

**On the Effect of a Partial Removal of Roots  
and Leaves upon the Development  
of Flowers.**

By

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The object of the present investigation is to ascertain whether, a partial removal of leaves, roots, etc., has any effect upon the formation of flowers, and to determine the degree of such effect. I intend at the same time to ascertain how far a difference of species or individuals may lead to different results for injuries of the same kind and degree.

Literature on this subject is scanty. Vöchting mentions in his book "Ueber Organbildung im Pflanzenreich", II. Theil, 1884, p. 104, the methods of promoting flower-formation, practised by gardeners of ancient times. He confirms the experiment of Rivers, an English gardener, who showed that if a part of the main root of a pear tree be removed, the plant is thereby prevented from taking sufficient water and nourishment, but nevertheless the development of the flowers is promoted.

Möbius in his essay entitled "Welche Umständen befördern und welche hemmen das Blühen der Pflanzen?" (Biologisches Centralblatt, 1892, p. 609) gives as the factors which affect flowering light, warmth, water, etc. He also shows that if the growth of the roots is prevented, a more profuse flowering is effected.

In the following pages I shall describe my own experiments

on this subject. The work has been done at the suggestion and under the guidance of Prof. M. Miyoshi of the Botanical Institute of the Science College of the Imperial University of Tōkyō, and I wish to express my sincere thanks to him.

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To ascertain the effect of an injury done to the root, I have in all cases used water-culture; whereas in determining the effect of the removal of leaves and stems, I have experimented with pot-culture.

#### 1. Water-culture.

Seeds of equal size after having been soaked in water about twenty-four hours, were allowed to germinate in damp sawdust, and when the seedlings attained some growth, they were selected and transferred to water-culture.

Glass cylinders holding about two liters, were used for this purpose. In each cylinder, I put five plants, nourished with Sachs' or Knop's solution in 0.5‰ concentration. The cultures stood in a south window, where they were left until the roots had attained a sufficient length. Then, some of the latter were removed with a pair of scissors.

#### 2. Pot-culture.

Two kinds of pots were used, the one containing three liters and the other one liter. No nourishment was supplied, except the water necessary to keep the soil moist.

Each pot held five seedlings of the same growth and was placed on the ground outside of the laboratory-building.

In all cases, a certain number of plants were left intact to serve as control.

The plants used for my experiments were the following :

*Pisum arvense* L.

*Pisum sativum* var. *arvense* Poir.

*Pharbitis hederacea* L.

*Vicia Faba* L. var. *equina* Pers.

*Fagopyrum esculentum* Moench.

## GENERAL RESULTS.

### A. Effect of partial removal of vegetative organs.

When the main root and most of the lateral roots were removed, leaving few lateral roots untouched, flowering was promoted (except in *Fagopyrum esculentum*; see Exp. I, 1, 4, 6).

When all the lateral roots were successively removed, flowering was prevented, and the leaves and stems became smaller than in control (see Exp. I, 3).

But when the removal was done once every four days, for a month, and after that once every week, the growth of the leaves and stems was not affected; and the flowering was promoted (see Exp. I, 5).

By the removal of lateral roots once every week, for a month, and once every two weeks during the second month, flowering was advanced, but the total number of flowers was nearly the same as in the control.

The length of the stem also remained the same (see Exp. I, 7).

It is clear that an excessive removal of lateral roots prevents

blossoming, while the removal of a proper number is favourable to flowering.

In all my experiments, when lateral roots were removed, the main root became very long ; while the stem was shorter than in the control.

When the main root was removed, leaving a few lateral roots, the stems were not affected.

In *Pharbitis*, when the sprouts were removed continually, the size of both flowers and leaves increased (see Exp. II, 1).

In *Pisum*, when the full grown leaves were removed continually, leaving only the bracts, flowering was prevented and the stems became shorter than in the control.

In *Pharbitis* and *Fagopyrum*, a continual removal of leaves stops the growth of the whole plant.

### B. Differences by species.

In *Pharbitis hederacea*, *Pisum arvense* and *Vicia Faba*, the removal of the main root and some of the lateral roots, leaving only a few lateral roots, caused flowers to appear earlier than usual and abundant flowers were produced, but this was not the case with *Fagopyrum esculentum*.

When all the lateral roots were removed, *Pisum arvense* was too much injured to blossom earlier than usual, while in *Vicia Faba* and *Pisum sativum* var. *arvense* blossoming was promoted.

In *Pisum arvense*, flowering was not promoted by a continual removal of the leaves, and *Pharbitis hederacea* and *Fagopyrum esculentum* did not flower on the removal of the foliar organs. In *Pisum*, the bracts seem to serve as assimilatory organs, whereas *Pharbitis* and *Fagopyrum* have no such advantage.

## EXPERIMENTAL DATA.

## I. Removal of root.

(1) *Pharbitis hederacea*.

As culture fluid, Sachs' solution was used and renewed once every week.

The water-cultures were arranged in three series. In the first series, the main root and a few lateral roots were removed once every day, leaving three lateral roots untouched. In the second series, they were removed once every three days and the third series served as the control.

As the following table shows, the first series flowered first and the flowers were normal.

In the third series, the vegetative parts grew very well, the leaves being about twice as large as those of the first series.

Many flowers of the third series were abnormal and small. The second series lay between these two extremes.

The size of flower given is that of the one which opened first.

Table I.

Water-culture of *Pharbitis hederacea*.

14 August. Seeds germinated.

21 August. Young plants were transferred to water-culture.

22 September. Last day of the removal of roots.

10 November. End of the experiment.

Series.	Number of plants.	Date of appearance of first flower.	Height of flower.	Diameter of flower.	Total number of flowers. <sup>1)</sup>
I.	1	October 12	2.8 cm.	2.8 cm.	2
	2	16	3.6	4.5	2
	3	22	4.1	3.5	2
	4	19	4.5	3.9	4
	5	22	4.5	4.1	2
	6	23	3.5	3.5	2
II.	1	14	3.2	4.2	1
	2	24	4.4	3.9	1
	3	28	4.4	3.8	2
	4	29	4.5	4.8	3
	5	31	4.3	3.9	1
	6	31	4.2	3.7	2
III.	1	23	4.2	3.5	1
	2	29	3.5	3.5	1
	3	31	2.8	3.5	1
	4	31	3.2	3.5	2
	5	November 1	2.2	3.2	1
	6	4	abnormal		1
	7	6	abnormal		1

1) By "total number of flowers" I mean the number of all the flowers, which were produced from the beginning up to the end of the experiments.

(2) *Fagopyrum esculentum*.

Sachs' solution was used. The specimens were arranged in three series. In the first series, the roots were removed once every day, leaving three lateral roots; in the second series the removal was performed every three days; and the third series served as control.

After about one month, the stems of the control plants became greater than those of the other plants and the leaves of the latter showed etiolement.

If we examine Table II, we shall find that the flowering time was about the same in all series. *Fagopyrum esculentum* seems to be much the most sensitive to the injury of the roots.

Table II.

Water-culture of *Fagopyrum esculentum*.

26 August. Young plants were transferred to water-culture.

10 October. End of the experiment.

Series.	Number of plants.	1	2	3	4	5	6	7	8
I.	Date of the appearance of the first flower.	Sep. 28	28	29	30	30	30	Oct. 4	5
II.	„	Sep. 28	28	29	29	30	Oct. 3	3	4
III.	„	Sep. 22	28	29	29	29	30	Oct. 1	5

The number of flowers was not counted.

(3) *Pisum arvense*.

Lateral roots of the plants of the first series were removed once every three days.

As the following table shows, the stems of the first series were shorter than those of the second series, but the roots were longer. The flowering of the first series was later than that of the second.

Table III.

Water-culture of *Pisum arvense*.

11 October, 1902. Seeds germinated.

13 " " Young plants were transferred to water-culture.

30 January, 1903. End of the experiment.

Series I.					Series II (control).				
	Total number of flowers.	Date of appearance of the first flower.	Length of the stem.	Length of the root.		Total number of flowers.	Date of appearance of the first flower.	Length of the stem.	Length of the root.
			cm.	cm.				cm.	cm.
1	4	16 Dec.	51.5	72.6	1	8	9 Dec.	154.3	30.7
2	2	13 Jan.	61.4	48.3	2	7	26 "	159.0	25.7
3	2	10 "	97.7	87.3	3	5	22 "	128.7	18.5
4	2	10 "	64.4	84.3	4	8	28 "	150.9	23.3
5	3	30 Dec.	74.1	72.2	5	3	5 Jan.	151.6	26.3
6	2	7 Jan.	48.4	38.5	6	6	27 Dec.	149.2	22.9
7	3	22 Dec.	74.8	65.0	7	5	9 "	154.2	28.1
8	1	23 Jan.	76.8	77.1	8	5	28 "	141.6	23.3
9	2	6 "	64.8	58.7	9	3	9 Jan.	120.3	23.3
10	1	23 "	66.7	89.7	10	3	27 Dec.	152.5	23.6
11	2	4 "	76.9	70.2					

(4) *Pisum arvense*.

Knop's solution was used. The plants of the first series remained as control. In the second series all the lateral roots, except three, were removed once every week.

Table IV shows that by a proper removal of roots flowering was promoted. In the second series, the flowering was earlier than in the first series, and moreover the number of flowers was larger.

The dry weights of the stems in the first series were more



than those of the second, but the lengths of the stems were about the same in both series.

Table IV.

Water-culture of *Pisum arvense*.

2 December, 1902. Young plants were transferred to water-culture.

30 April, 1903. End of the experiment.

Series I (control).							Series II.						
	Total number of flowers.	Date of appearance of the first flower.	Length of the longest stem.	Length of the longest root.	Total dry weight of stem.	Total dry weight of root.		Total number of flowers.	Date of appearance of the first flower.	Length of the longest stem.	Length of the longest root.	Total dry weight of stem.	Total dry weight of root.
1	7	April 12	cm. 61	cm. 31	gr. 2.67	gr. .48	1	11	March 20	cm. 52	cm. 25	gr. 1.59	gr. .28
2	3	15	54	30	2.82	.41	2	8	29	44	24	1.3	.26
3	2	25	53	38	3.35	.45	3	13	April 1	65	13	1.17	.15
4	4	20	68	31	1.02	.22	4	13	1	84	23	2.12	.37
5	3	20	62	31	1.54	.24	5	12	1	57	29	2.1	.37
6	1	22	66	31	2.38	.52	6	10	3	80	23	2.1	.2
7	1	28	49	30	1.75	.39	7	7	3	77	27	1.39	.28
8	4	20	67	31	2.93	.42	8	8	5	89	24	2.02	.3
9	2	19	61	31	2.48	.47	9	8	7	72	24	2.12	.36
10	1	29	77	31	2.68	.43	10	7	5	81	24	1.4	.21
11	4	20	41	29	2.42	.28	11	13	March 28	41	23	1.16	.22
12	2	20	44	30	2.93	.51	12	14	29	43	22	1.22	.24
13	4	18	43	32	2.4	.32	13	9	April 7	89	21	1.32	.33
14	7	15	65	31	2.48	.42	14	7	9	88	17	1.87	.23
15	7	13	61	29	2.6	.47	15	5	10	61	20	1.29	.24
16	1	30	86	26	1.92	.27	16	3	13	90	23	1.17	.42
17	3	20	61	29	2.29	.46	17	2	20	61	21	2.24	.17
18	3	20	57	28	2.32	.44	18	7	13	81	18	.77	.27
19	2	22	82	32	2.12	.38	19	5	13	59	16	.81	.11

From the above two experiments, we see that if the removal is excessive, flowering is prevented, but if properly done, it is promoted.

(5) *Vicia Faba* var. *equina*.

On November 8th, the secondary roots of the second series were all removed, and after that for a month, they were removed repeatedly every four days, and in the next month once every week.

After March 2nd, 1903, when the last removal took place, the plants were left untouched.

Knop's solution was used.

Table V.

Water-culture of *Vicia Faba*.

4 November, 1902. Young plant transferred to water-culture.

30 April, 1903. End of the experiment.

Series I (control).						Series II.							
	Date of appearance of the first flower.	Total flowers.	Length of the longest stem	Length of the longest root.	Total dry weight of stem.	Total dry weight of root.		Date of appearance of the first flower.	Total flowers.	Length of the longest stem.	Length of the longest root.	Total dry weight of stem.	Total dry weight of root.
			cm.	cm.	gr.	gr.				cm.	cm.	gr.	gr.
1	April 10	few	31	31	3.11	.68	1	April 7	few	45	30	1.9	.64
2	9	many	47	32	7.75	2.03	2	8	few	37	28	1.55	.48
3	9	few	35	25	4.63	.75	3	March 30	great	39	32	1.66	.51
4	11	few	47	30	4.9	.81	4	April 1	many	42	30	1.47	.45
5	11	few	46	25	6.88	.8	5	March 24	great	46	46	2.03	.58
6	13	few	49	30	7.38	1.27	6	23	,,	31	22	1.17	.53
7	14	few	52	24	6.75	1.34	7	April 9	many	36	38	2.21	.64
8	20	very few	53	28	4.92	.8	8	March 30	many	45	36	2.21	.54
9	10	many	40	20	3.81	1.04	9	April 1	many	41	40	3.69	.8
10	10	many	50	28	3.11	.68	10	March 23	great	46	51	2.21	.46
11	11	few	44	26	3.97	.65	11	31	,,	41	28	2.22	.55

Table V shows that the removal of lateral roots promoted flowering and produced more flowers than in the control.

In this experiment, the lateral roots were removed as in experiment I, except that the number removed was smaller.

(6) *Vicia Faba* var. *equina*.

The plants were arranged in two series, of which one remained as control. In each plant of the other series, five lateral roots were removed and afterwards a part of the main root and a few secondary roots were removed, once every ten days.

The following table shows that the flowering of the first series came earlier on account of the removal of the roots.

Table VI.  
Water-culture of *Vicia Faba*.

4 February. Seeds germinated.  
7 „ Young plants transferred to water-culture.  
4 March. The first removal of roots.  
24 May. End of the experiment.

Series I.							Series II (control).						
	Date of appearance of the first flower.	Total number of flowers.	Length of the longest stem.	Length of the longest root.	Total dry weight of stem.	Total dry weight of root.		Date of appearance of the first flower.	Total number of flowers.	Length of the longest stem.	Length of the longest root.	Total dry weight of stem.	Total dry weight of root.
	May		cm.	cm.	gr.	gr.		May		cm.	cm.	gr.	gr.
1	2	12	43	22	4.72	.55	1	9	7	41	24	2.72	.31
2	2	10	61	20.5	3.38	.59	2	8	8	59	34	4.02	.53
3	3	11	33	22	3.39	.8	3	11	4	61	31	5.31	.73
4	5	9	65	29	3.42	.35	4	12	5	59	32	4.37	.56
5	3	12	59	14	2.06	.22	5	13	4	53	33	3.37	.42
6	7	7	63	29	5.07	.57	6	11	6	48	31	2.7	.39
7	7	8	76	27	3.47	.49	7	11	5	50	32	3.2	.33
8	5	11	56	20	3.16	.36	8	14	5	61	32	3.12	.41
9	8	10	52	27	3.36	.42	9	20	2	62	46	5.35	.55
10	3	8	54	25	6.92	.54							
11	2	12	30	27	5.07	.28							
12	5	11	42	17	3.12	.36							

(7) *Pisum sativum* var. *arvense*.

I had two series of culture; Series II served as control. In Series I, lateral roots were removed once every week, for a month, and once every two weeks, during the next month.

Table VII shows that the flowering was promoted by the removal of lateral roots.

Table VII.

Water-culture of *Pisum sativum*.

30 December, 1902. Seeds germinated.

13 January, 1903. Young plants transferred to water-culture.

25 May. End of the experiment.

Series I.							Series II (control).						
	Date of appearance of the first flower.	Total number of flowers.	Length of the longest stem.	Length of the longest root.	Total dry weight of stem.	Total dry weight of root.		Date of appearance of the first flower.	Total number of flowers.	Length of the longest stem.	Length of the longest root.	Total dry weight of stem.	Total dry weight of root.
	May		cm.	cm.	gr.	gr.		May		cm.	cm.	gr.	gr.
1	17	3	42	45	1.21	.23	1	18	2	41	36	.54	.31
2	15	4	39	49	1.18	.21	2	20	2	42	22	1.42	.34
3	17	2	36	32	.98	.14	3	20	3	41	32	1.55	.29
4	13	4	46	51	1.46	.25	4	19	2	48	24	1.71	.34
5	14	5	32	33	1.17	.1	5	20	2	37	21	.99	.17
6	16	3	39	32	.62	.17	6	17	4	34	27	.79	.16
7	16	5	40	40	1.09	.22	7	19	1	42	24	1.12	.23
8	15	4	35	61	1.59	.14	8	20	2	36	26	1.05	.24
9	17	3	30	55	.95	.18	9	20	2	46	37	1.67	.24
10	19	2	31	34	1.0	.12	10	24	1	43	32	1.19	.28

**II. Removal of stem.**(1) *Pharbitis hederacea*.

The cultures were arranged in two series: in Series I, the sprouts were removed repeatedly. The plants of the two series flowered at about the same time, but the size of the flowers of the first series was greater than that of the control plants.

**Table VIII.**Pot-culture of *Pharbitis hederacea*.

19 August. Seeds germinated.

30 October. End of the experiment.

Series I.					Series II (control).				
	Date of appearance of the first flower.	Total number of flowers.	Height of flower.	Diameter of flower.		Date of appearance of the first flower.	Total number of flowers.	Height of flower.	Diameter of flower.
1	Sept. 30	3	cm. 7.	cm. 6.2	1	Sept. 27	3	cm. 4.55	cm. 5.1
2	Oct. 2	2	8.3	7.6	2	28	3	5.8	6.5
3	"	3	7.3	6.85	3	30	3	5.4	6.2
4	"	3	6.05	5.8	4	Oct. 2	3	5.5	5.17
5	"	2	6.35	6.05	5	"	2	5.4	5.55
6	"	2	6.8	6.75	6	"	2	4.58	4.7
7	"	2	6.05	6.35	7	"	3	6.2	5.9
8	Oct. 4	2	7.2	6.9	8	4	2	4.52	5.3
9	5	2	7.25	6.82	9	"	2	5.4	6.1
10	"	2	6.35	6.	10	"	2	5.34	5.7
11	"	2	5.3	5.7	11	6	2	5.2	5.3

The size of flower taken was that of the flower which opened first.

### III. Removal of leaves.

#### (1) *Pisum arvense*.

On the 29th October, the full grown leaves of the second series were all removed for the first time, and the removal was repeated afterwards.

The flowering of the first series was earlier than that of the second series. Continual removal of leaves prevented a too profuse growth of vegetative parts and even prevented the production of flowers.

Table IX.

#### Water-culture of *Pisum arvense*.

Knop's solution was used.

22 October. Transferred to water-culture.

31 March. End of the experiment.

Series I (control).						Series II.					
	Date of appearance of the first flower.	Total number of flowers.	Length of the longest stem.	Length of the longest root.	Total dry weight of root.		Date of appearance of the first flower.	Total number of flowers.	Length of the longest stem.	Length of the longest root.	Total dry weight of root.
1	Jan. 22	14	cm. 107.5	cm. 23.1	gr. .35	1	March 1	4	cm. 71.5	cm. 30.7	gr. .25
2	Feb. 11	8	90.4	24.4	.6	2	Feb. 28	5	58.8	25.9	.295
3	10	8	94.7	25.6	.42	3	March 1	4	57.5	26.3	.205
4	20	7	115.3	23.6	.44	4	2	2	59.0	24.1	.3
5	10	8	107.6	20.3	.48	5	Feb. 28	6	90.9	27.0	.385
6	Jan. 23	4	117.5	23.8	.505	6	28	7	56.3	28.8	.29
7	Feb. 15	6	94.9	30.7	.5	7	27	5	80.0	28.4	.19
8	16	8	112.6	31.8	.445	8	March 1	4	84.4	30.7	.25
						9	1	5	28.1	28.1	.24

*Pharbitis hederacea* and *Fagopyrum esculentum* was killed by the continual removal of the leaves, and did not come to flower; while *Pisum* owing to the existence of predominant bracts was not much injured by the operation.

