was 12.14%. Hanxiangli was the second 9.42%. Jinxianshui was the lowest 6.43%. There were significant differences in the number of flowering plants in the offspring population in different combinations of maternal parent and paternal parent, indicating that parental parent had a significant influence on the age of bearing fruit in the hybrid population. There was a big difference in the age of the first fruit in F1 generation in the combination of pear varieties in other cultivation systems. However, the progeny of the parent and parent groups of *Pyrus ussuriensis* had a lower flowering individual plant, and the combination of *Pyrus ussuriensis* × *Pyrus ussuriensis* was zero. It can be seen that the seed sex of *Pyrus ussuriensis* has a great influence on the early and late fruit age of offspring.

1. Introduction

During the breeding of new varieties of cold-resistant pear, we usually use the varieties of *Pyrus ussuriensis* or *Pyrus ussuriensis*-bearing as their parents, and cross with different varieties of pear system. The pear hybrid progeny must pass through the child stage to blossom and bear fruit, and the child period of different hybrid progeny is 3–10 years [1], which leads to the longer breeding period of pear. Therefore, how to shorten the breeding period of pear and improve the breeding efficiency has always been one of the main objectives of cold-resistant pear breeding in China.

The research on the genetic law of pear early fruit has always been the focus of many researchers at home and abroad. Visser [2], Li Xiugen et al. [3] pointed out that there was a significant positive correlation between the length of the child period of the hybrid and the nutritional period of the parents. Li Honglian et al. [4] found that early fruiting is a multi-gene controlled quantitative inheritance, and both parents have a significant effect on early-bearing.

A study on the effects of seed age difference and early-bearing of F1 generation of pear hybrids was carried out by inter-species and within-species hybridization of *Pyrus ussuriensis* and its progeny.
It provides a theoretical basis for parents’ selection and selection to shorten the breeding period of cold-resistant pear.

2. Materials and methods
The experiment was carried out in pear selection nursery of Pomology Research Institute, Jilin Academy of Agricultural Sciences. 17 hybrid combinations were selected in 2010, seeded in 2011, and planted in seed selection nursery by 1m × 1.5m × 3m row spacing in 2012 (table 1).

Table 1. The parents of different pear varieties were selected and combined.

| Female♀/provenances          | Combination                             | Male♂/provenances          | Number of hybrid seedlings |
|------------------------------|-----------------------------------------|----------------------------|---------------------------|
| Jinxiangshui/Pyrus ussuriensis | Early Red Comice/Pyrus communis L       | Eli 1/Pyrus pyrifolia      | 202                       |
|                              | Red Clapp Favorite/Pyrus communis L     |                            | 203                       |
| Hanxiangli/Pyrus ussuriensis | Early Red Comice/Pyrus communis L       |                            | 132                       |
|                              | Red Clapp Favorite/Pyrus communis L     |                            | 156                       |
|                              | Zaosu/Pyrus bretschneideri              |                            | 18                        |
|                              | Yunhong 1/Pyrus pyrifolia               |                            | 155                       |
|                              | Korla Pear/Pyrus sinkiangensis          |                            | 20                        |
|                              | Eli 1/Pyrus pyrifolia                   |                            | 14                        |
|                              | Jinxiangshui/Pyrus ussuriensis          |                            | 54                        |
|                              | Jinmi/Pyrus bretschneideri              |                            | 291                       |
|                              | Korla Pear/Pyrus sinkiangensis          |                            | 55                        |
|                              | Jingbai/Pyrus ussuriensis               |                            | 84                        |
| Dacili/Pyrus bretschneideri   | Eli 1/Pyrus pyrifolia                   |                            | 6                         |
|                              | Yunhong 1/Pyrus pyrifolia               |                            | 230                       |
|                              | Jinmi/Pyrus bretschneideri              |                            | 152                       |
|                              | Zaosu/Pyrus bretschneideri              |                            | 2                         |
| Total                        |                                         |                            | 1799                      |

The age and number of flowering plants were investigated, and the flowering rate of population was calculated. Flowering plant rate (%) is a number of flowering single plants devided to number of current surviving plants) multiplied on 100.

3. Results and Discussion
3.1 The Performance of different combinations of pear on early fruit of F1 generation
The results of F1 generations of pear hybrid combinations (table 2). At 6 years of age, Jinxiangshui × Early Red Comice and Hanxiangli × Yunhong 1 had flowering plants, the other 15 combinations no flowering. The 7 years old, Jinxiangshui × Early Red Comice, Hanxiangli × Early Red Comice, Hanxiangli × Red Clapp Favorite, Hanxiangli × Zaosu, Hanxiangli × Yunhong 1, Hanxiangli × Korla Pear, Hanxiangli × Jinmi, Dacili × Yunhong 1, Dacili × Jinmi el to 10 combinations have different numbers of flowering single plants, the other 7 combinations have no flowering. The 8 years old, Hanxiangli × Jinxiangshui and Dacili × Eli1 combinations did not blossom, the other 15 combinations all blossom and bear fruit. The survival rate of F1 combinations was 38.2~100% because of the difference of cold resistance of different parents.
Table 2. Flowering of F1 generation in different parent combination.

| Combination               | Number of hybrid seedlings | Number of existing hybrid seedlings | The survival rate (%) | 5years | 6years | 7years | 8years |
|---------------------------|----------------------------|------------------------------------|-----------------------|--------|--------|--------|--------|
| Female ♂♂ Female ♀♀       |                            |                                    |                       |        |        |        |        |
| Jinxian                  | Early Red Comice           | 202                                | 91                    | 45.0   | 0      | 1      | 8      | 12     |
|                           | Red Clapp Favorite         | 203                                | 146                   | 71.9   | 0      | 0      | 0      | 2      |
|                           | Eli 1                      | 25                                 | 12                    | 48     | 0      | 0      | 0      | 2      |
| Hanxia                    | Early Red Comice           | 132                                | 112                   | 84.8   | 0      | 0      | 4      | 4      |
|                           | Red Clapp Favorite         | 156                                | 109                   | 69.8   | 0      | 0      | 2      | 5      |
| Jinxing                  | Yunhong                     | 155                                | 93                    | 60     | 0      | 1      | 3      | 19     |
|                           | Korla Pear                 | 20                                 | 19                    | 95     | 0      | 0      | 1      | 4      |
|                           | Eli 1                      | 14                                 | 12                    | 85.7   | 0      | 0      | 0      | 1      |
| Dacili                    | Jinxiangshui               | 54                                 | 39                    | 72.2   | 0      | 0      | 0      | 0      |
|                           | Jinmi                      | 291                                | 211                   | 72.5   | 0      | 0      | 3      | 16     |
|                           | Korla Pear                 | 55                                 | 21                    | 38.2   | 0      | 0      | 0      | 5      |
|                           | Jingbai                    | 84                                 | 48                    | 57.1   | 0      | 0      | 0      | 2      |
|                           | Eli 1                      | 6                                  | 4                     | 66.7   | 0      | 0      | 0      | 0      |
|                           | Yunhong                    | 230                                | 123                   | 53.5   | 0      | 0      | 6      | 10     |
|                           | Jinmi                      | 152                                | 123                   | 80.9   | 0      | 0      | 15     | 21     |
|                           | Zaosu                      | 2                                  | 2                     | 100    | 0      | 0      | 0      | 1      |
|                           | Total                      | 1799                               | 1175                  | 65.3   | 0      | 2      | 47     | 112    |
3.2 Effects of pear varieties on early-bearing in F1 Generation

The results of the offspring of pear varieties of different initial fruit ages (table 3). At 6 years old, there were a small number of flowering plants in the combination of Jinxiangshui, Hanxiangli, the flowering rate was 0.4% and 0.17%. At the beginning of 7 years, all the combinations were flowering, with the highest Daci, followed by Jinxiangshui and the lowest Hanxiangli. At 8 years of age, the rate of flowering plants in each combination increased greatly, but the proportion of unopened plants >87.9%.

Table 3. Blossom of F1 generation of different pear varieties (types).

| Female          | Number of existing hybrid seedlings | The yield of hybrid seedlings at different ages (%) |
|-----------------|-------------------------------------|-----------------------------------------------|
|                 |                                     | 5years | 6years | 7years | 8years |
| Jinxiangshui    | 249                                 | 0      | 0.4    | 3.21   | 6.43   |
| Hanxiangli      | 605                                 | 0      | 0.17   | 2.98   | 9.42   |
| Daci            | 321                                 | 0      | 0      | 6.54   | 12.14  |

3.3 Effects of F1 generation early fruiting properties of different parent composition

3.3.1 Effect F1 generation on Early-bearing of male parent. The F1 generation outcomes for different male parents of the same female parent (table 4). The Jinxiangshui is female parent, Early Red Comice 6 years old flowering single plant, Red Clapp Favorite and Eli 1 8 years old have flowering single plant. The Hanxiangli is female parent, Early Red Comice, Red Clapp Favorite 7 years have flowering single plant, Eli 1 8 years have flowering single plant. It follows that the same female parent hybrid with different male parent varieties, F1 generation the first fruit is affected by the paternal influence is greater, Early Red Comice as the father of the combination of early fruit age is earlier, Red Clapp Favorite followed, the latest is Eli 1.

Table 4. Blossom of F1 generation of different combinations of the same female and the different male parent.

| Combination      | Number of existing hybrid seedlings | The yield of hybrid seedlings at different ages (%) |
|------------------|-------------------------------------|-----------------------------------------------|
| Female♀          | Male♂                               | 5years | 6years | 7years | 8years |
| Jinxiangshui     | Early Red Comice                    | 91     | 0      | 1.09   | 8.79   | 13.2  |
|                  | Red Clapp Favorite                  | 146    | 0      | 0      | 0      | 1.37  |
|                  | Eli 1                               | 12     | 0      | 0      | 0      | 16.7  |
| Hanxiangli       | Early Red Comice                    | 112    | 0      | 0      | 3.57   | 3.57  |
|                  | Red Clapp Favorite                  | 109    | 0      | 0      | 1.83   | 4.58  |
|                  | Eli 1                               | 12     | 0      | 0      | 0      | 8.33  |

3.3.2 Effect F1 generation on early-bearing of female parent. The F1 generation results of different male parent hybrids of the same female parent (table 5). The results showed that the Early Red Comice was male parent, the Jinxiangshui was female parent 6 years had the flowering single plant, the Hanxiangli was the female parent 7 years had the flowering single plant, the flowering Jinxiangshui was obviously higher than the Hanxiangli. The Red Clapp Favorite was male parent, Hanxiang pear is the female parent with 7 year-old had the flowering single plant and 8 year-old Jinxiangshui had the flowering single plant. Eli 1 is the male parent, Jinxiangshui, Daci pear is the female parent of 8 years to had the flowering single plant, Hanxiangli is the female parent of no flowering single plant. The Yunhong 1 is the male parent, Hanxiangli is the female parent of 6 years to had the flowering single plant.
plant, Dacili is the female parent of 7 years to had the flowering single plant. The Korla Pear is the father, Hanxiang li is the female parent of 7 years to had the flowering single plant. Dacili is the female parent of 8 years had the flowering single plant and the highest flowering rate of 23.8%. The Jinmi is the male parent, Hanxiangli and Dacili were the female parent of 7 years old had flowering single plant. It follows that the different combinations of the same male parent or the same female parent F1 generation flowering plants were significantly different, indicating that parents had a significant effect on the age of F1 generation fruit sooner or later.

Table 5. Blossom of F1 generation of different combinations of the same male and the different female parent.

| Combination | Number of existing hybrid seedlings | The yield of hybrid seedlings at different ages (%) |
|-------------|------------------------------------|---------------------------------------------------|
|             |                                    | 5years | 6years | 7years | 8years |
| Jixiangshui | Early Red                          | 91     | 0      | 1.09   | 8.79   | 13.2   |
| Hanxiangli  | Comice                             | 112    | 0      | 0      | 3.57   | 3.57   |
| Jinxiangshui| Red Clapp                          | 146    | 0      | 0      | 0      | 1.37   |
| Hanxiangli  | Favorite                           | 109    | 0      | 0      | 1.83   | 4.59   |
| Jinxiangshui|                                    | 12     | 0      | 0      | 0      | 16.7   |
| Hanxiangli  | Eli 1                              | 12     | 0      | 0      | 0      | 0      |
| Dacili      |                                    | 4      | 0      | 0      | 0      | 8.33   |
| Hanxiangli  | Yunhong                            | 93     | 0      | 1.08   | 3.22   | 20.4   |
| Dacili      | 1                                  | 123    | 0      | 0      | 4.88   | 8.13   |
| Hanxiangli  | Korla Pear                         | 19     | 0      | 0      | 5.26   | 21.1   |
| Dacili      |                                    | 21     | 0      | 0      | 0      | 23.8   |
| Hanxiangli  | Jinmi                              | 211    | 0      | 0      | 1.42   | 7.58   |
| Dacili      |                                    | 123    | 0      | 0      | 12.2   | 17.1   |

3.4 Effects of pairing F1 parental groups with different sources on early-bearing
The F1 generations of Flowering from different sources(table 6).As a result, Pyrus ussuriensis × Pyrus ussuriensis the F1 generation was not flowering at the age of 8 years, Pyrus ussuriensis × Pyrus sinkiangensis and Pyrus ussuriensis × Pyrus bretschneideri the F1 generation were flowering at the beginning of 7 years, Pyrus ussuriensis × Pyrus communis L and Pyrus ussuriensis × Pyrus pyrifolia were flowering at the beginning of 6 years. Pyrus bretschneideri × Pyrus ussuriensis and Pyrus bretschneideri × Pyrus sinkiangensis were flowering at the beginning of 8 years, Pyrus bretschneideri × Pyrus pyrifolia were flowering at the beginning of 7 years.All the results showed that the flowering rate of Pyrus ussuriensis combinations was lower than that of Pyrus ussuriensis × Pyrus ussuriensis. It can be seen that the seed nature of Pyrus ussuriensis has a great influence on the seed age of the offspring in the morning and evening, and it is not possible to shorten the breeding period of Pyrus ussuriensis only by parent selection.

Table 6. Blossom of F1 generation of different combinations of the different cultivated pear systems parent.

| Female♀ | Male♂ | Number of existing hybrid seedlings | The yield of hybrid seedlings at different ages (%) |
|---------|-------|------------------------------------|---------------------------------------------------|
| Pyrus   | Pyrus | 39                                 | 5years | 6years | 7years | 8years |
|         |       |                                    | 0      | 0      | 0      | 0      |
ussuriensis

| Pyrus | Pyrus | Pyrus |
|-------|-------|-------|
| communis L | pyrifolia | sinimangens is |
| 458 | 0 | 0.21 |
| 117 | 0 | 0.85 |
| 19 | 0 | 0 |
| 221 | 0 | 0 |

| Pyrus | Pyrus | Pyrus |
|-------|-------|-------|
| ussuriensis | ussuriensis | pyrifolia |
| 48 | 0 | 0 |
| 125 | 0 | 0 |
| 21 | 0 | 0 |
| 127 | 0 | 0 |

4. Conclusion
The first fruiting period of 15 hybrid combinations F1 generation 6~8 years, and 2 combinations were not flowering at 8 years of age. The initial fruiting period of pear hybrids was 3~12 years, which varied greatly in different pear systems[5-8].In the process of species evolution, different pear systems have their own species and variety characteristics, and the seed age of hybrid progenies is different, and the parent preparation of Pyrus ussuriensis the seed age of hybrid progenies is later.

In this study Pyrus ussuriensis×Pyrus ussuriensis the F1 generation was not flowering at the age of 8 years, Pyrus ussuriensis×Pyrus sinimangens and Pyrus ussuriensis×Pyrus bretschneideri the F1 generation were flowering at the beginning of 7 years, Pyrus ussuriensis ×Pyrus communis L and Pyrus ussuriensis×Pyrus pyrifolia were flowering at the beginning of 6 years.Pyrus bretschneideri×Pyrus ussuriensis and Pyrus bretschneideri×Pyrus sinimangens were flowering at the beginning of 8 years, Pyrus bretschneideri×Pyrus bretschneideri and Pyrus bretschneideri×Pyrus pyrifolia were flowering at the beginning of 6 years.A hybrid progeny of Pyrus ussuriensis and other cultivated pears was more than 6 years old, which was similar to the results of Pu Fu-shen (1979) study. The starting age of the hybrid progenies of Pyrus ussuriensis and Pyrus bretschneideri variety in western Liaoning Province was more than 7~10 years [9].The hybrid progenies of Pyrus bretschneideri and other cultivated pears with the first fruit age of more than 7 years, and the inter-species hybrid of Pyrus bretschneideri with period of 5~6 years are inconsistent with the results of the study [10]. The results showed that the seed property of Pyrus ussuriensis had a great influence on the seed age of the offspring in the morning and evening.The age of the fruit preparation of Pyrus bretschneideri as an anti-cold pear parent is also late, which may lead to the difference of parental heritability due to the different cultivation areas of the parents, and the specific reasons need to be further studied.

Among the results of this study, there were significant differences in the age of the hybrid F1 of pear varieties, and the parents had significant effects. In the breeding of cold-resistant pear varieties, some populations with poor cold-resistance were eliminated because of natural low temperature selection. Therefore, parents with early results or short nutrition period do not necessarily produce early results of offspring groups, which is inconsistent with previous research results [2-3,11]. Combination of cultivation techniques can effectively promote cross-breeding and flowering and fruiting [12]. After studying the effect of growth regulator on early flowering and fruiting of pear hybrid seedlings, it was found that different concentrations of PBO treatment had obvious effect on
early fruiting of pear hybrid seedlings in transition period [13]. Cultivation of hybrid seedlings in different places promotes the transformation of vegetative growth to reproductive growth of hybrid seedlings, and can be used as an effective method for early results of hybrid seedlings.

In order to shorten the breeding period and improve the efficiency of cross breeding, we should give priority to selecting the varieties with strong cold resistance or the varieties with the blood of *Pyrus ussuriensis*.

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