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Editor(s)	
Citation	Bulletin of the University of Osaka Prefecture. Ser. B, Agriculture and biology. 1961, 11, p.85-98
Issue Date	1961-03-31
URL	http://hdl.handle.net/10466/2896
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Bull. Univ. Osaka Pref.,
Ser. B. Vol. 11, 1961

Effects of the Enviromental Factors upon the Differentiation and Development of Fruit Buds of the Peach Trees

By

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(Received Nov. 8, 1960)

A number of evidences have been reported regarding the effects of various environmental factors upon the differentiation and development of fruit buds of the peach.

EGUCHI (1927, '28), AONO (1928), KAWAGUCHI (1932), MIWA (1937), KOMATSU (1949) and others have reported the close relations between the environmental factors such as temperature, light, and precipitation and the fruit bud formation.

However, the correlation of various environmental factors and the nutritional status in the tree which influences the formation of fruit buds are not sufficiently confirmed.

The present study was made regarding the time of fruit bud differentiation of the peach at twenty different regions in Japan and the effects of temperature, light, soil moisture, fertilizer application, and defoliation upon the fruit bud formation in 1956–1959.

And moreover chemical analyses in the shoots of the peach tree used in these experiments were made.

Materials and Methods

The peach variety "OKUBO" was used in all the experiments.

Bud samples were collected at ten days' intervals from early July to late August and then were collected at intervals of twenty days or at intervals of a month untill next January.

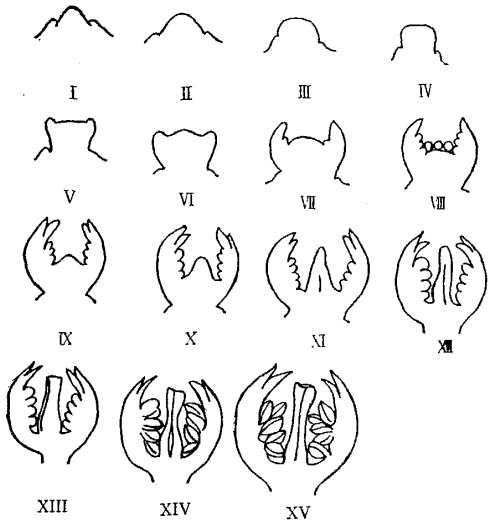
About ten to twenty buds were collected from the trees in all the treatments and were preserved immediately in 70 per cent alcohol.

These samples were prepared and sectioned for a microscopic examination.

A diagrammatical key to the various stages of bud development is shown in Fig. 1, following EGUCHI's determination.

The shoot samples collected in August, 1958 and 1959, were immediately oven-dried at 75 degrees C, and were ground in a mill. These samples were extracted by

This study has been supported in part by a Grant in Aid for Fundamental Scientific Reseach from the Ministry of Education.



I. No evidence of differentiation
II. First stage of differentiation
III. Second stage of differentiation
IV. Final stage of differentiation
V. Appearance of sepal primordia
VI. Development of sepal primordia
VII. Appearance of petal primordia
VIII. Appearance of stamen
IX. Pistil initial prominent; anthers well developed
X. Pistil larger than in stage IX.
XI. Enlargement of pistil and anthers and with ovarian cavity well formed
XII. Appearance of ovule initial in pistil; immature pollen mother cells in anthers
XIII. Further enlargement of ovule and development of pollen mother cells
XIV. Increased size of ovule and maturation of pollen mother cells
XV. Continued development of ovules

Fig. 1. Diagrammatical key to the stages of development of fruit buds of the peach.

80 per cent alcohol and used for the determination of total carbohydrate by the Somogyi modified method. The same ground samples were used for total nitrogen analyses by the semi-micro-Kjeldahl method. These ground samples were ashed at 500 degrees C, and were solved by using hydrochroric acid. With these ash solutions, phosphorus was determined by the Ammonium Molybdate method, and potassium was determined using the flame photometer, and then calcium and magnesium by the Chelate titration method.

Experiment 1. Correlations between the time of differentiation of fruit buds of the peach and the climatic conditions at twenty different regions in Japan.

Materials and Methods;

Bud samples were collected simultaneously at intervals of ten days from July 10 to August 30, 1957, from 5 to 10-year-old Okubo peach trees, which were cultivated in twenty different regions in Japan. These bud samples were gathered and the stages of development of buds were investigated.

As to the climatic data in 1957, Monthly Report of Japan Meteological Agency was referred to.

Results and Discussion;

The results shown in Table 1 indicate that the climatic conditions in these regions, which could be classified into three groups, had close relation with the time of dif-

Table 1. The range in stages of development of fruit buds observed in OKUBO peach trees (5 to 10-year-old) collected from twenty different regions in Japan, climatic conditions on June, July, and August, and heat summations above 10 degrees C in 1957. (1957)

	July 10	July 20	July 30	Aug. 10	Aug. 20	Aug. 30	Average Temp. on June, July, and August (°C)	Total Precip. on June, July, and August (mm)	Mean of percent of number of hours with sunshine on June, July, and August (%)	Heat Summations above 10°C from the time of sprouting to the time of differentiation of fruit buds (°C)
Fukushima(Fukushima)	I	I	I～II	II	III～IV	IV～V	22.0	523.7	33.7	856.6
Yamagata (Tsuruoka)	I	I	I～II	II～III	III～IV	IV～V	21.3	544.8	47.0	749.5
Niigata (Niigata)	I	I	I～II	II～III	III～IV	IV～VI	22.7	423.5	45.7	864.6
Ishikawa (Ishikawa)	I	I	I～II	II～III	III～IV	IV～V	23.3	490.2	39.0	875.1
Nagano (Ina)	I	I	I～II	II	III～IV	IV～VI	22.1	723.6	38.3	879.5
Chiba (Tateyama)	I	I～II	II～III	III～IV	III～IV	IV～V	23.0	630.7	42.6	918.0
Shizuoka (Iwata)	I	I～II	II～III	III～IV	IV～V	VI～VII	23.8	960.8	36.3	914.0
Aichi (Koromo)	I	—	II～III	III～IV	IV～V	V～VI	24.1	778.3	38.7	940.0
Mie (Tsu)	I	I～II	II～III	III～IV	IV～V	V～VI	23.8	606.3	41.3	898.7
Kyoto (Kyoto)	I	I	II	II～III	IV～V	VI～VII	24.6	759.9	36.0	1045.2
Osaka (Sakai)	I	I～II	II～III	III～IV	IV～V	VI～VII	25.1	874.4	40.0	1034.9
Tottori (Tottori)	I	I～II	II～III	IV～V	VI～VII	VII～VIII	23.3	519.4	35.7	858.7
Shimane (Matue)	I	I～II	II	III	IV～V	V～VI	23.4	606.2	38.8	869.9
Okayama (Okayama)	I	I～II	II～III	III～IV	V～VI	VI～VII	24.2	521.7	35.3	935.8
Hiroshima (Saijo)	I	I～II	II～III	III～IV	IV～V	VI～VII	23.9	917.7	34.7	935.0
Kagawa (Takamatsu)	I	I～II	II～III	III～V	IV～VI	VI～VIII	24.3	493.9	33.3	971.1
Ehime (Matsuyama)	I～II	II	II～III	IV～V	V～VI	VII～VIII	24.6	511.1	42.7	825.6
Kochi (Kochi)	I～III	II	III～IV	III～V	IV～VI	VI～VIII	25.0	1084.8	34.3	938.1
Fukuoka (Kurume)	I～III	I～II	II～III	IV～V	VI～VII	VII～VIII	24.8	1137.8	36.0	866.5
Miyazaki (Miyazaki)	I～II	II～III	III～IV	IV～V	VI～VII	VII～VIII	25.1	881.2	45.0	949.4

ferentiation of fruit bud, in spite of the differences of the tree age and the methods of cultivation.

The samples collected in the southern group, EHIME, KOCHI, and KYUSHU distinct, showed the initiation of floral primordia early on July 10, and the samples in the central group, CHIBA, OSAKA, KAGAWA and others, showed it on July 20, and in the northern group, FUKUSHIMA, NIIGATA, NAGANO and others, it was not seen until July 30, 1957.

The average mean temperature in June, July, and August of the districts of three groups was about 25 degrees C in the southern group, 23 to 25 degrees C in the central group, and below 23 degrees C in the northern group.

Furthermore, it was found that the heat summations above 10 degrees C from the time of sprouting in April to the time of fruit bud differentiation were about 900 degrees C in various regions from which the samples were collected.

EGUCHI (1931) recognized that there was a close relation between the time of differentiation of the fruit buds in peach, pear, and Japanese apricot and the time of maximum temperature in the year.

SUSA and MURAMOTO (1934), however, denied such a relation and found that high

temperature, drought, and day length in June influenced the fruit bud differentiation in an apple.

From the results of this experiment, it was impossible to deduce this correlation, since the maximum temperature in the year of various regions always arrived later than the time of fruit bud differentiation.

Experiment 2. Effects of high temperature on the differentiation and development of fruit buds of the peach.

Materials and Methods;

On March 15, 1958, one-year-old OKUBO peach trees were planted in 2-gallon-pots, and seven plants were used in each treatment. The plants were carried into a chamber which was made of wood, 2 meters on each side and was covered with semi-transparent binyl film to maintain the high temperature. Two treatments and the control were established as follows;

A; *High day and night temperature*—The plants were placed in the chamber throughout the experiment.

B; *Hight night temperature*—The plants were carried into the chamber from 6 p.m. to 9 a.m. every day.

C; *Control*—The plants were always put outdoors.

Results and Discussion;

The time of dfferentiation and development of fruit buds in plot A was about 10 days later than in plot B and C as shown in Table 2.

Table 2. The range in stages of development of fruit buds observed from the temperature trertments in OKUBO peach trees.

	July 10	July 20	July 30	Aug. 20	Sept. 20	Oct. 20
High day and night temp.	I	I	I～II	II～III	VIII	XI～XII
High night temp.	I	I～II	II	IV～V	VIII～IX	XI～XII
Control	I	I～II	II	IV～V	VIII～IX	XI～XII

However, the stages of development of fruit buds on October 20 were not found to be different in each treatment.

Mean degrees of the maximum temperature and those of the minimum temperature for ten days throughout the experiment in each plot were shown in Fig. 2.

Total fresh weight, number of fruit buds and leaf buds per unit shoot length and carbohydrate contents in the shoots were the highest in plot C, and successively lower in plot B and A. On the contrary, the shoot length and the total nitrogen contents in shoots were more remarkable in plot A. (Table 3)

The retardation of fruit bud formation and growth resulted from the defficiency of reserve carbohydrates, which might be due to the greater amount of respiration than the assimilation by the high temperature.

Although the differentiation of fruit bud in plot B was as early as in plot C, the number of fruit buds per unit shoot length and the ratio between carbohydrate and nitrogen contents in shoots of plot B, were smaller than in that of plot C. These results may be considered to be due to the effect of high night temperature.

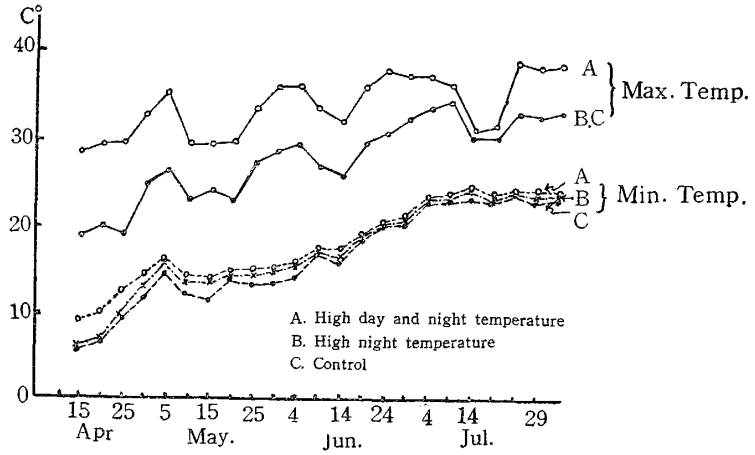


Fig. 2. Seasonal changes of mean degrees of the maximum temperature and those of the minimum temperature for ten days in each temperature treatment.

Table 3. Effects of the temperature treatments on the shoot growth, the number of fruit buds per meter and the nutritional status in shoots of OKUBO peach trees. (1958)

	Shoot Length	Total Fresh Weight	No. of Friut buds per meter shoot	No. of Leaf buds per meter shoot	N (Per cent dry wt.)	Carbo-hydrate (Pecent dry wt.)	C-N Ratio
	(cm)	(g)					
High day and night temp.	111.9	142.0	44.3	33.9	1.84	8.95	4.86
High night temp.	87.1	155.5	61.8	43.3	0.92	9.74	10.58
Control	74.0	171.0	83.6	44.0	0.90	9.67	10.74

EGUCHI (1934, 1936) found that in the young straw berry plants put in the refrigerator, controlled 5 degrees C, during the night from August 10 to September 10 the differentiation of fruit buds was promoted about a month.

KODERA (1952) observed that the differentiation of the fruit buds of the Japanese apricot trees which were carried into the glass house from May 15 to June 20 and from June 1 to July 15 was about a month earlier than the control respectively.

Experiment 3. Effects of photoperiodism and light intensity on the differentiation and development of fruit buds of the peach.

Materials and Methods;

One-year-old peach trees of OKUBO variety planted in 2-gallon-pots were used.

The treatments were started on April 22, 1957 and were continued until October 1, 1957. Ten plants were placed in each of the following treatments;

1. *Control*; The natural day length varied from 15 hours of light on July to 12 hours of light on September, at SAKAI, OSAKA.
2. *Long photoperiods-18 hours light*; To obtain 18 hours of day length, the plants were lighted by means of about 220 Lux of fluorescent lamps in the evening.
3. *Short photoperiods-6 hours light*; Plants were carried into the dark chamber covered with black binyl film from 4 p.m. to 10 a.m. each day.
4. *Shade I-about 25 per cent of day light*; Plants were shaded with a marsh-reed-screen during the experiments.

5. *Shade II–about 2 per cent of day light*; Plants were shaded with two marsh-reed-screens during the experiments.

Results and Disucassion

As shown in Table 4 and 5, the differentiations of fruit buds under the long

Table 4. The range in stages of development of fruit buds observed from the light treatments in OKUBO peach trees. (1959)

Date / Plot	July 20	July 30	Aug. 10	Aug. 20	Aug. 30	Sept. 16	Sept. 30	Nov. 21
Control	I	I～II	II	III～IV	V	VII～VIII	X	XII
Long Photoperiods	I～II	II	II～III	V	V～VI	VII～VIII	X～XI	XII～XIII
Short Photoperiods	I～II	I～II	II～III	III	III～VI	V～VI	X	XII
Shade I	I	I	I	II～III	VI～V	VI～VII	VIII～IX	XII
Shade II	I	I	I	I	I	II	III	IV

Table 5. Duration and intensity of light, and temperature in each treatment, and effects of the light treatments on the shoot length, number of fruit buds and leaf buds in OKUBO peach trees. (1959)

	Light Hours	Shoot Length (July 15)	No. of Fruit buds per meter shoot	No. of Leaf buds per meter shoot	Light Intensity			Temperature		
					May 10	July 31	Sept. 14	Jaly 24	Aug. 20	Sept. 20～26 Average
	(hours)	(cm)			Lux	Lux	Lux	(°C)	(°C)	(°C)
Control	12–15	16.1	86.6	27.4	56000	95000	89000	30.5	29.7	21.8
Long Photoperiods	18	18.8	88.9	40.0	56000 (Night 204)	95000 (Night 220)	89000 (Night 230)	30.5	29.7	23.0
Short Photoperiods	6	12.3	50.5	61.9	56000	95000	89000	33.5	33.0	27.0
Shade I	—	15.8	32.2	40.2	15000	22000	23000	27.3	27.0	21.4
Shade II	—	7.8	1.0	87.4	1050	1200	2900	26.0	25.8	20.3

photoperiods and also under the short photoperiods were about 10 days earlier than the control. The fruit buds were differentiated on July 20, 1957. Under short photoperiods, however, the succeeding development of fruit buds was not so early as under long photoperiods, and the number of fruit buds per unit shoot length was only about 60 per cent of the control.

KOMATSU (1949) found that under short photoperiods for three months on the branch of the peach the initiation of fruit buds was promoted about 5 days, although fruit dropping increased and shoot growing was retarded.

The effects of light intensity on the initiation and development of fruit buds were significantly visible.

Under one marsh-reed-screen where the light intensity was reduced 73 to 77 per cent, the fruit bud initiation was retarded about a month, and the fruit bud formation was reduced about 63 per cent.

Furthermore, under two marsh-reed-screens where the light intensity was reduced 97 to 99 per cent, the initiation of fruit buds was retarded about two months, and the number of fruit buds was reduced about 98 per cent.

With the decrease of the day length and light intensity, the ability of photosynthetic activity of the plant decreases.

It is clear that the fruit bud formation was greatly prevented by short photoperiods and low intensity of light, because of the defficiency of the reserve carbohydrates.

Experiment 4. Effects of soil moisture content on fruit buds differentiation and development of the peach.

Materials and Methods;

One-year-old peach trees of OKUBO variety were used during the growing season of 1956.

The trees were planted in 60 gallons concrete pots, and applied to the following six treatments. Eight trees were used in each treatment.

A ; *Soil moisture content was high throughout the growing season.*

B ; *Soil moisture content was high at the first half of the growing season and low at the latter half.*

C ; *Soil moisture content was low in the middle of the growing season and high at the first and last parts of the growing season.*

D ; *Soil moisture content was low at the first half of the growing season and high at the latter half.*

E ; *Soil moisture content was high in the middle of the growing season and low at the first and last parts of the growing season.*

F ; *Soil moisture content was low throughout the growing season.*

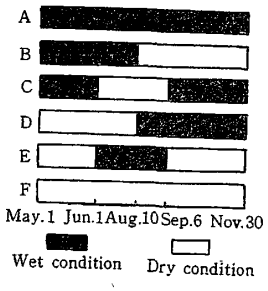


Fig. 3. Diagrams of soil moisture condition in each plot.

High soil moisture content was maintained by the weekly irrigation of 10 liters of water per pot. On the other hand, low soil moisture content was kept up by the same irrigation at intervals of a month.

The soil used in this experiment was a sandy loam with a water capacity of 39.86 per cent and with a moisture equivalent of 11.96 per cent.

The soil in all the pots were covered with a binyl film placed tightly around the trunk of the trees to prevent the penetration of rain.

Results and Discussion;

The moisture content of the soil 10 to 20 cm. in depth in each plot is shown graphically in Fig. 4. The comparative developments of the fruit buds under the

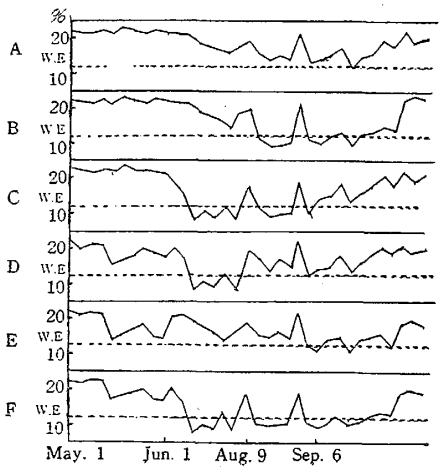


Fig. 4. Seasonal changes of the moisture content of the soil 10 to 20 centimeter in depth in each plot.

Table 6. The range in stages of development of fruit buds observed from the soil moisture treatments in OKUBO peach trees. (main shoot 1956)

	July 20	July 31	Aug. 9	Aug. 13	Aug. 19	Aug. 28	Sept. 10	Sept. 27	Oct. 19	Nov. 21
A	I	I	II	II	III	III～IV	V～VI	VII～VIII	X	XII
B	I	I	II	II～III	II～III	III～IV	V～VII	IX	X～XI	XII～XIII
C	I	I	II～III	III～IV	IV～V	V～VI	VII～VIII	IX	X～XI	XIII
D	I	II	III～IV	IV	V～VI	VI～VII	VIII	VIII	X～XI	XII～XIII
E	I	II	III～IV	V	V～VI	VI～VII	VII～VIII	IX	X	XII～XIII
F	I	II	II～III	IV	IV～V	VI～VII	VIII～IX	IX	X～XII	XII～XIII

Table 7. The range in stages of development of fruit buds observed from the soil moisture treatments in OKUBO peach trees. (secondary shoot 1956)

	July 20	July 31	Aug. 9	Aug. 13	Aug. 19	Aug. 28	Sept. 10	Sept. 27	Oct. 19	Nov. 21
A	I	I	I	I～II	II	III～IV	V～VI	VII～VIII	X～XI	XIII
B	I	I	I	I～II	II	IV～V	V～VI	VII～VIII	X～XI	XIII
C	I	I	I	I～II	II	IV～V	V～VI	VII～VIII	X～XI	XIII
D	I	I	I	II	II～III	IV～V	V～VI	VII～VIII	X～XI	XIII
E	I	I	I	II	II～III	V～VI	VI～VII	VIII	X～XI	XIII
F	I	I	I	II	II～III	V～VI	VI～VII	VIII	X～XI	XIII

different treatments on the main shoot and the secondary shoot are shown in Table 6 and 7.

The fruit bud differentiation on the main shoot was earlier on plots D, E and F, the soil moisture content of which was low at the first part of the growing season, and the succeeding development was advanced, especially on plot E.

While, the fruit bud differentiation on plot A, B and C, the soil moisture content of which was high at the first part of the growing season, retarded about 10 days, and the succeeding developments were delayed, except on plot C.

It was found out, however, that the stages of the fruit buds development in late October were the same in all the plots.

The fruit buds differentiation and development on the secondary shoots were delayed about 5 to 10 days, although the differences of them in each plot were not so visible as on the main shoots.

The differences of shoot length in each plot were not significant, as shown Table 8.

Table 8. Effects of the soil moisture treatments on the shoot length, the number of fruit buds and leaf buds on the main shoot and the secondary shoot per meter.

	Shoot Length Aug. 3	No. of buds on main shoot per meter		No. of buds on secondary shoot per meter	
		Fruit buds	Leaf buds	Fruit buds	Leaf buds
	(cm)				
A	66.3	25.3	28.8	44.4	44.9
B	69.0	35.1	35.3	34.5	32.0
C	68.3	31.0	39.4	40.8	36.4
D	67.0	25.8	31.9	18.9	32.8
E	54.5	33.1	33.9	23.9	36.5
F	58.6	26.2	27.8	30.3	32.8

The number of fruit buds which were differentiated on a main shoot on plots A, D and F, was reduced about 20 per cent as compared with the other plots.

On the secondary shoot, the number was the smallest on plot D.

DEGMAN, FURR, and MAGNESS (1933) investigated the influence of moisture supply on fruit buds formation in apples, and concluded that in the case of the Oldenburg there was no relation between moisture supply and fruit bud formation, while the case of the Rome Beauty the trees that became dry bore a great number of fruit buds. They found also that in seriously devitalized trees which had suffered severely from drought previously, and which did not carry any crop, irrigation tends to quicken the fruit bud formation.

BROWN (1952, '53) investigated the development of fruit buds on differentially irrigated Royal apricot trees in California, and found that water deficit in late summer markedly retarded flower-bud formation. The results of this investigation indicate that soil moisture content was a factor in determining the time of differentiation and the rate of development of differentiated buds. Namely, they indicate that the fruit bud differentiation and development were stimulated under the dry conditions of the soil at the early stage of growth, but they were markedly retarded, if the soil conditions were extremely dry or extremely wet throughout the growing season.

Experiment 5. Effects of the fertilizer application on the differentiation and development of fruit buds of the peach.

Materials and Methods;

The materials were one-year-old OKUBO peach trees. These trees were carefully planted in 2-gallon-pots with extremely non-fertile reddish sandy loam on March 8, 1958.

On April 1 (twenty-four days after planting) these were divided into ten plots uniformly. In each plot six plants were put and the different amount of the fertilizer materials was applied as follows;

	$(NH_4)_2SO_4$	(N)	$Ca(H_2PO_4)+2CaSO_4$	(P_2O_5)	K_2SO_4	(K_2O)
3NPK	30 g	(6) g	10 g	(2) g	4 g	(2) g
2NPK	20	(4)	10	(2)	4	(2)
NPK	10	(2)	10	(2)	4	(2)
NP	10	(2)	10	(2)	—	—
NK	10	(2)	—	—	4	(2)
PK	—	—	10	(2)	4	(2)
N	10	(2)	—	—	—	—
P	—	—	10	(2)	—	—
K	—	—	—	—	4	(2)
None	—	—	—	—	—	—

Results and Discussion;

Effects of different fertilizer treatments on the differentiation and development of fruit buds of the peach trees are presented in Table 9. Shoot length, total fresh weight, nutritional status in the shoots and the number of fruit buds and leaf buds are shown in Table 10.

In general, the fruit buds differentiation was somewhat delayed in three plots

Table 9. The range in stages of development of fruit buds observed from the fertilizer treatments in OKUBO peach trees. (1958)

	July 10	July 20	July 30	Aug. 10	Aug. 20	Aug. 30	Sept. 10	Sept. 30
3NPK	I	I	II	II～III	III	IV	V～VI	IX～X
2NPK	I	I	I～II	II～III	III	V～VI	VI～VII	X
NPK	I	I～II	II～III	III	III～IV	V	VI	X
NP	I	I～II	II	II～III	III	IV～V	VI～VII	IX～X
NK	I	I～II	II～III	III	III	IV～V	VI	IX～X
PK	I	I～II	II～III	II～III	IV～V	V	VI～VII	X
N	I	I	I～II	II	III	IV～V	VI～VII	IX～X
P	I	I～II	II	III～IV	IV～V	V～VI	VII～VIII	X
K	I	II	II～III	III	IV	V	VI～VIII	X
None	I	I～II	II～III	III～IV	IV～V	V～VI	VI～VII	X

Table 10. Effects of the fertilizer treatments on the growth, the number of fruit buds and leaf buds, and the nutritional status in shoots of OKUBO peach trees.

	Shoot Length (cm)	Total Fresh Weight (g)	No. of Fruit Buds per meter shoot	No. of Leaf Buds per meter shoot	Total carbohydrate contents in shoot (per cent dry wt.)	Mineral contents in shoot (Per cent dry weight)					C-N Ratio
						N	P	K	Ca	Mg	
3NPK	15.9	65.7	22.8	41.6	13.06	0.82	0.075	0.54	0.81	0.031	15.93
2NPK	24.5	112.8	29.5	60.9	14.53	0.79	0.066	0.55	0.70	0.051	18.39
NPK	23.7	98.0	89.4	45.7	16.13	0.70	0.071	0.46	0.56	0.041	23.04
NP	18.9	94.5	91.9	19.5	12.99	0.78	0.067	0.39	0.67	0.056	16.65
NK	21.1	110.4	89.7	29.1	14.18	0.65	0.063	0.50	0.59	0.051	21.82
PK	14.3	60.4	121.2	38.8	12.74	0.61	0.074	0.48	0.65	0.041	20.89
N	20.2	108.0	82.7	51.2	15.69	0.82	0.060	0.43	0.56	0.051	19.13
P	10.5	63.4	146.3	9.8	14.07	0.55	0.081	0.47	0.63	0.059	25.58
K	12.1	71.6	118.6	16.9	13.82	0.50	0.053	0.48	0.67	0.053	27.64
None	13.4	65.2	127.9	52.3	12.36	0.30	0.062	0.33	0.61	0.051	23.32

with 3 NPK, 2 NPK and N treatments, but it was nearly equal in the other plots. While, in the three plots with PK, P and None-Fertilizer, the time of the appearance of sepal primordia of fruit buds was about ten days earlier than in the other plots.

But, the number of fruit buds per unit shoot length indicated that the four plots with PK, P, K and None-Fertilizer treatments had a great number of fruit buds, especially P plot, and the two plots with 3 NPK and 2 NPK treatments had remarkably fewer buds than the other plots.

It suggests that a close relationship was found between the number of fruit buds and the nutritional status in shoots. With the increased of the ratio between carbohydrate and nitrogen, the corresponding increase in number of fruit buds was recognized.

FUKUDA and KONDO (1957) reported that, in sand culture experiment with four-year-old HAKUHO peach trees, the number of fruit buds per unit shoot length was increased with the increase of the concentration of phosphorus, and their number decreased with the increase of the concentration of nitrogen and potassium in solution respectively.

The results of the present study agree with the above-stated conclusion, and it is very interesting that the application of phosphorus increase the number of fruit buds.

Experiment 6. Effects of defoliation upon the differentiation and development of fruit buds of the peach.

Materials and Methods;

The peach trees used in this experiment were three-year-old OKUBO variety. They were planted in the orchard of sandy loam in the University of Osaka Prefecture in 1955, and were uniformly managed until this experiment was started in the early summer of 1958. Each treatment was replicated four times in a randomized block design with single tree plots.

Eight treatments and one control were conducted as follows;

A. *Control*
B. *Complete defoliation on June* 10
C. *Complete defoliation on July* 10
D. *Complete defoliation on July* 30
E. *Complete defoliation on August* 30
F. *Removal of three-fourths leaves on June* 10
G. *Removal of three-fourths leaves on July* 10
H. *Removal of three-fourths leaves on July* 30
I. *Removal of three-fourths leaves on August* 30

Results and Discussions;

In Table 11 the stages of development of fruit buds on the main shoots of the

Table 11. The range in stages of development of fruit buds on the main shoots observed from the fertilizer treatments in OKUBO peach trees. (1958)

	July 10	July 21	July 31	Aug. 10	Aug. 20	Aug. 30	Sept. 10	Sept. 30	Oct. 31	Jan. 31
A	I	I～II	II	II～III	III～IV	IV～V	VI～VII	VIII～X	XII～XIII	XV
B	I	I	I	I	I	I	I	I～II	I～III	XV(I)
C	—	I	I	I	I	I～II	I～II	I～II	I～III	XV(I)
D	—	—	—	I～II	II	II～III	II～III	VII(II)	XII(II～IV)	XV(II～V)
E	—	—	—	—	—	—	IV(III)	VII～IX(III)	XII～XIII (V～VII)	XV(V)
F	I	I	I	I	II～III(I)	IV(I)	V～VII(I)	VI～VII(I)	XII～XIII(I)	XV(I)
G	—	I～II	I～II	I～II	II～III(I)	II～III(I)	III～VII(I)	VIII(I)	XII～XIII(I)	XV(I)
H	—	—	—	I～II	II	IV～V(II)	V～VI(II)	VIII～IX (II～IV)	XII～XIII (II～IV)	XV(II～V)
I	—	—	—	—	—	—	IV～VI	VIII～IX(V)	XII～XIII(V)	XV(V)

peach influenced by each treatment are presented. The complete defoliations before the differentiation period, on June 10 and July 10, prevented the differentiation or greatly reduced the formation of fruit buds. Some buds were destroyed, and others were stimulated to sprout the secondary shoots as the results of defoliation. The similar effects, though less severe, were recognized also in plots F and G, on June 10 and July 10, in which three-fourths leaves were removed. In plot D, in which all

the leaves were defoliated on July 30, the development of some buds differentiated already was prevented and other buds was stopped by the treatment. The numerical scales in the parentheses shown in Table 11 indicate the situation of these buds in which the development was prevented. The same tendency was also found in other plots.

Table 12. The range in stages of development of fruit buds on the secondary shoots observed from the fertillizer treatments in OKUBO peach trees. (1958)

	July 10	July 21	July 31	Aug. 10	Aug. 20	Aug. 30	Sept. 10	Sept. 30	Oct. 31	Jan. 31
A	I	I	I～II	II	II～III	IV～V	V～VI	VIII～X	XII～XIII	XV
B	I	I	I	I	I～II	III(I)	V(I)	VIII(I)	XII(I)	XV(I)
C	—	I	I	I	I～II	I～II	III～IV(I)	V～VII(I)	XIII(I)	XV(I)
D	—	—	—	I～II	I～II	II～IV	II～IV	III～VI	XIII(IV～V)	XV(IV)
E	—	—	—	—	—	—	IV～V	IV～VIII	XIII(IV)	XV(IV～V)
F	I	I	I	I	I～II	III～IV	V～VI	VIII～X	XII～XIII	XV
G	—	I	I～II	I～II	I～II	II～IV	V～VII	VIII	XIII	XV
H	—	—	—	I～II	I～II	III～IV	V～VI	VIII～IX	XIII	XV
I	—	—	—	—	—	—	V～VI	VIII～IX	XIII	XV

The results of the same treatments on the secondary shoots are shown in Table 12. The stage of development of fruit buds on the secondary shoots in each treatment was similar to that on the main shoots, although the effects were not so great. The effects of the treatments on the number of fruit buds, undeveloped fruit buds, leaf buds, and the sprouting of secondary shoots per unit shoot length were shown in Fig. 5.

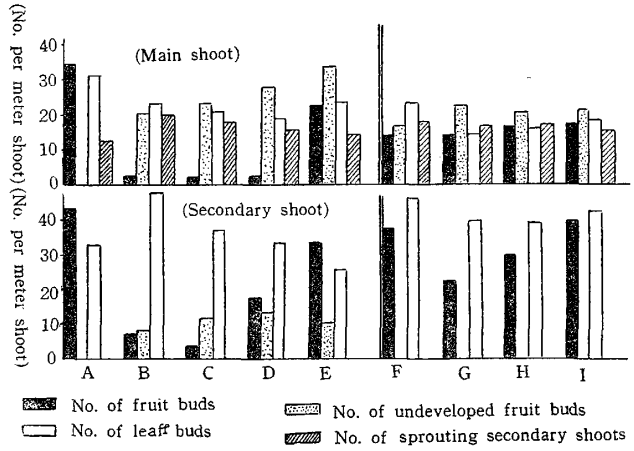


Fig. 5. The effects of the defoliation treatments on the number of fruit buds, undeveloped fruit buds, leaf buds, and the sprouting of secondary shoots per meter.

The complete defoliations on June 10, July 10, and July 30 entirely prevented the formation of fruit buds. The earlier the time of complete defoliation, the greater the number of the sprouting of secondary shoots. On the contrary, the number of undeveloped fruit bubs was increased as the time of complete defoliation was delayed. Furthermore, the number of fruit buds on the main shoots was reduced about 50 per cent in each plot where three-fourths leaves were removed as compared with the

control. On the secondary shoots the number of fruit buds was reduced in plots G and H.

HARVEY and MURNEEK (1921) investigated the effect of defoliation upon the fruit bud formation in apple spurs in Oregon, and found that the rate of fruit bud formation was reduced 40 to 60 per cent by the removal of apple leaves on June 15. They perceived the increase of water and nitrogen contents, and the decrease of total carbohydrate contents in the defoliated apple spurs.

ROBERT (1923) stated that the defoliation at the early stage of growing period greatly reduced the fruit bud formation and the buds on the nodes whose leaves were removed became smaller, and also stated that it might be due to the differences of the reserve nitrogen contents in the treated shoots.

WEINBERGER and CULLINAN (1933) reported that the peach branches that had 20 leaves per fruit had almost six times as many fruit buds per 100 nodes as the branches which had 10 leaves per fruit. The number of fruit buds increased about 10 per cent with the increase of ten leaves, when a branch came to possess more than 20 leaves per fruit. They concluded that fruit bud formation in peaches, under the conditions where nitrogen was not a limiting factor, has some relationship with carbohydrate content, especially under conditions favoring starch accumulation in a shoot.

In Japan, KAWAGUCHI (1932) investigated the effect of the defoliation in peaches on the fruit bud formation. He found that the fruit bud formation was remarkably reduced, and many flowers with small petals came into existence by the complete defoliation in a branch of the peach tree, though the differentiation and development of fruit buds were not so delayed.

MIWA (1937) also found that the differentiation and development of peach fruit buds usually resulted from the repressive influence by the removal of the leaves on a branch of 7-year-old peach tree.

The conclusion may be drawn that the removal of the leaves or the decrease of leaf area, causes the injuries of diseases, insects and others, reduces the carbohydrate accumulation in shoots, and then greatly prevents the differentiation process and the fruit bud formation.

Summary

1. The development of peach fruit buds collected simultaneously from twenty different regions in Japan was classified into three groups according to the climatic conditions, in spite of the differences of tree age and methods of cultivation. It was related with the mean temperature in June, July, and August in 1957.

It was also known that about 900 degrees C of heat summations above 10 degrees C from the time of sprouting in April to the time of fruit bud differentiation in the peach in various regions was required.

2. As the results of temperature treatments, high day and night temperatures markedly prevented the fruit bud formation, and also high night temperature reduced the number of fruit buds.

3. The time of differentiation of fruit bud in the peach does not definitely respond to light duration, but, under short photoperiods the number of fruit buds was considerably reduced.

The shading of the peach trees greatly reduced the fruit bud formation, and with the severe shading the peach tree finally died. It indicated that in the interior of

dense, unpruned trees, the flower formation may be greatly prevented by the low intensity of light.

4. The differentiation and development of fruit buds were stimulated under dry conditions of the soil at the early stage of growth, and they were greatly reduced, if the soil conditions were either extremely dry or wet throughout the growing season.

5. The excessive application of inorganic nitrogen fertilizer to young peach trees definitely delayed the differentiation and formation of fruit bud, while the application of phosphorus fertilizer considerably increased fruit bud formation.

6. The complete defoliation at the early stages of growing season entirely prevented the formation of fruit bud. Some buds were destroyed, and others were stimulated to sprout the secondary shoot. The similar effects, though less severe, were found also in plots where three-fourths leaves were removed.

Literature Cited

1. AONO, M. (1928); Jour. OKITSU Hor. Soc. No. 23; 40–46 (in Jap.)
2. BROWN, D. S. (1952); Bot. Gaz. 114; 95–102.
3. ———— (1953); Proc. Amer. Soc. Hort. Sci. 61; 119–124.
4. DEGMAN, E. S., FURR, J. R. and MAGNESS, J. R. (1933); Proc. Amer. Soc. Hort. Sci. 29; 199–201.
5. EGUCHI, Y. (1927); NOGAKU KAIHO 292; 11–121 (in Jap.)
6. ———— (1928); Agr. Hor. Vol. 3, No. 8; 875–892 (in Jap.)
7. ———— (1934); Jour. Hor. Assoc. Jap. 5, 2; 232–250 (in Jap.)
8. ———— (1936); Jour. Hor. Assoc. Jap. 7, 1; 19–26 (in Jap.)
9. FUKUDA, T. and KONDO, G. (1957); Stu. Ins. Hor. Kyoto Univ. Vol. 8; 16–23 (in Jap.)
10. HARVEY, E. M. and MURNEEK, A. E. (1921); Ore. Agr. EXp. Sta. Bul. 176; 1–47.
11. KAWAGUCHI, M. (1932); Agr. Hor. Vol. 7, No. 6.; 1085–1098 (in Jap.)
12. KODERA, M. (1952); Lec. at Meet. of Assoc. Hor. Jap. (Autumn 1952) (in Jap.)
13. KOMATSU, A. (1949); Stu. Ins. Hor. Kyoto Univ. Vol. 4; 42–46 (in Jap.)
14. MIWA, T. (1937); Stu. Ins. Hor. Kyoto Univ. Vol. 2: 123–146 (in Jap.)
15. ROBERT, R. H. (1923); Wis. Agr. Exp. Sta. Res. Bul. 56; 1–15.
16. SUSA, T. and MURAMOTO, M. (1934); Agr. Hor. Vol. 9, No. 10; 2135–2141.
17. WEINBERGER, J. H. and CULLINAN, F. P. (1933); Proc. Amer. Soc. Hort. Sci. 29; 23–27.