Pollination and Pollen Source Influence Fruit of Oriental Persimmon 'Fuyu' and 'Tanenashi'

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Additional index words. *Diospyros kaki*, fruit set

Abstract. Fruit characteristics of Oriental persimmon (*Diospyros kaki* L.) ['Fuyu' (Expts. 1 and 2) and 'Tanenashi' (Expt. 3)] were assessed as a function of five pollination treatments: 1) hand-pollination (HP) with 'Gailey' pollen (G); 2) HP with 'Nishimura Wase' pollen (NW); 3) HP with 'Turkeytown' pollen (T) (not used for 'Tanenashi'); 4) open-pollination (OP), which did not necessarily result in pollination; and 5) nonpollination (NP) where pollination was prevented by covering the flower. Final fruit set of 'Fuyu' and 'Tanenashi' was higher for G and NW pollen than for NP. Differences in fruit set among the remaining treatments depended on the particular experiment. For example, fruit set for OP was higher than for NP in Expts. 1 and 3 but not Expt. 2. Fruit weight and soluble solids concentration (SSC) of 'Fuyu' were not affected by treatment in Expts. 1 and 2; however, in Expt. 2, fruit height and diameter of G, NW, T, or OP were larger than for NP. Seed count per fruit was inversely related to fruit development period but did not influence fruit size or SSC. Fruit height, diameter, weight, and total soluble solids of 'Tanenashi' for G, NW, and OP exceeded those for NP, although rarely were seeds present.

The degree of parthenocarpy in Oriental persimmon depends on cultivar (Miller, 1984; Sharpe, 1966) but also is influenced by geographic region (Kitagawa and Glucina, 1984; Miller, 1984; Suzuki et al., 1989b), climate (Isoda, 1985; Mason et al., 1989; Miller, 1984; Yamada et al., 1987), and nutritional status (Suzuki et al., 1989a). Consequently, many growers and researchers are uncertain as to the extent a given persimmon cultivar will set fruit without pollination and retain it until harvest.

Seedless persimmon fruit often are preferred by consumers over seeded fruit. However, seeded Oriental persimmon fruit have several advantages over nonpollinated fruit because they are generally larger, compete better for assimilates, and are less prone to abscise than nonpollinated fruit (Bargioni et al., 1980; Hasegawa and Nakajima, 1990a, 1990b; Ito, 1986; Kitagawa and Glucina, 1984; Yamada et al., 1987). 'Fuyu' has low to mod-

erate parthenocarpic tendency, while 'Tanenashi' is highly parthenocarpic.

Environmental and physiological factors influencing fruit set of parthenocarpic cultivars of persimmon are not well known. Seedlessness in *D. kaki* has been attributed to the degeneration of the embryo sac and the embryo sac mother cell (Fukui et al., 1993). Ishida et al. (1990), working with highly parthenocarpic 'Hiratanenashi', found that ovules contained abnormal embryo sacs 30 to 60 days after anthesis. Ovules did not contain viable embryos but rather densely clustered cells, which they termed "bar tissue." Ishida et al. (1990) suggested that bar tissue substituted for the embryo in stimulating the early stages of fruit growth in 'Hiratanenashi'.

Incorporating pollinizer cultivars is recommended most often in the culture of Oriental persimmon (Ito, 1986; Kitagawa and Glucina, 1984). To our knowledge, little research has been performed concerning the influence of pollination on fruit set and fruit quality of two popular persimmon cultivars, 'Fuyu' and 'Tanenashi', in the United States. In Florida, good crops of seedless 'Fuyu' fruit (ostensibly nonpollinated) have been obtained (P. Miller and J. Mercer, personal communication). 'Tanenashi' traditionally has been grown without pollinizers (Crocker and Andrews, 1983; Hume, 1914). There have been no staminate flowers on either cultivar. Our objective was to determine the influence of pollination and pollen source on fruit set and fruit characteristics in the Oriental persimmons 'Fuyu' and 'Tanenashi'.

Materials and Methods

Two experiments were conducted using Oriental persimmon 'Fuyu' (1988 and 1989) and one experiment on 'Tanenashi' (1988). Both cultivars were grafted on *D. virginiana* L. rootstocks.

'Fuyu' (Expt. 1)

Plant material. Four, 5-year-old 'Fuyu' trees, ≈2 m tall, located in Gainesville (28.43 N and 82.25 W) on the Univ. of Florida campus were used. Trees were spaced 5 m within and between rows. A 2-m-wide, in-row strip was kept free of weeds using *N*-(phosphonomethyl) glycine (glyphosate). The soil was a well-drained loamy sand. Overhead irrigation was applied based on the condition of the surrounding peach [*Prunus persica* (L.) Batsch] orchard. The trees were fertilized three times a year using 10N–4.3P–8.3K, which also contained 1% Zn, 2% Mg, and 10% Cl. Nitrogen was in the form of NH_4NO_3 . *O,S*-dimethyl acetylphosphoramidothioate (acephate) was applied twice in March, and *O,O*-diethyl *O*-(3,5,6-trichloro-2-pyridyl) phosphorothioate (chlorpyrifos) was applied in June to control trunk and limb borers. There were three separate fungicide applications: 1) fosetyl aluminum in March; 2) a 1-(4-chlorophenoxy)-3,3-dimethyl-1-(1*H*-1,2,4-triazol-1-yl)-2-butanone (triadimefon)–mancozeb (a coordination product of Zn^{2+} and Mn^{2+} ethylene bisdithiocarbamate, in which the ingredients are 15% Mn^{+2} , 1.87% Zn^{+2} , and 58.13% ethylene bisdithiocarbamate ion) tank mix in March, and 3) *N*-trichloromethylthio-4-cyclohexene-1,2-dicarboximide (captan) in September.

Pollination treatments. The three pollinizer cultivars were 'Gailey', 'Nishimura Wase', and 'Turkeytown'. Pollen was collected from trees in Gainesville ('Gailey' and 'Nishimura Wase') and near Chiefland (29.30 N and 82.50 W), Fla. ('Turkeytown'). In Florida, these cultivars are classified as pollination variant (i.e., nonastringent when seeded and astringent when not seeded) (Miller, 1984). Fruit of 'Nishimura Wase' trees are much higher in quality than those of 'Turkeytown' or 'Gailey' (J. Mercer, personal communication). 'Nishimura Wase' does not produce as many staminate flowers as the other two cultivars, but it does produce them reliably each season.

The following treatments were randomly assigned to individual flower buds of four trees: 1) hand-pollination (HP) with 'Gailey' pollen (G); 2) HP with 'Nishimura Wase' pollen (NW); 3) HP with 'Turkeytown' pollen (T); 4) open-pollination (OP), which did not necessarily result in pollination; and 5) nonpollination (NP), which was accomplished by preventing insect pollination. Although all treatments were applied to all trees, the number of flowers used for each treatment varied as a result of the limited availability of pollen and the uneven anthesis of pistillate flowers. Individual flower buds were tagged and numbered. The flower buds selected were ≈12 to 15 cm apart with ≈15 leaves per fruit, which

Received for publication 26 June 1995. Accepted for publication 14 Nov. 1995. This is Florida Agricultural Expt. Station Journal Series no. R-04508. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.

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resulted in most limbs having two buds per shoot and six buds per 2-year-old branch. Buds on branches that were not used also were thinned to ≈ 12 to 15 cm apart. Two days before anthesis, drawstring pouches, made from a fine mesh nylon fabric, were placed on the flower bud for each treatment to prevent insect pollination. Pouches were removed only to allow hand-pollination and were kept on until the stigmas were nonreceptive (i.e., denoted by being brown and dried).

Pollen was collected from the male flowers every 2 to 3 days. These flowers were collected just before anthesis and were air-dried overnight. Pollen was stored in airtight glass sample bottles and refrigerated at 5.5 to 6°C. Persimmon pollen is viable under refrigeration at 5.5°C for ≤ 1 week (Ito, 1986). Opened flowers were pollinated during midday using a small camel hair brush. A separate brush was used for each treatment. After pollination, the flowers were recovered until the stigmas were nonreceptive. Pollinations were performed from 22 to 29 Apr., although the actual pollination date for each flower was not recorded. Also, the exact number of flowers pollinated on each date varied. Thus, fruit development period was not calculated.

Variables measured. The date of fruit abscission was estimated by examining fruit from 22 Apr. to 20 Nov. at 10-day intervals. Fruit height and diameter were measured with calipers at these intervals. Fruit were harvested from the end of August through October, when the fruit was pigmented light orange to deep orange with no yellow or green visible. Harvest date was recorded and final fruit weight, height, and diameter were measured. Fruit were dissected at harvestable maturity. Fruit shape is defined by fruit height $\div$ fruit diameter. A section was taken from each fruit at the middle top (peduncle region) and the middle bottom (calyx region). Mean soluble solids concentration (SSC) was calculated from fruit sections located in the peduncle and the calyx regions. Fruit sections then were squeezed through fine nylon mesh, and the SSC was measured with a temperature-compensated refractometer (AO Instrument Co., Buffalo, N.Y.). The total soluble solids (TSS) per fruit was calculated as mean SSC $\times$ fruit weight.

Seed count per fruit and seed weight were recorded. Persimmon seeds were dipped in a 1.05% sodium hypochlorite and triple-rinsed in tap water. The percentage of seeds that germinated for each treatment was determined after 6 weeks of stratification at 6°C. Seeds were placed in a 1 vermiculite : 1 peat : 1 potting soil in a greenhouse and misted several times a day. The greenhouse air ranged from 22 to 32°C, and the germination period lasted 60 days.

Statistical analyses. Experiment 1 was designed and analyzed as a completely random design. Data were analyzed using the general linear models (GLM) procedure of the Statistical Analysis System (SAS Institute, 1985). The experimental unit in all cases was the individual flower or fruit. Sample sizes per treatment varied with treatment due to differ-

ences in the availability of pollen and the treatment-dependent variation in fruit set. Fruit drop was recorded as categorical data distinguished on the basis of whether a fruit abscised before harvest. The categorical fruit drop and final fruit set data were analyzed using a cross-tabulation table and Cochran–Mantel–Haenszel statistics (equivalent to χ^2 test but used for unbalanced and sparse data sets) (Agresti, 1990). Where significant differences in fruit set or fruit drop occurred, a Tukey–Kramer multiple comparison procedure, which is suitable for nonparametric data, was used for the statistical separation of treatments (Hochberg and Tomhane, 1987). If significant, means of noncategorical data were separated using SAS's GLM procedure (SAS Institute, 1985). The same statistical procedures were used for all experiments.

'Fuyu' (Expt. 2)

Plant material. A second 'Fuyu' experiment was conducted in 1989 using ten, 10-year-old 'Fuyu' trees located at Turkeytown Orchards. Trees were spaced 6 m within and between rows. A cover crop of rye (*Secale cereale* L.) and oats (*Avena sativa* L.) were used in row middles. In-row strips 2 m wide were maintained free of weeds with herbicides. The soil was a well-drained sandy loam. Trees were grown without irrigation, except during extended periods of drought (i.e., >1 month without significant precipitation). The orchard was fertilized twice per year with 8.0N–5.2P–13.3K, which also contained 5% Mg and 1% Mn. Insecticides and fungicides were applied as needed.

Flowers were pollinated from 9 to 19 Apr. 1989. Eleven days were required because the availability of pollen depended on cultivar and the period of stigma receptivity varied for 'Fuyu'. The pollination methods, treatments, dependent variables, and statistical analysis used were the same as those described for Expt. 1. Fruit size was not recorded continuously in Expt. 2 over the fruit development period. Pollination date was recorded for HP treatments, and fruit development period was estimated as harvest date minus pollination date. Fruit development periods were estimated for OP and HP dates by subtracting mean HP dates from the actual dates of harvest. The development period of fruit from HP and OP treatments also were correlated with seed number using GLM procedures of SAS.

'Tanenashi' (Expt. 3)

Plant material. Three, 12-year-old 'Tanenashi' trees (≈ 2.5 m tall) at Turkeytown Orchard were used in this experiment. Fertilizer and pesticide schedules were similar to those of 'Fuyu' in Expt. 2.

Pollination procedures. Pollen was applied on 5 days during an 8-day period (10 to 18 Apr.). Pollination methods, pollination treatment variables, and statistics were the same as described for Expt. 1. Insufficient availability of 'Tanenashi' and 'Nishimura Wase' pollen and variable fruit drop among

treatments resulted in uneven sample sizes.

'Tanenashi' fruit were harvested from mid-August through October when fruit was a light orange with no green or yellow visible. After harvest, 'Tanenashi' fruit were allowed to ripen and soften until juice could be extracted. Before softening, soluble tannins interfere with the SSC determination, resulting in abnormally high readings (Sugiura et al., 1983). The number of seeds, the number of ovules containing abnormal embryo sacs, and bar tissue (Ishida et al., 1990) were recorded based on visual observation.

Results

'Fuyu' (Expt. 1)

Percent final fruit set and fruit drop periods. Fruit set for G, NW, T, and OP was higher than for NP (Table 1). Final fruit set of T was higher than of NW, yet G, T, and OP did not differ from one another. Of the fruit abscission of 'Fuyu', $>75\%$ occurred within 40 days of anthesis for all treatments (data not shown). Of the fruit that abscised, $<2\%$ did so >100 days following anthesis. Harvest date was not influenced by treatment (range 14–20 Nov.) (data not shown).

Fruit characteristics. The relative increase in fruit height and width was rapid and curvilinear during the first 65 days of fruit development but was linear and more gradual 65 to 220 days after the mean pollination date (data not shown). Fruit characteristics were not influenced by treatments in Expt. 1 (Table 2). Seed count per fruit was higher for G than OP; there were no other significant differences in seed count per fruit among treatments. Seeds were absent in NP fruit. All HP fruit contained seeds at harvest, and $\geq 85\%$ of fruit from these treatments had at least three seeds (data not shown). Similarly, 85% of OP fruit had two to five seeds. Seed count per fruit was not correlated with fruit size or shape (data not shown). Seed viability was not influenced by pollination treatment (viability was $>70\%$ for all treatments; detailed data not shown).

Table 1. Percent final fruit set as related to pollen donor in the Oriental persimmon 'Fuyu' and 'Tanenashi'.^z

Treatment	Final fruit set (%)		
	Fuyu		Tanenashi
	Expt. 1	Expt. 2	Expt. 3
Gailey	57.7 ab ^y (26)	48.6 a (70)	63.0 a (27)
Nishimura Wase	30.0 b (30)	54.0 a (63)	60.5 a (43)
Turkeytown	66.7 a (12)	44.6 ab (65)	---
Open pollination	43.2 ab (291)	15.9 c (69)	56.9 a (394)
Nonpollination	2.8 c (142)	26.0 bc (66)	31.8 b (85)

^zPercent means separation in columns by Cochran–Mantel–Haenszel statistics (based on table scores) at $P \leq 0.01$.

^yNumbers in parentheses indicate the number of observations.

'Fuyu' (Expt. 2)

Percent final fruit set and fruit drop periods. Fruit set for G and NW was higher than for OP or NP, yet T differed only (i.e., higher) from OP (Table 1). Fruit set among HP treatments did not differ. Of the fruit drop, $\geq 75\%$ occurred within 60 days after anthesis (data not shown).

Fruit development period was inversely related to seed count per fruit (Fig. 1), and 75% of the variation in fruit development period was explained by seed count per fruit. Each seed contributed to a 4.5-day average reduction in fruit development period.

Fruit characteristics. Fruit height and diameter for G, NW, T, and OP exceeded those for NP (Table 2). Fruit weight, SSC, and TSS were not significantly influenced by treatment.

Fruit from G, NW, and T contained 3.0 to 4.2 seeds, while fruit from OP and NP contained no seeds (Table 2). Seeded fruit represented 78%, 86%, and 86% of the G, NW, and T fruit at harvest, respectively. Fruit with three or more seeds accounted for 64% and 76% of the fruit from the HP treatments at harvest. Mean seed weight for T exceeded that for NW but not G. Seed per fruit was not correlated with fruit height, fruit diameter, fruit weight, SCC, or TSS (data not shown).

'Tanenashi' (Expt. 3)

Percent final fruit set and fruit drop periods. Final fruit set was higher for G, NW, T, and OP compared to NP (Table 1); however, fruit set did not differ between OP and HP. Fruit abscission in all treatments occurred mainly between 21 and 100 days after anthesis; $<2\%$ of the total drop occurred during the next 40 days. No fruit abscised later than 100 days after anthesis in any of the HP treatments.

Fruit characteristics. Height and weight for fruit of G, NW, and OP exceeded those for NP (Table 3). Fruit diameter was smaller for NP compared to the remaining treatments, except NW. Fruit height and diameter were about equal, so that fruit shape was nearly spherical in all treatments. There were no differences in SSC among treatments (Table 3). TSSs were higher for G and OP than for NP. Only four of 182 'Tanenashi' fruit (2.7%) had seeds, and five seeds were the most found in a single fruit. Aborted embryos (means = 0.45 to 0.83 per fruit) occurred only in HP and OP fruit. 'Tanenashi' fruit subjected to HP or OP contained numerically, but not statistically, more bar tissue than OP (1.9 to 2.1 vs. 1.6).

Discussion

Final fruit set of 'Fuyu' increased more markedly by pollination in Expt. 1 than Expt. 2 (Table 1). Only 2.8% of NP fruit reached harvestable maturity in Expt. 1 and 26% in Expt. 2. The yearly variability in fruit set of 'Fuyu' is in accordance with that reported for persimmon cultivars with low to moderate parthenocarpic ability (Bargioni et al., 1980; Ito, 1986). One possible reason why OP was less successful in Expt. 2 (16%) compared to

Table 2. The influence of pollen donor on various fruit characteristics of the Oriental persimmon 'Fuyu' (Expts. 1 and 2).

Dependent variable ^z	Pollen donor				
	Gailey	Nishimura	Turkeytown	Open	None
Fruit height (cm)					
Expt. 1	5.6	5.7	5.8	5.5	5.4
Expt. 2	5.4 a	5.2 a	5.3 a	5.2 a	4.5 b
Fruit diameter (cm)					
Expt. 1	7.9	7.8	8.0	7.6	7.6
Expt. 2	7.6 a	7.2 a	7.4 a	7.5 a	6.5 b
Fruit weight (g)					
Expt. 1	200	198	210	180	175
Expt. 2	188	168	173	184	145
Mean SSC (%) ^y					
Expt. 1	17.7	18.6	17.2	18.0	18.2
Expt. 2	17.4	17.6	17.2	17.2	18.6
TSS (g/fruit) ^y					
Expt. 1	35.9	36.8	35.9	32.5	31.4
Expt. 2	32.7	29.8	29.8	32.7	27.5
Seed count/fruit					
Expt. 1	4.9 a	4.3 ab	4.1 ab	3.4 b	0.0 c
Expt. 2	3.0 a	3.1 a	4.2 a	0.0 b	0.0 b
Mean seed weight (g)					
Expt. 1	0.95 a	1.10 a	0.87 a	0.95 a	---
Expt. 2	1.05 ab	0.98 b	1.12 a	---	---

^zMean separation in rows was performed using the least square method at $P \leq 0.05$ only if means were significantly different.

^ySSC = soluble solids concentration; TSS = total soluble solids.

Fig. 1. Relationship between seed count per fruit and mean fruit development period of *Diospyros kaki* 'Fuyu' during 1989. Linear regression equation $Y = 216.4 - 4.57x$; $r^2 = 0.75$; $P < 0.003$. Vertical bars represent ± 1 SE.

Table 3. The effects of pollen donor on fruit characteristics of the Oriental persimmon 'Tanenashi' (Expt. 3).

Dependent variable ^z	Pollen donor			
	Gailey	Nishimura Wase	Open	None
Fruit height (cm)	7.62 a	7.17 b	7.23 ab	6.76 c
Fruit diameter (cm)	7.81 a	7.30 a-c	7.54 ab	7.02 c
Fruit weight (g)	258.2 a	223.8 a	237.7 a	185.9 b
Mean SSC (%) ^y	14.18	14.40	14.312	15.04
TSS (g/fruit) ^y	37.0 a	33.2 ab	33.8 a	27.6 b
Seed count/fruit	0.39 a	0.25 ab	0.02 b	0.00 c

^zMean separation in rows was performed using the least square method at $P \leq 0.05$ only if means were significantly different.

^ySSC = soluble solids concentration; TSS = total soluble solids.

Expt. 1 (43%) was that pollinizer trees were planted less densely (1:40 vs. 1:16), which likely contributed to seedlessness of abscised and harvested fruit (i.e., fruit was parthenocarpic). Cultural practice and climate can greatly affect crop load (Hasegawa et al., 1991; Matsumoto and Kuroda, 1982). Differences in tree age (5 years older in Expt. 2) may have contributed to a higher set of OP or HP fruit in Expt. 2 (25.6%) compared to Expt. 1 (0.9%) because older *D. kaki* trees usually set more parthenocarpic fruit than young trees (Crocker and Andrews, 1983; Isoda, 1985). 'Fuyu' fruit with three or more seeds represented $\geq 60\%$ of the fruit at harvest in both years. These results agree with those of Suzuki et al. (1988), where persimmon fruit with three or more seeds represented most fruit at maturity.

The influence of pollination was primarily manifested in increased fruit set and not in differences in fruit size or quality. Similarly, increasing seed number per fruit was correlated with a reduced fruit development period but not with differences in fruit size. Pollination affected fruit shape of 'Fuyu' in 1989 but not in 1988. However, in 1989, more seedless fruit developed to harvestable maturity, thus yielding a larger sample from which to accurately quantify and compare variables of fruit quality. Hasegawa and Nakajima (1990a) found that 'Maekawa-Jiro' fruit with partially developed seeds had higher SSC and better color than fruit with no evidence of seeds. In contrast, fruit weight, SCC, and TSS of 'Fuyu' were not influenced by pollination treatment or seed number in our experiments.

The significant increase in fruit set for 'Tanenashi' subjected to HP or OP (57% to 63%) compared to NP (32%) was unexpected because this cultivar is vegetatively parthenocarpic and 'Tanenashi' fruit seldom form seed (Crocker and Andrews, 1983; Miller, 1984). Fruit weight, height, diameter, and TSS for HP and OP fruit exceeded those for NP. These data suggest that stimulative parthenocarpy and stenospermarpy increased fruit set and fruit size (Bargioni et al., 1980; Ishida et al., 1990). The development of bar tissue in response to pollination may have been responsible for increased fruit set and fruit size of 'Tanenashi', similar to that reported for the highly parthenocarpic persimmon 'Hiratanenashi' (Ishida et al., 1990).

Our data support the contention that 'Fuyu' and 'Tanenashi' should be planted with pollinizer cultivars to increase the likelihood of acceptable fruit set and yield. Fruit set was influenced by pollinizer cultivar, although fruit characteristics were generally similar. We were not able to establish an optimum pollinizers ratio for 'Fuyu' from these experiments because of the confounding effects of differences in cultural practice, climate, and tree age in the two experiments, although final fruit set was 2.5-fold higher for OP in Expt. 1 (1 pollinizer : 16 'Fuyu' ratio) than in Expt. 2 (1 pollinizer : 40 'Fuyu' ratio). Because 'Fuyu' often bears heavy and light crops in alternate years (Jackson, 1986; Miller, 1984; Suzuku et al., 1988; Yamada et al., 1987), a lack of pollination may result in an especially poor crop during the off year.

Literature Cited

- Agresti, A. 1990. Categorical data analysis. Wiley, New York. p. 230-234.
- Bargioni, G., P.L. Pisani, A. Ramina, and F. Castelli. 1980. Physiological aspects of fruit set, drop and growth of parthenocarpic and normal fruit in *Diospyros kaki*. Hort. Abstr. 50:31-37.
- Crocker, T.E. and C.P. Andrews. 1983. Fruit crops fact sheet: The persimmon. Univ. of Florida, Gainesville, Publ. FC-20.
- Fukui, H., Y. Wakayami, and M. Nakamura. 1993. Yearly fluctuation of abnormal embryo sacs observed in Japanese persimmon *Diospyros kaki* cv. Nishimurawase. J. Jpn. Soc. Hort. Sci. 62(1):21-26.
- Hasegawa, K., K. Imafuji, and Y. Nakajima. 1991. The influence of dormant pruning (heading back) on flower formation and fruit development on young persimmon (*Diospyros kaki* L.) trees. J. Jpn. Soc. Hort. Sci. 60(1):9-18.
- Hasegawa, K. and Y. Nakajima. 1990a. Effects of seediness on fruit quality of Japanese persimmon cv. Maekawa-Jiro. J. Jpn. Soc. Hort. Sci. 59(2):255-262.
- Hasegawa, K. and Y. Nakajima. 1990b. Effects of flowering date, seediness, GA treatment and location of fruits in the foliar canopy on the fruit quality of persimmon (*Diospyros kaki* Thunb.). J. Jpn. Soc. Hort. Sci. 59(2):263-270.
- Hochberg, Y. and A.C. Tomhane. 1987. Multiple comparison procedures. Wiley, New York. p. 275-277.
- Hume, H.H. 1914. A kaki classification. J. Hered. 5:400-406.
- Ishida, M., M. Konishi, A. Kitajima, and Y. Sobajima. 1990. Abnormalities of seed development in a parthenocarpic Japanese persimmon, *Diospyros kaki* cv. Isoda, Hiratanenashi. J. Jpn. Soc. Hort. Sci. 59:65-73.
- Isoda, R. 1985. Effects of environmental factors on fruit quality of Saijo persimmon. Bul. Hiroshima Agr. College (Japan) 7(4):477-483.
- Ito, S. 1986. Persimmon, p. 355-370. In: S.P. Monselise (ed.). CRC handbook of fruit set and development. CRC Press, Boca Raton, Fla.
- Jackson, D. 1986. The persimmon, p. 251-255. In: S.P. Monselise (ed.). Temperate and subtropical fruit production. Butterworth, Wellington, New Zealand.
- Kitagawa, H. and P. Glucina. 1984. Persimmon culture in New Zealand. Science Information Publishing Center, Wellington, New Zealand.
- Mason, K.A., P.G. Glucina, and E.A. Macrae. 1989. Maturation and chilling sensitivity of 'Fuyu' persimmon in New Zealand. N.Z. J. Crop & Hort. Sci. 17(3):251-257.
- Matsumoto, Y. and K. Kuroda. 1982. Studies in bud and fruit thinning of Japanese persimmon. The establishment of the standard of thinning to obtain large 'Fuyu' fruits. Bul. Nara Agr. Res. Sta. 13:9-20.
- Miller, E.P. 1984. Oriental persimmons in Florida. Proc. Fla. State Hort. Soc. 97:340-344.
- SAS Institute. 1985. SAS/STAT guide for personal computers, Version 6 ed. SAS Inst., Cary, N.C.
- Sharpe, R.H. 1966. Persimmon variety and rootstock observations. Proc. Fla. State Hort. Soc. 79:374-379.
- Sugiura, A., I. Kataoka, and T. Tomana. 1983. Use of refractometer to determine soluble solids of astringent fruits of Japanese persimmons. J. Hort. Sci. 58(2):241-246.
- Suzuki, A., K. Aoba, Y. Murakami, and T. Maotani. 1989a. Effect of nitrogen nutrition on physiological fruit drop of Japanese persimmon, *Diospyros kaki* (Thunb.). Bul. Fruit Tree Res. Sta. A (Ibaraki) 16:39-45.
- Suzuki, A., Y. Murakami, and Y. Maotani. 1988. Studies on physiological fruit drop of persimmon, *Diospyros kaki* Thunb. IV. Effect of fruit growth on physiological fruit drop of persimmon. Bul. Fruit Tree Res. Sta. A (Yatabe) Japan 15:41-49.
- Suzuki, A., T. Sugiura, Y. Murakami, and T. Maotani. 1989b. Physiological studies on physiological fruit drop of Japanese persimmon, *Diospyros kaki* (Thunb.). V. Relationship between auxin in fruit and physiological fruit drop of Japanese persimmon cv 'Hiratanenashi'. Bul. Fruit Tree Res. Sta. A (Ibaraki) 16:31-37.
- Yamada, M., A. Kurihara, and T. Sumi. 1987. Varietal differences in fruit bearing in Japanese persimmon *D. kaki* Thunb. and their yearly fluctuations. J. Jpn. Soc. Hort. Sci. 56(3):293-296.