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Seed and Pollen Parents Affect the Weight of F_1 Seeds and the Number of Days until Emergence in Tea

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Abstract

In tea breeding, the relationship between seed weight and growth after germination has implications for the selection of hybrid seedlings. We found that the seed weight was positively correlated with the fresh shoot weight of 6-month-old seedlings. No relationship was observed between the seed weight and the number of seeds per fruit in some of the populations derived from natural crosses. Both seed and pollen parents influenced the weight of F_1 seeds. The influence of the pollen parent on the seed weight resembled xenia, a genetic effect of endosperm (3n). However, since tea seed is exalbuminous, and the cotyledons of the embryo occupy most of the volume and weight of the mature seed, the phenomenon of "pseudo-xenia" that we observed might correspond to the effects of the F_1 embryo (2n). Both seed and pollen parents also influenced the number of days until the emergence of F_1 seed. However, the seed weight did not play a major role in the time of emergence. Our results indicate that tea seed weight and the number of days until emergence are controlled independently by genetic factors of both seed and pollen parents.

Discipline: Plant breeding / Tea industry
Additional key words: *Camellia sinensis*, pseudo-xenia, xenia, exalbuminous seed

Introduction

Tea (*Camellia sinensis*) seeds measure over 1 cm in diameter. The seed contains a large amount of oil and saponin, which is an important ingredient of oil, foaming agent and chemical for eliminating fish for prawn farms in the sea. On the other hand, in tea breeding, the relationship between seed weight and growth after sowing affects the selection of hybrids, especially during the juvenile phase. The number of seeds per fruit depends on the seed parent: generally, fruit of var. *assamica* produces more seeds than that of var. *sinensis*. We found that both the pollen parent and the seed parent affected the weight and the number of days until the emergence of tea seeds.

Materials and methods

1. Relationship between seed weight and growth of seedlings

Fruits derived from a natural cross of the tea clonal cultivar 'Toyoka' were collected and stored for about 50 days at 4°C. This vernalization leads to reliable germination[5]. From 191 fruits, 365 seeds were taken out and dropped in fresh water. Those that sank (350) were dried and used for the experiment. First the seeds were weighed on an electronic balance to an accuracy of 0.01 g. Then they were sown at depths of 1.0 to 1.5 cm in about 200 mL volume of granular clay in polyvinyl-chloride (PVC) pots. The pots were maintained in a greenhouse

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under a temperature regime of 25°C (day) and 15°C (night). Pots were checked every 3 days from 16 days after sowing, and the number of days until emergence was recorded. Six months after germination, the fresh shoot weight was measured.

2. Effects of seed and pollen parents on F_1 seed weight and number of days until emergence

Fruits derived from a natural cross of the tea clonal cultivars 'Izumi, Koyanishi, Benikaori, Hatsumomiji' and 'Okuyutaka' in 1996 were collected and the seed weight and number of seeds per fruit were determined.

Tea cultivars were crossed in 1994. Eight seed parents were crossed with 1 pollen parent (Table 1) to assess the effect of the seed parent on the seed weight. Two seed parents were crossed with 3 pollen parents (5 combinations, Table 2) to assess the effect of the pollen parent on the seed weight. Three seed parents were crossed with 1 pollen parent (Table 3) to assess the effect of the seed parent on the number of days until emergence. Two seed parents were crossed with 3 pollen parents (5 combinations, Table 4) to assess the effect of the pollen parent on the number of days until emergence. Seeds were sown according to the above method after measurement of the weight. The number of days until emergence was recorded as indicated above.

Table 1. Effect of seed parent on the weight of tea F_1 seeds

Seed parent	Pollen parent	Crossing period	Area of field with mother trees	Average no. of seeds per fruit	Total no. of seeds	Average weight of seed (g)	Analysis of variance
Izumi	Sayamakaori	1994/11/1–1994/11/18	Naka-2	2.06	99	0.71	a*
Ryofu	Sayamakaori	1994/10/25–1994/11/18	Kita-6	1.70	136	0.75	a
Kanaya-13gou	Sayamakaori	1994/10/25–1994/11/8	Kita-7	2.89	77	0.93	b
Kana-Cp13	Sayamakaori	1994/10/26–1994/11/7	Naka-10	2.31	134	0.96	b
Gokou	Sayamakaori	1994/10/18–1994/10/28	Kita-7	2.43	68	1.04	b
Kana-Ck24	Sayamakaori	1994/10/24–1994/11/4	Naka-10	3.29	46	1.06	bc
Kanaya-15gou	Sayamakaori	1994/10/7–1994/10/28	Kita-7	2.04	206	1.15	bc
Yutakamidori	Sayamakaori	1994/10/11–1994/10/25	Naka-5	1.49	357	1.19	c

*Values shown by the same letter are not significantly different (P = 0.05) by Scheffe's test.

Table 2. Effect of pollen parent on the weight of tea F_1 seeds

Seed parent	Pollen parent	Crossing period	Area of field with mother trees	Average no. of seeds per fruit	Total no. of seeds	Average weight of seed (g)	Analysis of variance
Izumi	Kanayamidori	1994/11/1–1994/11/18	Naka-2	2.04	104	0.63	a*
Izumi	Sayamakaori	1994/11/1–1994/11/18	Naka-2	2.06	99	0.71	b
Ryofu	Kanayamidori	1994/10/18–1994/10/25	Kita-6	2.31	185	0.62	l
Ryofu	Sayamakaori	1994/10/23–1994/10/13	Kita-6	1.77	73	0.67	m
Ryofu	Kanaya-25gou	1994/10/25–1994/11/18	Kita-6	1.70	136	0.75	n

*Values shown by the same letter are not significantly different (P = 0.05) by Scheffe's test.

3. Relationship between F_1 seed weight and number of days until emergence

Cultivars 'Yutakamidori' and 'Sayamakaori' were crossed. The weight of 340 F_1 seeds was measured, and the seeds were sown as indicated above. The number of days until emergence was recorded as indicated above.

Results and discussion

1. Relationship between seed weight and growth of seedlings

From the 350 seeds sown, 322 seedlings germinated and grew normally. Fig. 1 shows the correlation (r = 0.55) between the seed weight and shoot weight. In particular, no individuals were observed in the upper left area of the figure (high shoot weight, low seed weight), although some individuals were found in the lower right area (low shoot weight, high seed weight). The distribution indicates that an adequate seed weight is indispensable for seedling growth. The low shoot weight in spite of the high seed weight could be due to unidentified stresses. These results indicate that seed weight (and thus nutrient content) is very important for seedling growth for at least 6 months.

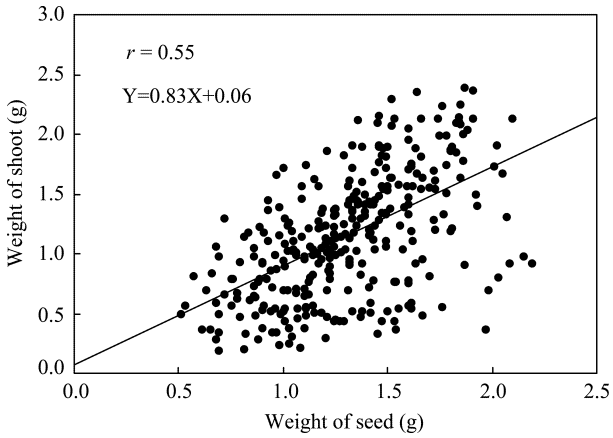

Fig. 1. Correlation between seed weight and shoot weight of 6-month-old tea seedlings derived from natural crosses of tea clonal cultivar 'Toyoka'

Table 3. Effect of seed parent on the number of days until emergence

Seed parent	Pollen parent	Area of field with mother trees	No. of seeds	No. of germinated seeds	Average no. of days until emergence	Analysis of variance
Izumi	Sayamakaori	Naka-10	99	96	37.16	a*
Kanaya-15gou	Sayamakaori	Kita-7	206	183	38.92	a
Kanaya-13gou	Sayamakaori	Kita-7	81	64	43.67	b

*Values shown by the same letter are not significantly different (P = 0.05) by Scheffe's test.

Table 4. Effect of pollen parent on the number of days until emergence

Seed parent	Pollen parent	Area of field with mother trees	No. of seeds	No. of germinated seeds	Average no. of days until emergence	Analysis of variance
Izumi	Sayamakaori	Naka-10	99	96	37.16	a*
Izumi	Kanayamidori	Naka-10	106	98	40.48	b
Ryofu	Sayamakaori	Kita-7	73	62	38.77	l
Ryofu	Kanayamidori	Kita-7	185	157	40.38	l
Ryofu	Kanaya-25gou	Kita-7	136	121	41.27	l

*Values shown by the same letter are not significantly different (P = 0.05) by Scheffe's test.

2. Effects of seed and pollen parents on F_1 seed weight

Fig. 2 shows that no detectable relationship was observed between the number of seeds per fruit and the seed weight in some populations derived from a natural cross.

There were clear differences in the weight of the seeds derived from crosses between different seed parents and the same pollen parent (Table 1). Because the mother trees were grown in the same field, the environmental conditions (such as nutrients and soil) were similar. Therefore, the differences in F_1 seed weight among the seed parents resulted from genetic differences among the seed parents.

Similarly, there were clear differences in the weight of the seeds derived from crosses between the same seed parent and different pollen parents (Table 2). Seed weight in 'Izumi' was distinctly different between the pollen parents 'Kanayamidori' and 'Sayamakaori', even though the same bush was used, the crossing dates were the same, and the number of seeds per fruit was nearly the same. This finding indicates that the pollen parent is an important genetic factor that affects the weight of F_1 seed. This effect is similar to xenia, a genetic effect of endosperm (3n). However, since tea seed is classified as an exalbuminous one, and the cotyledons of the embryo occupy most of the volume and weight of the mature seed, this phenomenon might be an effect of the F_1 embryo (2n). A similar phenomenon was observed in chestnut, whose seed is also exalbuminous[2–4,6]. When the tea seed is developing, the embryo is very small relative to the seed, and the seed is filled with endosperm. When the seed is maturing, the embryo grows rapidly and fills the seed. It is not clear whether this "pseudo-xenia" phenomenon is caused by the endosperm during the development stage or the embryo itself.

3. Effects of seed and pollen parents on number of days until emergence

There were significant differences among the seed parents in the number of days until the emergence of seeds derived from the same pollen parent (Table 3). Because the growing conditions were the same, the main influence of the seed parent appears to be genetic.

There were also significant differences among the pollen parents in the number of days until the emergence of seeds derived from the same seed parent (Table 4). Because tea seed is exalbuminous, the pollen parent seems to act on seed emergence via the F_1 embryo.

These results suggest that both seed parent and pollen parent genetically affect the number of days until the emergence of F_1 seed.

4. Relationship between F_1 seed weight and number of days until emergence

By 58 days after sowing, 338 F_1 seedlings had emerged from 340 seeds. Fig. 3 plots the seed weight

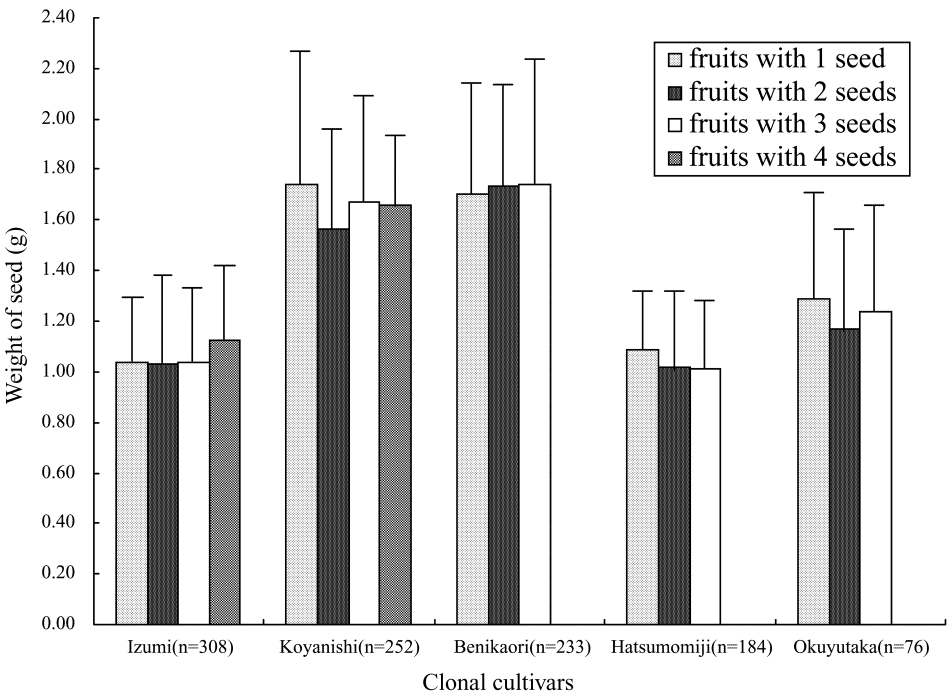

Fig. 2. Relationship between seed weight and number of seeds per fruit derived from a natural cross of tea in 1996

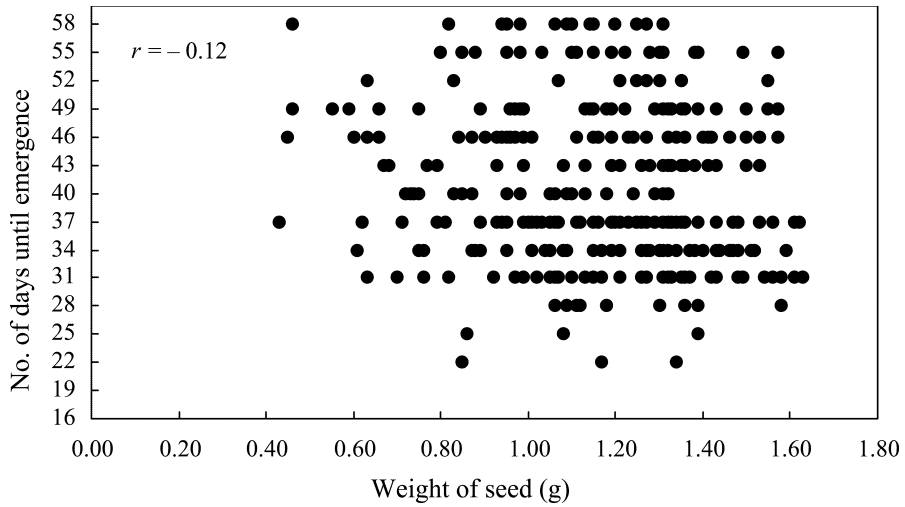

Fig. 3. Relationship between seed weight and number of days until emergence in an F_1 population derived from a cross between 'Yutakamidori' and 'Sayamakaori'

against the number of days until emergence. The value of the correlation coefficient was very low (r = –0.12) and almost no relationship could be revealed. As in the case of cauliflower, there was no relationship between the seed size and germination rate[1]. Thus, it is considered that the weight of tea seed is not a major factor that affects the number of days until emergence.

Our results indicate that tea seed weight and the number of days until emergence are controlled independently by genetic factors of both seed and pollen parents.

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