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Studies on Correlation between Flowering and Maturing Stage in Pears

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Summary

It is known that in the phenophase of crops exists several correlations. Former studies showed that the flowering stage was significantly correlated with the maturing stage in a negative manner and that the flowering stage could be used as the basis for early identification of the future fruit maturing stage. To study the correlation between the flowering stage and the maturing stage in pears, 113 pear varieties and 3 cross combinations consisting of 165 hybrid seedlings were used as materials to study the correlation between the flowering stage and the maturing stage in pears. The results showed that, in pears, there was a tendency that the later the flowering, the earlier the maturing, and that the florescence of very early flowering was significant later than middle and late maturity varieties. There was significant negative correlation between flowering period and fruit maturing period of 113 varieties. However, there was no correlativity in four maturity types, very early maturity, early maturity, middle maturity and late maturity, and the three cross combinations got the same results. The relatively centralized maturing stage of hybrid seedlings may constitute the main reason for the insignificant correlation between the flowering stage and the maturing stage thereof. So, florescence can't be used to predict maturity in not extensive segregation cross combination.

Key words. correlation – flowering stage – hybrid seedlings – maturing stage – pear – phenophase

Introduction

In the process of pear (*Pyrus L.*) variety breeding, quality evaluation is very laborious, especially in cases where the fruit maturing stages of the hybrid seedlings in the same combination widely diverge. In cases where the time of maturing is uncertain, repeated sampling is required. Generally, the juvenility period of pear seedlings is three or more years (Wu et al. 2006). In addition, trees fruiting for the first time provide only a limited number of fruit, which cannot meet the requirements of repeated sampling. Furthermore, the use of bagging to protect against birds, insects and disease is an important measure in pear breeding. However, after bagging, changes in color on the fruit surface as it approaches maturity are not readily perceived, and so it is hard to judge fruit maturity. Thus, how to effectively identify the maturing stage of pear hybrid progenies has become a main priority in pear breeding.

Shen et al. (1980) and Sun et al. (2002) found that, for pears, the sprouting stage was significantly negatively correlated with the flowering stage, and positively correlated with maturing stage – hence the sprouting stage could be used for early identification of the future fruit maturing stage. However, inheritance in fruit trees is relatively complex, and the hybrid progeny of different combinations show different inheritance patterns. Over the years, a large number of new pear varieties have been developed. Whether various combinations of these new varieties conform to the above described rule requires further verification. Thus, this study addressed the correlations between the flowering and maturing stages in pears – using 113 varieties and three cross-combinations, consisting of 165 seedlings as sample trees, as the theoretical basis for identifying the maturing stage of hybrid progenies.

Materials and Methods

There were 113 pear varieties and three cross-combinations consisting of 165 hybrid seedlings used as test materials, all of which were from the Pear Selective Nursery, Gardening Station, Jiangsu Academy of Agricultural Sciences (Nanjing).

The times of initial flowering and full flowering were determined during the flowering stage, and the maturing stage was also determined. For specific indices, refer to the descriptors for pear (Cao et al. 2006).

Time of initial flowering – The date when approximately 5 % of the flowers were open.

Time of full flowering – The date when approximately 50 % of the flowers were open.

Maturing stage –The date when the fruits are judged to be ripe for picking.

Growth period – The period from full flowering to picking.

Pears were categorized in terms of the flowering and fruit maturing stages (Table 1). For statistical analysis, the date of flowering was digitalized, e.g. March 20 was recorded as 20, March 21 as 21, April 1 was recorded as

Table 1. Beginning and ending dates of each type of flowering stage and maturing stage in pears.

Flowering stage		Maturing stage	
Type	Beginning/ending date	Type	Beginning/ending date
Early flowering	Before March 24	Very early maturing	Before July 20
Medium flowering	From March 25 to 28	Early maturing	From July 21 to August 10
Late flowering	After March 29	Medium maturing	From August 11 to 31
		Late maturing	After September 1

32, and so on. The days between the times of full flowering and fruit ripening constitute the fruit growth stage.

Within each phenological stage, flowering stage and maturity arrangement was made in a chronological order so as to calculate rank correlation.

Distribution of flowering stage of pear varieties of different types of maturing stages

The 113 varieties were categorized into four types: very early, early, medium and late maturing. The corresponding numbers of varieties of the four types were 15, 17, 39 and 42 (Table 2). For the four types of pears, the time of initial flowering was negatively correlated with the maturing stage, i.e. varieties that flowered early had fruit that matured late, while varieties that flowered late had fruit that matured early. For example, the time of initial flowering of the late maturing varieties was March 23–24, which was 1.2, 1.8 and 3.9 d earlier than that of the medium, early and very early maturing varieties, respectively. Furthermore, among varieties of different types of maturing stages, the times of initial flowering and full flowering exhibited the same tendency. The flowering stage of the very early maturing varieties was March 29, significantly later than that of the early maturing varieties. The difference in the flowering stage between the early and medium maturing varieties was not significant, but their flowering stages were 2 d later than that of the late maturing varieties. There was no significant difference in the interval between the times of initial and of full flowering for these varieties: the early maturing varieties had the longest interval of 1.9 d, and the very early, early and medium maturing varieties had an interval of 1.6 d.

The intervals between the times of initial and full flowering were consistent for varieties of different types of maturing stage; in practice, times of full flowering were hard to observe. Since the time of initial flowering was readily observed, it was thus used as an evaluation index.

Analysis of correlations between flowering and maturing stages

For the different pear varieties and hybrid seedlings, negative correlations were commonly observed between the flowering and maturing stages, but were not significant (Table 3). For the 113 varieties, the flowering stage was significantly negatively correlated with the maturing stage, and correlation coefficient (R) = −0.28. However, within each of the four types of maturing stages (i.e. very early, early, medium and late maturing types) the correlations between the flowering and maturing stages were not significant: for the very early and early maturing types, this correlation was negative with R = −0.29 and −0.50, respectively; for the medium and late maturing types, this correlation was slightly positive and R = 0.21 and 0.04, respectively.

For the three cross-combinations, analysis of the correlations between the flowering and maturing stages provided inconsistent results: for 'Housui' × 'Aikansui' and 'Xizilv' × 'Cuiguan', this correlation was negative but not significant with R = −0.10 and −0.02, respectively; for 'Xizilv' × 'Huasu', this correlation was positive with R = 0.14 and also not significant.

Distribution of maturing stages of hybrid fruit trees

The fruit maturing stage of the three cross-combinations was relatively concentrated, and for each of these combinations, the proportion of the very early and early maturing seedlings was ≥ 84 % (Table 4). The 'Xizilv' × 'Huasu' combination had the largest coefficient of variation of 7.73 %: the shortest growth stage of its progeny was 91 d

Table 2. Difference in flowering stage between pears having different types of maturing stages.

Type	Number of varieties	Time of initial flowering	Time of full flowering	Interval between time of initial and full flowering (days)
Very early maturing	15	27.4 ± 0.52 A	29.0 ± 0.53 A	1.6
Early maturing	17	25.3 ± 0.74 B	27.2 ± 0.74 B	1.9
Medium maturing	39	24.7 ± 0.38 BC	26.3 ± 0.37 BC	1.6
Late maturing	42	23.5 ± 0.46 C	25.3 ± 0.40 C	1.8

Note: Values with different letters in the same line show significant difference at P < 0.01 level.

Table 3. Correlation between flowering stage and maturing stage.

	Type	Number of individuals	Correlation coefficient (R)
Variety	Very early maturing	15	−0.29 (P = 0.33)
	Early maturing	17	−0.50 (P = 0.09)
	Medium maturing	39	0.21 (P = 0.26)
	Late maturing	42	0.04 (P = 0.84)
	Total	113	−0.28 (P < 0.01)
Hybrid seedling	'Housui' × 'Aikansui'	26	−0.10 (P = 0.64)
	'Xizilv' × 'Cuiguan'	97	−0.02 (P = 0.87)
	'Xizilv' × 'Huasu'	42	0.14 (P = 0.37)

Table 4. Distribution of maturing stages of hybrid progenies.

Cross combination	Maturing stage of parents (M/D)		Growth period of hybrids (days)				Proportion (%) Maturing			
	Female	Male	Average	Cv	Min.	Max.	Very early	Early	Medium	Late
'Xizilv' × 'Huasu'	7/15	7/15	116.09	7.73	91	147	35.71	57.14	4.76	2.38
'Xizilv' × 'Cuiguan'	7/15	7/28	117.85	6.51	94	139	32.99	64.95	2.06	0.00
'Housui' × 'Aikansui'	8/15	7/12	118.27	6.72	106	135	26.92	57.69	15.38	0.00

and the longest 147 d (a difference of 56 d); of its progeny, 35.71 % were very early, 57.14 % were early, and both medium and late maturing seedlings represented ≤ 5 % each. The 'Xizilv' × 'Cuiguan' combination had the smallest coefficient of variation of only 6.51 %: the proportion of very early and early maturing seedlings was 97.9 %, of medium maturing only 2.06 % and there were no late maturing seedlings. For the progeny of the 'Housui' × 'Aikansui' combination, the average growth stage was 118.27 d and the difference between the early and late maturing seedlings was 29 d: the very early and early represented 84.62 %, and the medium maturing seedlings were 15.38 % of the total. Thus, for the hybrid progeny, the flowering and maturing stages were not significantly correlated, which may be attributable to the too concentrated distribution of the maturing stages.

Discussion

The phenological stages of plants are attributable to the interactions between the plant genes and the environment, and there were some correlations between different phenological stages of crops. Visser and Schaap (1967) found that the time of leaf bud break was significantly related to the time of flowering in apple seedlings. De Vries (1967) found highly significant positive correlations between the flowering and fruit maturing stages in sweet cherries. Shen et al. (1980) and Sun et al. (2002) identified significant correlations between sprouting and flowering, sprouting and maturing, and flowering and maturing stages, but not between the leaf fall stage and other phenological stages. The present study analyzed the correlations between the flowering and maturing stages in 113 pear varieties and found highly significant negative correlations between the flowering and maturing stages, and also that the flowering stage was significantly later for the very early maturing compared to medium and late maturing varieties.

For the early, medium and late maturing pear varieties, there were significant negative correlations between the flowering and maturing stages. However, within each of the four types of maturing stages (i.e. very early, early, medium and late maturing) there were no significant correlations: with slightly negative correlations in the very early, early and late maturing varieties; and a positive correlation for the medium maturing varieties.

Shen et al. (1980) and Sun et al. (2002) found that the individual phenological stages of hybrid progeny shared the same tendency as the parents, i.e. for hybrid seedlings, the sprouting stage was significantly positively correlated with the flowering stage and negatively with the maturing stage, thus sprouting stage could be used for early identification of the future flowering or fruit maturing stages. For all of the three cross-combinations used in the present study there were no significant correlations between the flowering and maturing stages. The non-significant correlation between the flowering and maturing stages within a cross combination may be attributable to a relatively centralized fruit maturing stage of hybrid seedlings. However, the ranges of differences within these combinations differed significantly; for most combinations, the range was 30–50 d, and the range was not significantly correlated with the difference in maturing stages of the two parents, indicating that the range of hybrid progenies was not affected by the difference in maturing stages of the parents (Yang 1982). Pu (1979) found that the hybrid progeny of early and medium maturing varieties were prone to early maturing, and hybrid progeny of late maturing varieties were prone to late maturing. For changes in the growth stage of the three combinations tested in the

present study, the smallest was 29 d and the largest 56 d, and the proportion of very early and early maturing varieties was ≥ 84 %. Correlation analysis within each of the four types of maturing stages showed no significant correlation between the flowering and maturing stages. Thus, the flowering stage can only be used for qualitatively predicting whether a hybrid seedling was very early, early, medium or late maturing, instead of predicting the order of the time of maturing within a cross combination.

Conclusions

In pears, there was a tendency for earlier maturing with later flowering, and there was a significant negative correlation between the flowering and maturing stages. The flowering stage of very early maturing varieties was significantly later than that of medium and late maturing varieties. However, within the same cross combination, there was no significant correlation between the flowering and maturing stages. The flowering stage can be used as a basis for identifying the type of maturing stage of a hybrid seedling. However, for cross combinations where the maturing stages did not widely diverge, the order of the time of flowering could not be used to predict the order of the time of fruit maturing.

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