

招 請 講 演  
Invited Lecture

## Study About the Appearing Mechanism of the Effect of Allelopathy

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### Introduction

There are many reports about the effect of allelopathy. Most of them, however, was shown by total weight and size of organism of plant affected by allelopathy, so that we have few reports what kind of changes appear on plant tissue by the effect of allelopathy. I put bioassay into operation to research the appearing mechanism of the effect of allelopathy which appeared on tissue and cell in germinative radicles by using the allelopathy ingredient got from *Lycoris radiata*. I also examined about the appearing mechanism of the effect of allelopathy through the comparison between the effect of allelopathy of *Lycoris radiata* to weeds and the effect of allelopathy of weeds to crops. I report the general and basic information about the appearing mechanism of the effect of allelopathy from these results.

### Materials and Methods

I adjusted the formulated concentrate of the allelopathy ingredient A got from bulb of *Lycoris radiata* to 1000ppm and diluted it from double to a hundred twenty-eight. Each root cap, meristem part, elongation part, and root hair of *Rumex crispus* and *Imperata cylindrica* under the temperature condition at 22°C, and of *Solidago altissima* and *Digitaria ciliaris*, at 28°C, were investigated in detail. Moreover, I fixed each materials by niacin and measured cells size of each

tissue in germinative radicles. I also tested the effect of the allelopathy ingredient A of *Lycoris radiata* to each tissue in germinative radicles of several weeds besides the above weeds.

Meanwhile I investigated the effect of the allelopathy ingredient A extracted from weeds to each tissue in germinative radicles of lettuce to compare the effect of allelopathy of *Lycoris radiata* to weeds. The allelopathy ingredient of leaves of *Pueraria lobata* was tested its conditions of cells, especially. Besides above bioassays, I investigated growth and taking root of several kinds of weeds, for example, *Solidago altissima* and *Rumex crispus* in cultural pots which density of bulb of *Lycoris radiata* were 50%.

### Results and Discussion

#### 1. The effect of the allelopathy ingredient to each tissue in germinative radicles of weeds.

① The effect of the allelopathy ingredient A extracted from *Lycoris radiata* to weeds.

Fig. 1, 2, 3, 4, 5, 6 show the effect of the allelopathy ingredient A of *Lycoris radiata* as time to each tissue in germinative radicles of *Solidago altissima*. The elongation of each tissue in germinative radicles of weeds as well as *Solidago altissima* in treatments showed reactions which were quite different from the control. Table 1, 2, 3, 4 show reaction of each tissue in germinative radicles of them at 48 hours after beginning of the experiment. These results show that the allelopathy ingredient of *Lycoris radiata* inhibits the growth of every tissue, root

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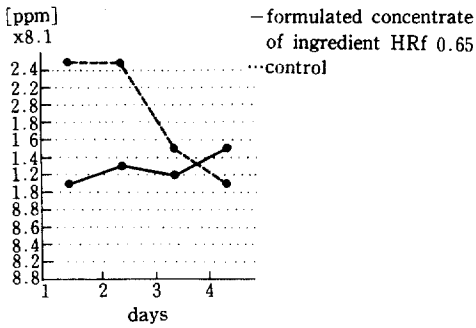


Fig. 1. The change of length of root cap. (formulated concentration : 1000ppm).

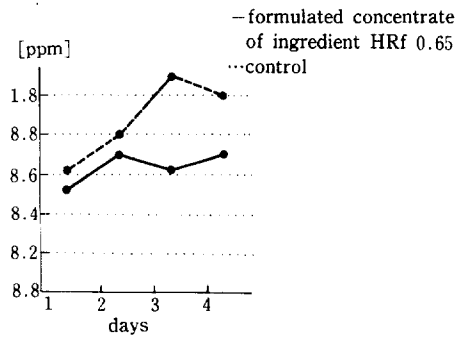


Fig. 4. The change of hypocotyl length. (formulated concentration : 1000ppm).

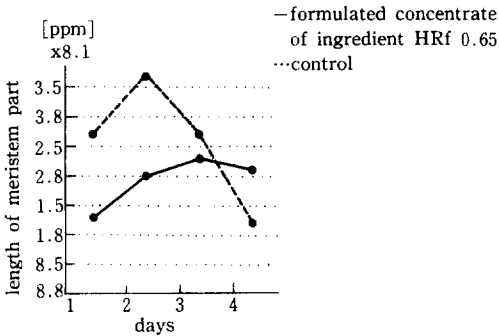


Fig. 2. The change of length of meristem part. (formulated concentration : 1000ppm).

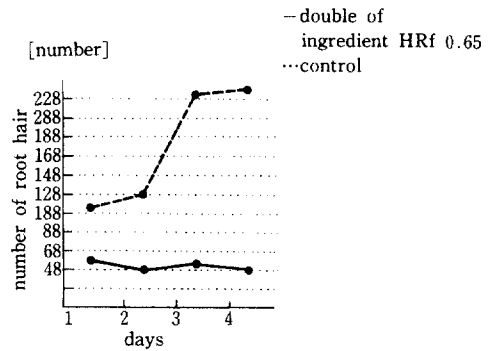


Fig. 5. The change of the number of root hair. (formulated concentration : 1000ppm).

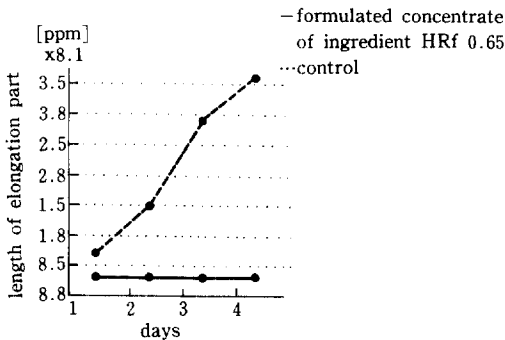


Fig. 3. The change of length of elongation part. (formulated concentration : 1000ppm).

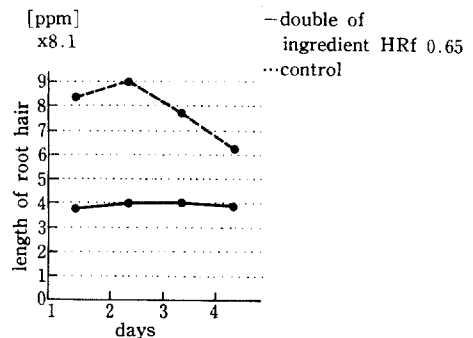


Fig. 6. The change of the length of root hair. (formulated concentration : 1000ppm).

caps, meristem parts, and elongation parts, especially the elongation of meristem parts, in germinative radicles of *Solidago altissima*, *Rumex crispus*, *Imperata cylindrica*, and *Digitaria chlaris*. The formation of new organs in radicles are also inhibited because elongation part is the tissue forming them. I guess this phenomenon causes different physiological effects in treatments from that in control.

② The effect of inhibitory ingredients contained in leaves of several kinds of weeds to the germinative radicles of lettuce.

Table 5 shows the results of bioassay which examined the effect of inhibitory ingredients of weeds besides *Lycoris radiata* to tissues in germinative radicles of lettuce. The effects of these weeds to lettuce were similar to that of *Lycoris*

**Table 1.** The effect of the ingredient A extracted from *Lycoris radiata* to each tissue in germinative radicle of *Solidago altissima*

sections tissues	formatted concentrate	2	4	8	16	32	64	128	control
length of root cap	52	52.4	52.8	54.4	56.8	62.0	72.4	93.2	100
length of meristem part	56.2	56.5	57.3	58.7	61.4	66.7	77.7	99.7	100
length of elongation part	13.3	13.7	14.7	16.2	19.7	26.6	40.2	27.6	100
width of root cap	78.3	79.0	79.7	81.9	85.5	92.8	108.7	139.1	100
width of meristem part	113.3	113.3	113.3	113.3	113.3	113.8	114.7	117	100
width of elongation part	105.5	105.5	105.1	104.7	104	102.5	99.3	93.1	100

\* at 48 hours after beginning of experiment, relative ratio to control as 100%.

**Table 2.** The effect of the ingredient A extracted from *Lycoris radiata* to each tissue in germinative radicle of *Rumex crispus*

sections tissues	formatted concentrate	2	4	8	16	32	64	128	control
length of roots cap	91.2	91.5	91.8	92.1	92.6	94.1	98.5	99.1	100
length of meristem part	43.6	43.7	44.1	44.7	46.1	48.7	54.1	64.8	100
length of elongation part	27.6	27.6	27.6	27.6	27.6	27.0	26.5	25.1	100
width of root cap	74.7	75.3	76	78	82	90	105.3	136.7	100
width of meristem part	142.7	142.7	143.2	143.6	145.0	147.3	151.8	158.2	100
width of elongation part	76.8	76.8	77.2	77.7	78.7	80.5	84.5	92.3	100

\* at 48 hours after beginning experiment, relative ratio to control as 100%.

*radiata*, even though degree of reactions were different in each weeds.

## 2. The effect of the allelopathy ingredient to cell in germinative radicles of weeds.

① The effect of the allelopathy ingredient of *Lycoris radiata* to *Solidago altissima*.

The allelopathy ingredient of *Lycoris radiata* affected to make every cell in root caps, meristem parts, and elongation parts of *Solidago altissima*, *Rumex crispus*, *Imperata cylindrica*, and *Digitaria ciliaris* big. Morphogenesis in treatments are obviously different from the control in these investigations, and results of them are shown in table 6, 7, 8, 9.

② The effect of inhibitory ingredient of *Pueraria lobata* to cell in lettuce.

I tested the effect of inhibitory ingredient extracted from leaves of *Pueraria lobata* to cell in top of meristem part of lettuce. The relative ratio of cell area in treatment was 248% to in control as 100%. Cell in treatment was elongated lengthwise rather than sideways, and this phenomenon was very similar to the effect of allelopathy of *Lycoris radiata*.

## 3. The effect of allelopathy to weeds in cultural pots of *Lycoris radiata*.

① Result of effect to *Solidago altissima*.

I planted in pot, which density of bulb of *Lycoris radiata* was 50%, with subterranean stems of

**Table 3.** The effect of ingredient A of *Lycoris radiata* to each tissue in germinative radicle of *Imperata cylindrica*

tissues	hours	formulated concentrate	2	4	8	16	32	64	128	control
length of root cap	24	54	54	54	55	56	57	60	67	100
	48	88	89	89	89	91	93	97	106	100
	96	112	113	114	117	122	132	153	196	100
width of root cap	24	92	92	91	91	91	91	90	87	100
	48	123	123	122	122	119	116	109	94	100
	96	110	110	111	111	112	114	117	124	100
length of meristem part	24	110	110	110	110	110	110	110	109	100
	48	88	89	89	89	89	90	92	96	100
	96	238	237	235	232	226	212	186	133	100
width of meristem part	24	128	128	128	127	127	125	123	118	100
	48	137	137	136	135	133	129	120	103	100
	96	168	167	166	164	160	152	136	104	100
length of elongation part	24	30	30	31	32	36	42	55	81	100
	48	24	25	25	27	29	35	46	68	100
	96	16	16	16	18	21	27	39	63	100
width of elongation part	24	98	99	99	99	100	101	103	108	100
	48	138	137	137	135	132	125	112	86	100
	96	109	109	108	108	108	106	104	99	100
length of leaf sheath	24	65	65	66	67	70	75	86	108	100
	48	53	53	54	57	61	70	88	124	100
	96	42	43	44	46	50	59	77	113	100
width of leaf sheath	24	75	75	75	76	77	79	83	91	100
	48	80	81	82	83	87	94	107	135	100
	96	66	67	68	70	74	82	98	130	100

\* Relative ratio to control as 100%.

**Table 4.** The effect of ingredient A of *Lycoris radiata* to each tissue in germinative radicle of *Digitaria ciliaris*

tissues	hours	formulated concentrate	2	4	8	16	32	64	128	control
length of root cap	24	58	58	58	58	57	55	52	46	100
	48	89	89	89	90	90	92	96	103	100
	96	97	97	97	97	98	99	100	104	100
width of root cap	24	133	133	135	137	141	150	168	204	100
	48	149	148	147	146	142	135	121	93	100
	96	185	184	183	180	175	165	145	105	100
length of meristem part	24	110	110	110	110	110	110	111	112	100
	48	96	96	95	94	91	85	73	50	100
	96	132	132	133	134	137	142	152	173	100

tissues	hours	formulated concentrate	2	4	8	16	32	64	128	control
width of meristem part	24	131	131	132	133	136	142	153	176	100
	48	111	111	111	112	113	116	120	130	100
	96	129	128	128	127	126	122	116	102	100
length of elongation part	24	74	75	76	79	84	96	118	162	100
	48	44	45	46	48	52	60	77	111	100
	96	36	37	37	37	39	41	45	54	100
width of elongation part	24	114	114	115	115	116	118	123	131	100
	48	140	140	139	138	136	131	121	100	100
	96	119	118	118	116	113	108	96	129	100
length of leaf sheath	24	135	135	134	134	133	131	127	120	100
	48	80	80	80	80	80	80	80	80	100
	96	48	49	50	54	61	74	101	155	100
width of leaf sheath	24	131	131	132	133	136	142	153	176	100
	48	111	111	112	112	113	116	120	130	100
	96	129	128	128	127	126	122	116	102	100

\* Relative ratio to control as 100%.

**Table 5.** The effect of inhibitory ingredients of several kinds of weeds to lettuce(great lake)

weeds	sections tissues	formulated concentrate	×2	×4	×8	×16	×32	×64	×128	control
<i>Imperata cylindrica</i>	length of root cap	60.66	61.04	61.16	61.65	64.58	64.58	68.51	76.35	100
	length of meristem part	91.41	91.42	91.45	91.50	91.60	91.81	92.22	93.05	100
	length of elongation part	78.21	74.48	79.00	80.04	82.14	86.32	94.49	111.43	100
	number of root hair	26.64	26.70	26.82	27.05	27.51	28.43	30.28	26.58	100
<i>Artemisia princeps</i>	length of root cap	333.60	336.00	334.80	337.20	322.80	318.00	298.80	260.40	100
	length of meristem part	90.21	90.13	89.97	89.66	89.03	87.77	85.25	80.20	100
	length of elongation part	70.22	69.90	69.26	67.99	65.44	60.35	50.17	29.81	100
	number of root hair	106.17	105.45	104.01	101.11	95.33	83.76	60.63	14.36	100
<i>Houttuynia cordata</i>	length of root cap	157.85	157.11	156.86	158.88	157.85	146.01	142.06	126.28	100
	length of meristem part	130.37	130.23	129.95	129.39	126.02	121.53	112.54	100	100
	length of elongation part	668.56	663.65	653.82	634.17	594.88	113.06	59.09	44.72	100
	number of root hair	75.20	74.92	74.92	74.55	73.81	72.33	69.36	63.42	100
<i>Erigeron annuus</i>	length of root cap	89.84	89.70	89.43	88.89	87.81	85.64	89.97	64.00	100
	length of meristem part	68.17	68.40	68.85	69.76	71.57	75.19	82.43	96.92	100
	length of elongation part	60.68	61.15	62.11	42.05	67.83	60.20	90.73	121.26	100
	number of root hair	47.00	47.59	48.78	51.14	55.86	65.30	84.19	121.96	100

<i>Pueraria lobata</i>	length of root cap	153.59	153.25	152.58	151.25	148.57	153.52	132.52	111.11	100
	length of meristem part	97.70	97.60	98.23	98.43	99.29	97.60	104.37	111.15	100
	length of elongation part	114.82	115.25	116.11	117.84	121.30	129.04	142.03	169.68	100
	number of root hair	67.99	68.50	69.54	36.57	75.72	83.97	100.48	133.48	100
<i>Bromus catharticus</i>	length of root cap	103.43	103.46	103.50	103.60	103.78	104.16	104.91	106.40	100
	length of meristem part	127.83	127.77	127.65	127.42	126.94	125.99	127.89	120.30	100
	length of elongation part	130.88	130.85	130.73	130.52	130.10	129.26	127.59	124.24	100
	number of root hair	94.64	94.72	94.88	95.21	95.86	97.17	99.79	98.40	100

\* at 48 hours after beginning of experiment, relative ratio to control as 100%.

**Table 6.** The effect of allelopathy ingredient of *Lycoris radiata* to cell in germinative radicle of *Solidago altissima*

items	length	area	ratio of the number of cells
root cap	length 114	150	111.11
	width 131		
meristem part	length 109	149	62.50
	width 136		
elongation part	length 27	218	200
	width 275		

\* at 48 hours after beginning of experiment, relative ratio to control as 100%.

**Table 7.** The effect of allelopathy ingredient of *Lycoris radiata* to cell in germinative radicle of *Rumex crispus*.

items	length	area	ratio of the number of cells
root cap	length 162	95	50
	width 68		
meristem part	length 127	189	33
	width 140		
elongation part	length 155	160	40
	width 116		

\* at 48 hours after beginning of experiment, relative ratio to control as 100%.

**Table 8.** The effect of allelopathy ingredient of *Lycoris radiata* to cell in germinative radicle of *Imperata cylindrica*.

items	length	area	the number of cells per 0.002028mm <sup>2</sup>
root cap	length 138.00	157.170	72.222
	width 136.38		
meristem part	length 134.19	237.830	42.857
	width 157.57		
elongation part	length 32.09	22.968	133.333
	width 66.85		

\* Relative ratio to control as 100%.  
Ingredient A (1000ppm).

**Table 9.** The effect of allelopathy ingredient of *Lycoris radiata* to cell in germinative radicle of *Digitaria ciliaris*.

items	length	area	the number of cells
root cap	length 320	128.808	109.09
	width 575		
meristem part	length 720	169.7069	42.105
	width 86.707		
elongation part	length 321	80.7105	100.0
	width 65.420		

\* Relative ratio to control as 100%.  
Ingredient A (1000ppm).

**Table 10.** Growth of stems under the ground of *Solidago altissima* in cultural pot of *Lycoris radiata*.

germination of new roots	length of stems	width of stems	number of germinated leaves per stem	area of leaves	thickness of leaves
54.0	71.5	73.0	77.0	68.0	93.0

\* Relative ratio to control as 100%.

**Table 11.** The effect of allelopathy of *Lycoris radiata* and seed weight of *Solidago altissima*.

items sections	X±SD	relative ratio to control as 100%
in a pot of <i>Lycoris radiata</i>	4.9±0.41	71.01
control	6.9±0.41	100

**Table 12.** The state of taking root of germinative seeds of *Rumex crispus* in cultural pots of *Lycoris radiata*.

days	treatment		control	
	number of taking root	ratio of taking root	number of taking root	ratio of taking root
4	30	73	21	51
5	32	78	31	76
6	32	78	36	88
7	34	83	38	93
8	24	59	39	45
9	9	21	39	95
10	6	15	39	95
11	1	2.4	40	97.6
50	1	2.4	40	97.6

\* Total number of planted seeds: 41.

*Solidago altissima* cut into 15cm long, rooted and sprouted, to research its growing state. The result is shown in table 11. Growth of subterranean stems was inhibited, especially inhibition in area and thickness of leaves were obvious at a look. The effects to flower bud, peduncle, and inflorescence are shown in table 12. As the result of this experiment, relative ratio of fresh weight of a hundred grains of *Solidago altissima* in treatment was 70.1% to control, and there is 0.05 significant

difference in t-test. Allelopathy also inhibited the weight of seeds.

### ② The effect to *Rumex crispus*

I planted germinative seeds of *Rumex crispus* in pot which density of bulb of *Lycoris radiata* is 50% and showed its result in table 13. The treatment is 2.4% and the control is 97.6%, so germinative seeds was inhibited to take root as time goes on by the allelopathy ingredient extracted from bulbs of *Lycoris radiata*. As table 14 shows, growth of germinative seeds of *Rumex crispus* planted in pot of *Lycoris radiata* were inhibited even if they could take root. It was found that the allelopathy ingredient of *Lycoris radiata* inhibit the taking root after germination and growth afterwards of germinatives seeds of *Rumex crispus*.

③ States of taking root of germinative seeds of several kinds of weeds in cultural pot of *Lycoris radiata*.

I examined the states of taking root of germinative seeds of 12 kinds of weeds in cultural pot of *Lycoris radiata*. *Lycoris radiata* clearly inhibited the taking root of the germinative seeds of most weeds as table 15 shows.

## Conclusion

As the result of bioassay of the effect of allelopathy of *Lycoris radiata* to weeds, it was found that every tissue in germinative radicle, root cap, meristem part, elongation part, and root hair of weeds in treatments had different morphology from

**Table 13.** Growth of *Rumex crispus* in cultural pots of *Lycoris radiata*.

days	items sections	ratio of taking root (%)	height of weed (mm)	number of leaves	length of foliage leaf (mm)	thickness of stem (mm)	length of root (mm)
	control	90	92.00±25.28	2.55±0.49	47.10±25.72	0.97±0.17	80.00±1.00

**Table 14.** The states of taking root of germinative seeds of weeds in cultural pots of *Lycoris radiata*.

kinds of weeds	treatment	number of taking root	ratio of taking root (%)	control	number of taking root	ratio of taking root (%)
<i>Pueraria lobata</i>	10	1	10	10	6	60
<i>Taraxacum officinale</i>	10	0	0	10	10	100
<i>Miscanthus sinensis</i>	30	15	50	30	22	73
<i>Digitaria ciliaris</i>	20	4	20	20	20	100
<i>Commelina communis</i>	10	4	40	10	10	100
<i>Ajuga decumbens</i>	5	2	40	5	3	60
<i>Polygonum cuspidatum</i>	20	0	0	20	20	100
<i>Eragrostis ferruginea</i>	10	0	0	10	10	100
<i>Kalimeris yomena</i>	10	0	0	5	3	60
<i>Rasa wichuraiana</i>	10	0	0	10	5	50
<i>Solidago altissima</i>	100	0	0	100	65	65
<i>Setaria glauca</i>	100	40	40	100	80	80

\* Density of bulb : 50%.

that of in control. The effect appeared especially in the tissue of meristem part and root hair. Similar effect also appeared by using inhibitory ingredients of other weeds. Not only allelopathy has the special effect to each tissue in germinative radicle, but also it makes forming of organ and its unusual water physiology by making big cell morphology rather than in control. The experiment of taking root of germinative seeds of weeds in cultural pot of *Lycoris radiata* shows the seeds wither as time goes on even if they could germinate, and their growth are

inhibited even though they could survive.

The effect of allelopathy clearly makes morphology of each tissue in unusual germinative radicle and cell forming big tissue, and these phenomena inhibit formation of organ in elongation part. Morphological change of each tissue in radicle, which is base of plant, appear as the change of cell size forming tissues, and these phenomena cause to inhibit organogenesis in weeds and crops which were affected by allelopathy, from this investigation.