Department of Agriculture and Food
GOVERNMENT OF WESTERN AUSTRALIA

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# Natural and environmentally friendly way of managing weeds without herbicides

## by Allelopathy

Yoshiharu FUJII,

Tokyo University of Agriculture and Technology,

2.50pm-3.20pm, Monday 24 February 2014

Crown Perth, Burswood

CROP updates

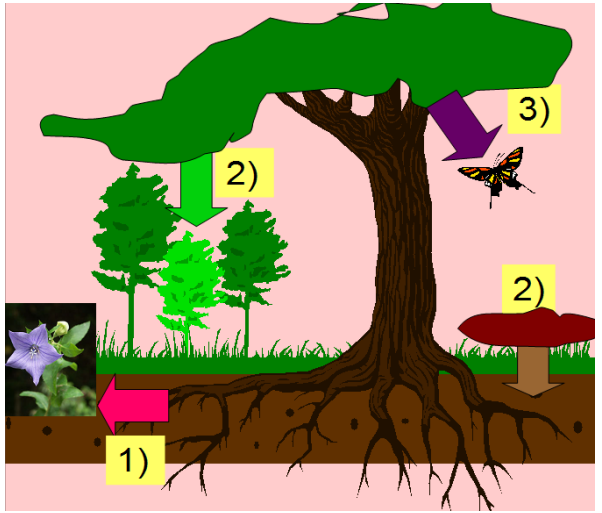
# Outline of Talk

What is **Allelopathy**

- Selection of allelopathic plants by **Bioassays**
- New Concept of Total Activity for the isolation of Allelochemicals.
- **Cover crop** with allelopathic activity provides natural and environmentally friendly way of managing weeds without herbicides.

# Allelopathy

Interaction (inhibitory or stimulatory) between plants or plant to other life by natural chemicals (allelochemicals)




Plant to Plants ・・・・・・・・・・weed control
Plant to Microorganisms・・・disease control
Plant to Insects ・・・・・・・・・・ harmful Insect control
Plant to Animals ・・・・・・・・・・nematode, boar, etc.

**Allelopathy is the same concepts as “Antibiotics”**

# Bioassay for Three Route

All these Bioassays are my original Assay

**1)** Exudation (from root)

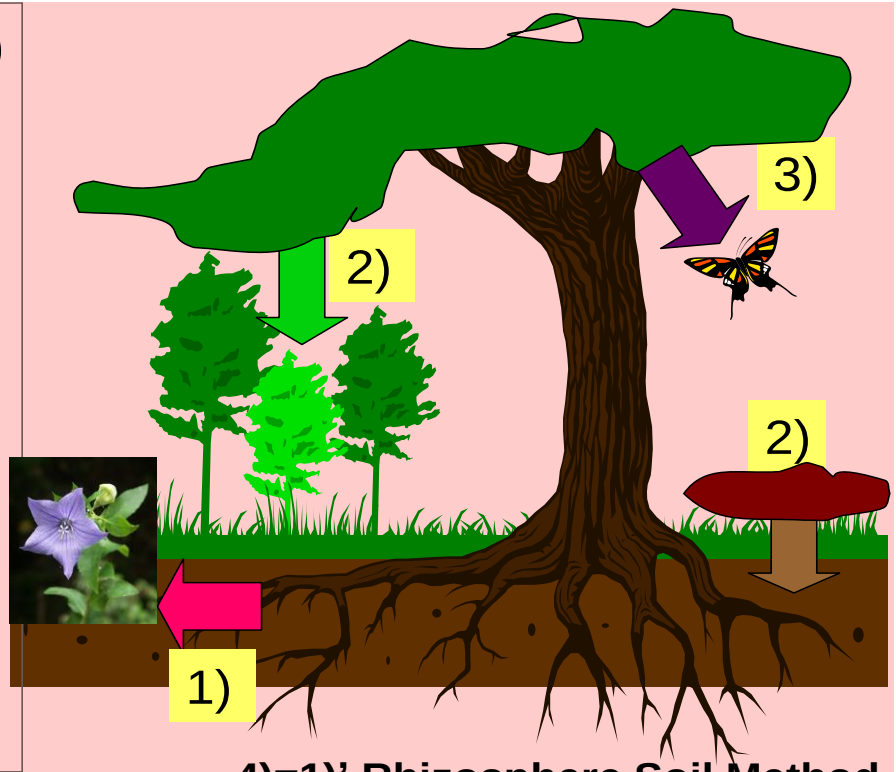
→ **Plant Box Method**

**2)** Leaching (from leaf or litter)

→ **Sandwich Method**

**3)** Volatilization (mainly from leaf as volatile chemicals)

→ **Dish Pack Method**




**4)=1)' Rhizosphere Soil Method**

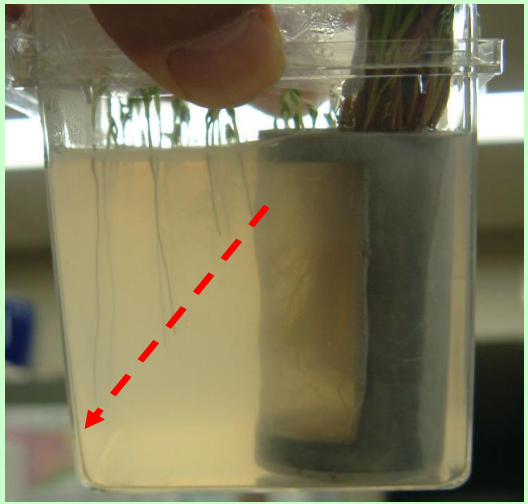
**Fig. 1 Route of Allelopathy and Bioassay**

# 1) Specific Bioassays for Allelopathy

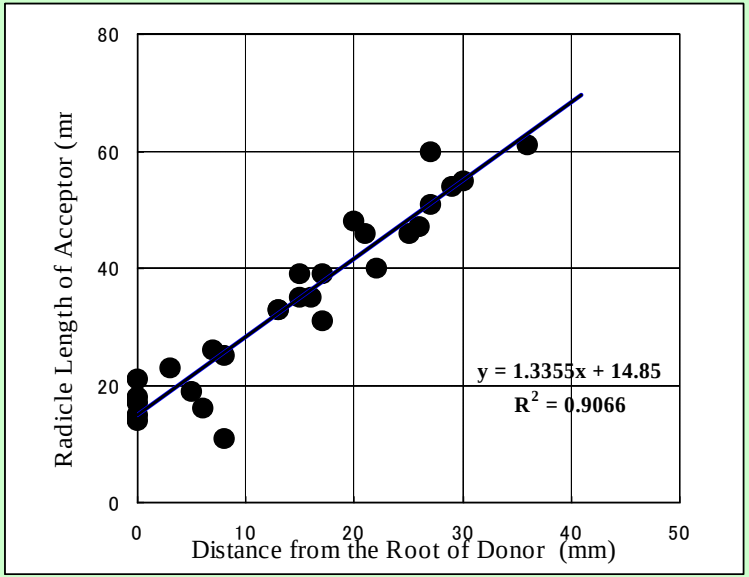
## For the screening of Allelopathic Plants

# 1 Plant Box Method

## *for root exudates (Mixed planting)*



Root zone separating tube




- Sand Culture for1-2 month
- **Plant Box (for tissue culture)**
- Agar Medium (no nutrients)

Dr. Fujii, 1991

Fujii, Y. et al., Plant-Box Method: A Specific Bioassay to Evaluate Allelopathy through Root Exudates. Allelopathy, New Concepts and Methodology, Science Publisher, 39-56 (2007).

Table 1. Allelopathic activity Leguminosae Family by Plant Box Method

| Scientific name | | |
|---|---|---|
| *Pachyrhizus erosus* | | |
| *Mucuna pruriens* var. | | |
| *Mimosa invisa* | | |
| *Crotalaria zanzibaricc* | | |
| *Medicago scutellata* | | |
| *Galega orientalis* | | |
| *Coronilla varia* | | |
| *Medicago arabica* | | |
| *Trifolium album* | | |
| *Medicago lupulina* | | |
| *Phaseolus vulgaris* | | |
| *Vicia villosa var. dasy* | | |
| *Abrus praecatorius* | | |
| *Canavalia ensiformis* | | |
| *Lupinus bicolor* | | |
| *Vicia villosa var. villos* | | |
| *Melilotus albus* | | |
| *Dolicos lablab* | | |
| *Vicia sativa* | | |
| *Pueraria lobata* | | |
| *Crotalaria juncea* | | |
| *Trigonella foenum-gra* | | |
| *Vigna unguiculata* | | |
| *Cassia tora* | | |
| *Medicago sativa* | | |
| *Vicia faba* | | |
| *Onobrychis viciifolia* | | |
| *Pachyrhizus tuberosus* | | |
| *Phaseolus vulgaris* | | |
| *Vigna angularis* | | |
| *Trifolium incarnatum* | | |
| *Cajanus cajan* | | |
| *Crotaralia spectabilis* | | |
| *Pisum sativum* | | |
| *Cicer arietinum* | | |
| *Lathyrus odoratus* | | |
| *Amorpha fruticosa* | | |
| *Latyrus sativus* | | |
| *Lupinus albus* | | |
| *Arachis hypogaea* | | |
| *Calopogonium mucun* | | |
| *Desmodium paniculat* | | |
| *Vigna unguiculata sub* | | |
| *Mimosa pudica* | Sensitive plant | 55 |
| *Vicia angustifolia var. segetalis* | Karasunoendou | 55 |

# Allelopathic Leguminous Plants

***Pachyrhizus***

***Mucuna***

***Mimosa***

***Crotalaria***

***Medicago***

***Vicia***

***Mucuna***

***Mimosa***

# Plant Box Method

Table Allelopathic activity of Poaceae family evaluated by Plant Box Method (selected results)

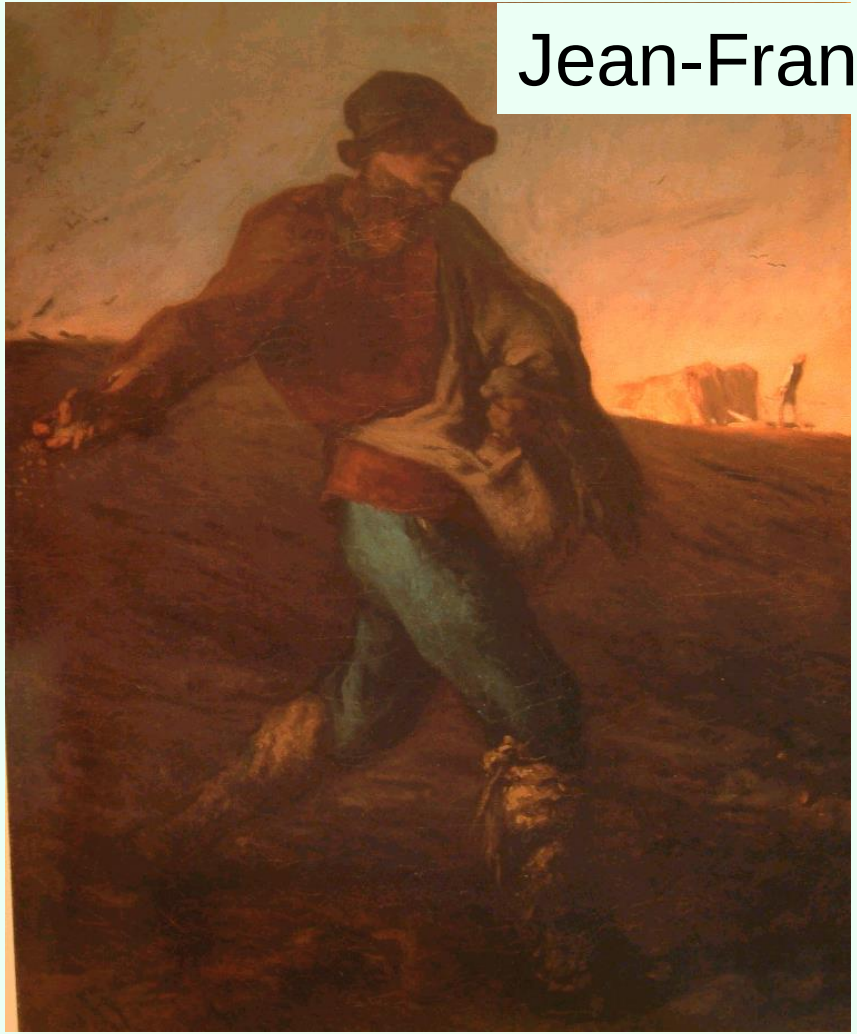
| *Scientific name* |
|---|
| *Hordeum vulgare* (Barley, cv. HVG-1) |
| *Avena strigosa* (Wild Oat) |
| *Triticum polonicum* (Polish Wheat) |
| *Avena sativa* (Oat, Hokuren) |
| *Avena murphyi* (Wild Oat) |
| *Secale cereale* (Rye, Samusa-shirazu) |
| *Avena barbata* (Wild Oat) |
| *Triticum compactum* (Club Wheat) |
| *Avena longiglumis* (Wild Oat) |
| *Triticum spelta* (Spelta Wheat) |
| *Triticum sp. x Secale sp.* (Triticale) |
| *Avena orientalis* (Wild Oat) |
| *Chloris gayana* (Rhodesgrass) |
| *Avena wiestii* (Wild Oat) |
| *Avena byzantina* (Byzantine Oat) |
| *Hordeum vulgare* (Barley, Sansyu) |
| *Phalaris tuberosa* (Hardinggrass) |
| *Triticum aestivum* (Common Wheat, Mulchmugi) |
| *Anthoxanthum odoratum* (Sweet Vernalgrass) |
| *Festuca rubra* (Chewing Fescue) |
| *Panicum coloratum* (Coloured Guinea Grass) |
| *Avena fatua* (Common wild oat) |
| *Triticum aestivum* (Common Wheat,cv. Norin 61 |

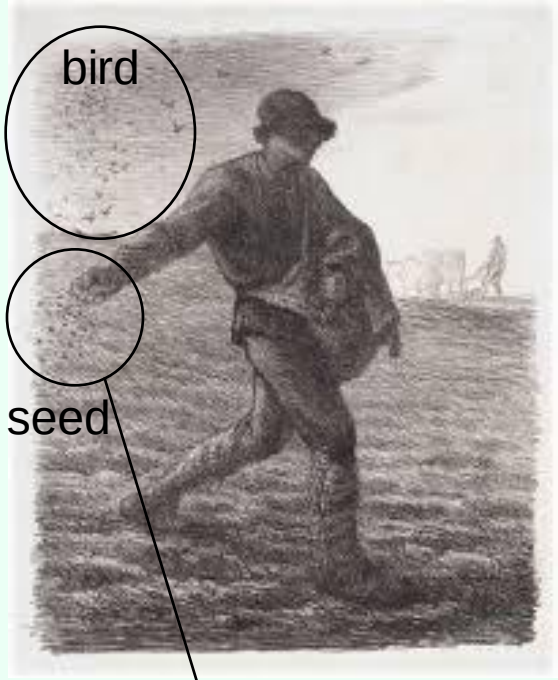
# Allelopathic Crops

**Barley (*Hordeum vulgare*)**
**Oats (*Avena* sp.)**
**Rye (*Secale cereale*)**
**Wheat (*Triticum* sp.)**

**These upland crops are originally resistant for weed**

# Jean-François Millet, Le semeur (1850)






We Japanese love Millet !

**Wheat** wheat has allelopathic activity

amount of seeding rate = 3 to 5 times

For bird loss and weed suppression

Table Allelopathic activity of Triticum family evaluated by Plant Box Method

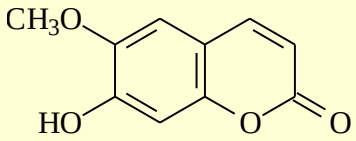
| Scientific name | Radicle growth (%) |
|---|---|
| *Triticum polonicum* (Polish Wheat) | 13.2 |
| *Triticum compactum* (Club Wheat) | 19.5 |
| *Triticum spelta* (Spelta Wheat) | 22.4 |
| *Triticum sp. x Secale sp.* (Triticale) | 22.6 |
| *Triticum aestivum* (Common Wheat, cv. Mulchmugi) | 28.0 |
| *Triticum aestivum* (Common Wheat, cv. Norin 61) | 33.5 |
| *Triticum monococcum* (Einkorn Wheat) | 34.3 |
| *Triticum durum* (Durum Wheat) | 37.3 |
| *Triticum dicoccum* (Emmer Wheat) | 40.5 |

"MACE" is King variety in AU now
(by Cristine Zaicou-Kunesch)
At today's morning session

Proposal
for Project
Breeding of
Weed Resistant Wheat
with
high allelopathic
activity !

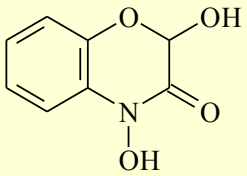
# Allelochemicals reported from Oats, Rye, Wheat, Barley

Oat

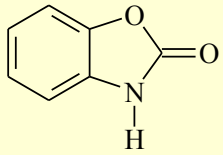


7-Hydroxy-5-methoxycoumarin
**(Scopoletin)**

Rye

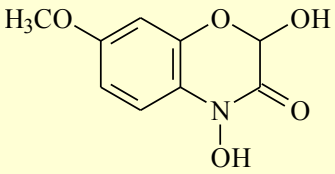


2,4-dihydroxy-
1,4-benzoxazine-3-one
**(DIBOA)**

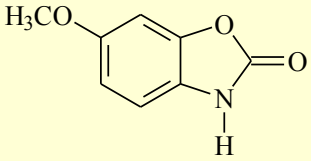


2-benzoxazolinone
**(BOA)**

Wheat

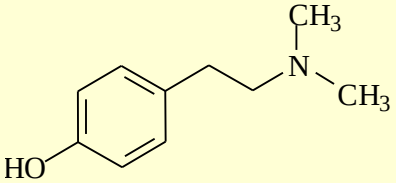


2,4-dihydroxy-7-methoxy-
1,4-benzoxazine-3-one
**(DIMBOA)**



6-methoxy-
2-benzoxazolinone
**(MBOA)**

Barley



N,N-dimethyltyramine
**(Hordenine)**

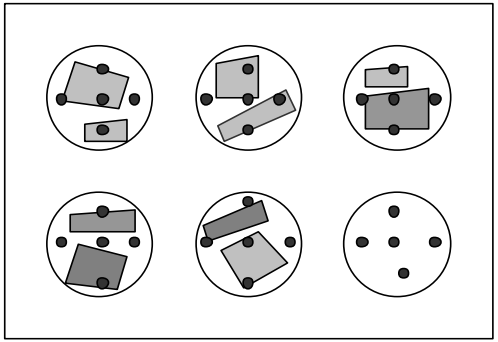
Many other chemicals are reported, but I guess these traditional compounds are important as allelo-chemicals based on TA

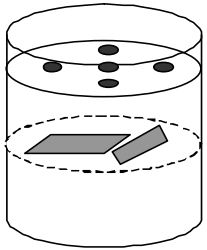
As for "TA", Total Activity, Will explain later.


1. **Belz**, G.R. and **Hurle**, K., Dose-Response - A Challenge for Allelopathy? *Nonlinearity Biol. Toxicol. Med*. 3 (2), 173–211 (2005)
2. **Liu**, D. L. and **Lovett**, J. V., Biologically active secondary metabolites of barley. II. Phytotoxicity of barley allelochemicals, *J. Chem. Ecol*. 19, 2231-2244 (1993)

# 2. Sandwich Method

*for leaf leachates (Mulching, Litter)*





6 well multi-dish

make sandwich by agar

→10 or 50 mg d.w./10 $cm^2$

For allelopthy by fallen leaves and litters

fallen leaves are constant

（3 ton / ha / year）= 30 mg d.w./10 $cm^2$ Dr. Fujii, 1991

Fujii, Y. et al., Assessment method for allelopathic effect from leaf litter leachates. *Weed Biology and Management*, 4(1), 1923 (2004)

Table 3. Allelopathic activity by Sandwich Method

| Scientific name | Radicle | Hypocotyl |
|---|---|---|
| *Cymbopogon citratus* | 0** | 0** |
| *Derris scandens* | 0** | 0** |
| *Piper betle* | 3** | 18** |
| *Tamarindus indica* | 3** | 26* |
| *Gliricidia sepium* | 5** | 19* |
| *Sesbania grandiflora* | 11* | 45* |
| *Acacia farnesiana* | 15* | 37 |
| *Duranta repens* | 17* | 51 |
| *Diospyros mollis* | 23* | 22 |
| *Afgekia sericea* | 38 | 120 |
| *Ipomea pes-caprae* | 39 | 90 |
| *Jatropha integerrima* | 44 | 122 |
| *Melia azedarach* | 52 | 115 |
| *Citharexylum spinosum* | 70 | 60 |
| *Molineria latifolia* | 75 | 167 |
| *Passiflora coccinea* | 86 | 117 |
| *Calophyllum inophyllum* | 94 | 146 |
| *Amhersita nobilis* | 96 | 127 |
| *Cynometra cauliflora* | 101 | 113 |
| *Litchi chinensis* | 113 | 115 |

Radicle and hypocotyl means % growth of lettuce seedling to the control (in agar medium). ** after the data means inhibitory activity stronger than standard deviation value of 60, and * means 55.

# Sandwich Method

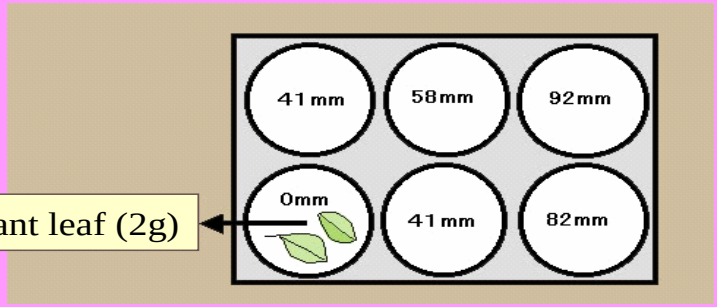
**Cymbopogon**

**Tamarindus**

Fujii, Y. et al., Screening of 239 medicinal plant species for allelopathic activity using the sandwich method. *Weed Biology and Management*, 3(4), 233-241 (2003)

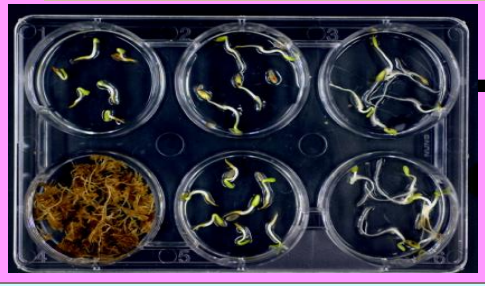
# 3. Dish Pack Method

## *for volatile allelochemicals*

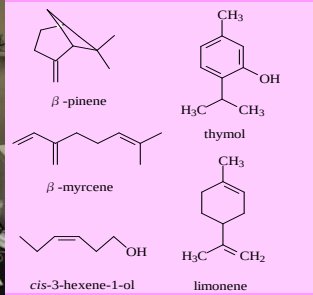



6 well multi-dish
sealed by tape

→ measure after 3 days



Volatile chemicals were analyzed by GC-MS




Fujii, Y. et al., Dish pack method: a new bioassay for volatile allelopathy. In Proceedings of the 4th World Congress on Allelopathy, August 21 -26, 2005, Wagga Wagga, Australia, 493-497 (2005).

# Allelopathic plant for biofumigation

Cleome from Takii seed Co.

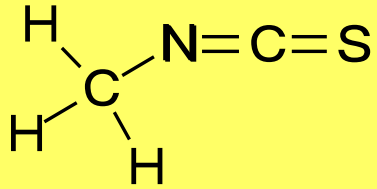
## Cleome
## *Cleome spinosa*

Strongest activity by Dish Pack Method

Allelochemical : Methyl Isothiocyanate (MITC)

EC100 for lettuce is 18 ppm

Kill most specise of nematode




**Methyl Isothiocyanate**

| Concentration of MITC in Cleome | |
|---|---|
| | ppm |
| Leaf (fresh) | 39 |
| Root (fresh) | 15 |
| Seed pod | 16 |
| Seed | 14 |
| Seed (macerated) | 133 |

Table Database for Allelopathic activity evaluated by PB, SW, and DP method

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Abutilon theophrasti* | イチビ | アオイ科 | 31 | 105 | 21 | 1 | *Echinochloa frumentacea* | | イネ科 | 38 | 109 | 55 | 0 | *Melilotus officinalis* | セイヨウエビラハギ | マメ科 | 2 | 62 | 19 | 3 | | | | | | | | | | | | |
| *Aegilops cylindrica* | ヤギュムギ | イネ科 | 60 | 111 | 27 | 1 | *Echinochloa hispidula* | | イネ科 | 46 | 109 | 68 | 0 | *Melilotus sulcata* | | マメ科 | 1 | 37 | 30 | 2 | | | | | | | | | | | | |
| *Agropyron repens* | | イネ科 | 44 | 119 | 60 | 0 | *Echinochloa oryzzoides* | ノゲタイヌビエ | イネ科 | 25 | 94 | 30 | 1 | *Mentha arvensis* | シソ科 | 32 | 75 | 97 | 1 | | | | | | | | | | | | |
| *Agrostis canina* | ヒメヌカボ | イネ科 | 36 | 97 | 29 | 0 | *Echinochloa utilis* | | イネ科 | 22 | 131 | 54 | 1 | *Myosotis arvensis* | ムラサキ科 | 64 | 88 | 37 | 0 | | | | | | | | | | | | |
| *Agrostis capillaris* | イトコヌカグサ | イネ科 | 42 | 90 | 24 | 1 | *Echium italicum* | | ムラサキ科 | 73 | 89 | 41 | 0 | *Nicotiana sylvestris* | ナス科 | 71 | 100 | 40 | 0 | | | | | | | | | | | | |
| *Agrostis castellana* | | イネ科 | 46 | 106 | 43 | 0 | *Echium plantagineum* | シャゼンムラサキ | ムラサキ科 | 28 | 129 | 43 | 0 | *Oenanthe crocata* | セリ科 | 25 | 95 | 93 | 1 | | | | | | | | | | | | |
| *Agrostis gigantea* | | イネ科 | 43 | 88 | 43 | 0 | *Echium vulgare* | シベリナガムラサキ | ムラサキ科 | 39 | 107 | 46 | 0 | *Oenothera erythrosepala* | アカバナ科 | 65 | 113 | 47 | 0 | | | | | | | | | | | | |

# Evaluation of Allelopathy by specific bioassays and evaluated about 4,000 species in 20 years

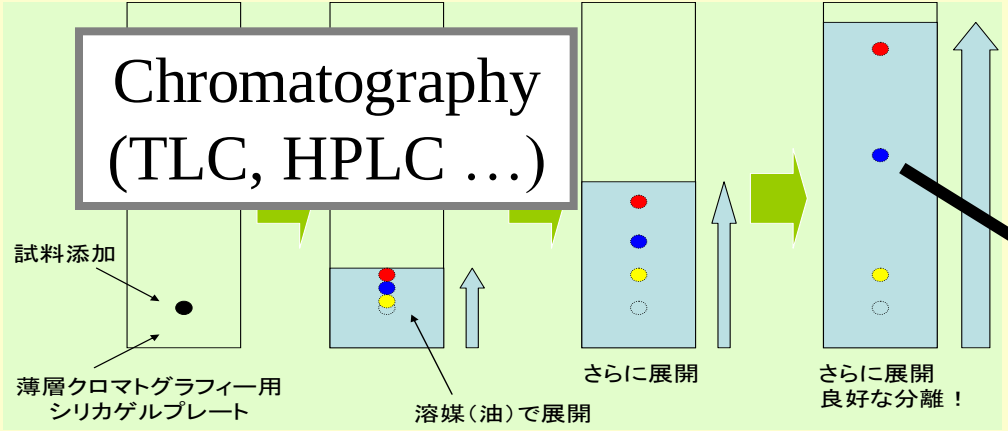
→

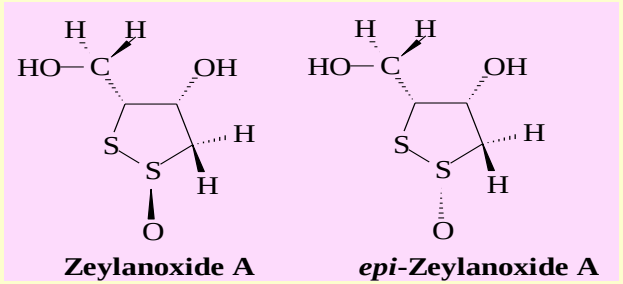
1) Medicinal Plants
2) Tropical Plants
3) Endangered Plants
4) Invasive Alien Plants
5) Oats, Barley, Wheat

} are Allelopathic

(My dream) Database for Allelopathic activity evaluated by PB, SW, DP method

# 2) Isolation of Allelochemicals based on Total Activity




Structure

Solvent Extraction

GC-MS, MS,
NMR, IR, ESR,
X-ray analysis,
etc

Conventional Method for Isolation of natural chemicals

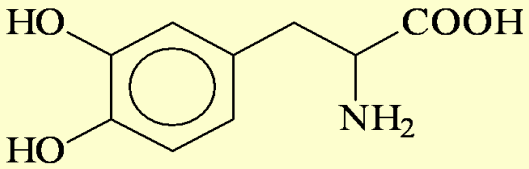
# New strategies for isolation of allelochemicals in agriculture

## Comparison of Total Activity and Specific Activity

| Target | Compounds | Index (g-weight base) |
|---|---|---|
| Direct use of Allelopathy | Allelochemicals in action *in situ* | **Total Activity** = $1/EC_{50}$ × Concentration in Plants<br>1/(kg/L) x (kg/L in fresh weight)<br>=(L/kg) x (kg/L) = (no unit)<br>high value ～ high activity |
| Use of Natural Chemicals | Bioactive Chemicals with high specific activity | **Specific Activity** = $EC_{50}$ (50% inhibitory Concentration)<br>(kg/L)～ppm<br>low ppm ～ high activity |

# Isolation of L-DOPA from Velvet bean

## Velvet bean *(Mucuna pruriens)*




**High concentration**
**10g/kg in fresh leaves, root**
**50-100g/kg in seeds**

**L-DOPA (L-3,4-Dihydroxyphenylalanine)**

**Total activity = 200**

**Total activity = 200**

**Endemic plant to Himalayas Distributed in Sino-Japan Area**

**Used as food in Japan from more than 1000 years ago (but now disappearing)**

Fujii Y, Shibuya T. and Yasuda T. L-3,4-dihydroxyphenylalanine as an allelochemical candidate from *Mucuna pruriens* (L.) DC. var. *utilis*. *Agricultural and Biological Chemistry* 55, 617-618. (1991)

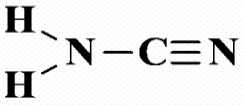
# Isolation of cyanamide from hairy vetch

## Hairy vetch *(Vicia villosa)*

Cyanamide was already known as synthetic fertilizer, but never isolated as natural chemical

**Endemic plant to central Asia,**

**now we are recommending to Japanese farmers for weed control**



**Cyanamide**

- **Antibacterial activity**
- **fungicidal activity**
- **herbicidal activity**

**Biochemical mechanisms**

**Ammonia**

- **Nitrogen fertilizer**

**Total activity = 35 - 100**

Kamo T, Hiradate S. and Fujii Y. First isolation of natural cyanamide as a possible allelochemical from hairy vetch *Vicia villosa*., *J. Chem. Ecol.*, 29 (2), 275-284 (2003)

# 3) Practical use of Allelopathic Cover Crops

# Mucuna (velvetbean) (*Mucuna pruriens*)

for Green manure, **Food**, **Medicinal plants**, and Cover Crop

Fujii, Y. Allelopathy of Velvetbean: Determination and Identification of Allelopathic Substances. H. G. Cutler and S. Cutler (Eds), Biologically Active Natural Products: Agrochemicals, CRC Press, pp.33-47 (1999)

# Velvetbean : *Mucuna pruriens* var. *utilis*

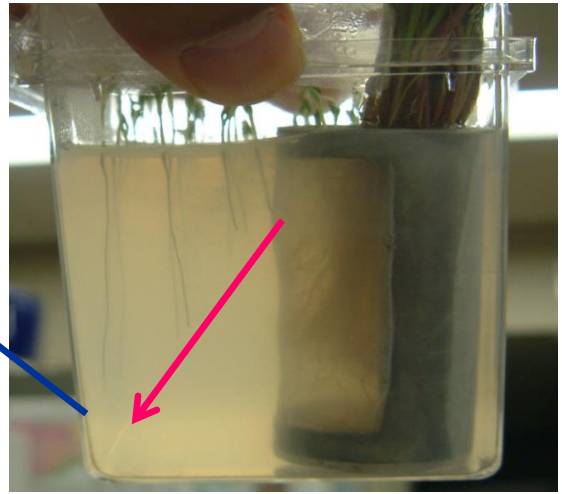
High production of forage

Legume, rich in protein

## Table 1. Assessment of Allelopathic Activity of Leguminous Cover Plants by Plant Box Method

| Scientific name (English name) | [%]*1 | Criteria*2 |
|---|---|---|
| Mucuna pruriens var.utilis (Mucuna) | 87 | ★★★ |
| Vicia faba (Broad Bean) | 81 | ★★ |
| Vicia villosa (Hairy Vetch) | 80 | ★★ |
| Calopogonium mucunoides | 78 | ★★ |
| Melilotus albus (White Sweet Clover) | 77 | ★★ |
| Vicia sativa (Common Vetch) | 75 | ★★ |
| Medicago rugosa | 74 | ★★ |
| Canavalia ensiformis (Jack Bean) | 72 | ★★ |
| Pueraria phaseoloides (Tropical Kudzu) | 71 | ★★ |
| Vigna angularis (Azuki bean) | 69 | ★ |
| Medicago sativa (Alfalfa) | 68 | ★ |
| Trifolium incarnatum (Crimson Clover) | 64 | ★ |
| Tephrosia candida (White Tephrosia) | 63 | ★ |
| Cajanus cajan (Pigeon Pea) | 62 | ★ |
| Latyrus sativus (Grass Pea) | 59 | ★ |
| Cicer arietinum (Chickpea) | 56 | ★ |
| Vigna radiata (Mung Bean) | 53 | |
| Stylosanthes hamata (Stylo) | 52 | |
| Arachis hypogaea (Peanut) | 51 | |
| Trifolium pratense (Red Clover) | 47 | |
| Crotaralia juncea (Sunn Hemp) | 43 | |
| Astragalus sinicus (Chinese Milk Vetch) | 41 | |
| Lupinus albus (White Lupine) | 40 | |
| Trifolium subterraneum (Sub Clover) | 30 | |
| Trifolium repens (White Clover) | 28 | |
| Glycine max (Soybean) | 24 | |

Plant Box Method
(for root exudates)



*1 Inhibition (%) means allelopathic activity measured by the Plant Box Test. All data are compared to the control and 100 means complete inhibition.

*2 Criteria for the allelopathic activity are ; ★★★ ; >85 %, ★★ ; 70 to 84% , ★ :<69 %, respectively.

**Table Weed population in continuous cropping fields**

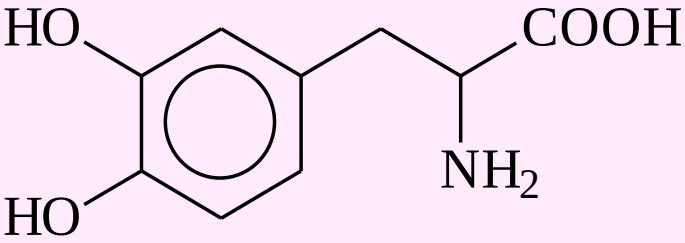
| Crop | Treatment | Weed population (g dry weight per $m^2$) | Weed species observed [6] |
|---|---|---|---|
| Upland Rice | 3yr.c [1] | 5.11(49.4) [4] | 1), 3), 5), 6), 7), 8), 9), 10), 11) [5] |
| Egg plant | 3yr.c | 16.82(40.1) | 1), 2), 3), 5), 6), 7), 8), 9), 10), 11), 12), 13), 1 |
| Tomato | 3yr.c | 4.92(64.9) | 1), 5), 6), 9), 12), 13), 17) |
| Velvetbean | 2yr.c | 0.00( 0.0) | no emergence |
| Fallow | 3yr.f [3] | 0.97(37.3) | 1), 2), 6), 10), 12), 13), 15), 16) |

1) Continuous cropping for 3 years.
2) Cultivated for 1 year, followed by fallow next year(test year).
3) Fallow for 3 years, without fertilizer.
4) Numbers in parenthesis are percentages of chickweed, a dominat species.
5) Species appeared in each plot: 1) Sticky chickweed (*Cerastium glomeratum*), 2) 'Miminagusa' (*Cerastium vulgatum* var. *augustifolium*), 3) Annual fleabane (*Erigeron annuus*), 4) Philadelphia fleabane (*Erigeron philadelphicus*), 5) Starwort (*Stellaria alsine* var. *undulata*), 6) Floating foxtail (*Alopecurus geniculatus*), 7) Narrowleaf vetch (*Vicia angustifolia*), 8) Flexuosa bittercress (*Cardamine flexuosa*), 9) 'Inugarashi' (*Rorippa atrovirens*), 10) Common dandelion (*Taraxacum officinale*), 11) Japanese mugwort (*Artemisia princeps*), 12) Danadian fleabane (*Erigeron canadensis*), 13) 'Hahakogusa' (*Gnaphalium affine*), 14) Blady grass (*Imperata cylindrica*), 15) Meadowgrass (*Poa annua*), 16) Creeping wood-sorrel (*Oxalis corniculata*), 17) Shepherd's-purse (*Capsella bursa-pastoris*),


Fujii, Y. Shibuya, T. and Usami, Y. Allelopathic effect of *Mucuna pruriens* on the appearance of weeds, *Weed Res, Japan* 36, 43-49 (1991)

# Allelochemical in *Mucuna* (Velvetbean)

## L-3,4-Dihydroxyphenylalanine (L-DOPA)




- Extremely **high concentration** in *Mucuna pruriens* **leaves, roots (0.5 to 1.5%) and seeds (5 to 8%) in fresh wt**.
- Relatively **strong inhibition** to broadleaf weeds ($EC_{50}$=5-50ppm), but not so active to grass (monocot.)

Fujii, Y., T. Shibuya, and T. Yasuda, L-3,4-Dihydroxyphenylalanine as an allelochemical candidate from *Mucuna pruriens*(L.) DC.var.*utilis*. Agric.Biol.Chem. 55(2), 617-618 (1991)

# How to use *Mucuna*

1) Green Manure
2) Vegetable (Young pod)
3) Seeds as food, but after proper Cooking.
4) Medicine, as a source of L-DOPA

# Hairy vetch (*Vicia villosa*)

for Green manure and Weed control

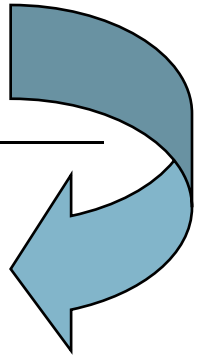
Fujii, : Screening and Future Exploitation of Allelopathic Plants as Alternative Herbicides with Special Reference to Hairy Vetch. R. K. Kohli, H. P. Singh, and D. R. Batish (Eds), Allelopathy in Agroecosystems, pp.257-275 (2001)

First observation of strong weed suppression on the field, August, 1990

Table Effect of Cover Crops on Weed Control in Abandoned Paddy Field

; First Trial on the Experimental Station (1992-1993)

| Cover Crop (English Name) | W (%)[*1] | Crop Yield [g m$^{-2}$] |
|---|---|---|
| First Sampling (May 7, 1993) | | |
| Control(No-weeding) | 0 a [*2] | ---- |
| ***Astragalus sinicus*** **（Chinese Milk Vetch)** | **82 b** | **431 a** |
| ***Vicia villosa*** **(Hairy Vetch)** | **99 b** | **584 ab** |
| *A. sativa*＋*V. villosa* （Oat and Hairy Vetch Mix.) | 99 b | 730 b |
| Second Sampling (June 10, 1993) | | |
| Control (No-weeding) | 0 a | ---- |
| ***Astragalus sinicus*** **（Chinese Milk Vetch)** | **59 b** | **135 a** |
| ***Vicia villosa*** **(Hairy Vetch)** | **100 c** | **147 b** |
| *A. sativa*＋*V. villosa* （Oat and Hairy Vetch mix.) | 100 c | 137 a |



*1 Percentage of weed control. 100 % means complete control. Dry weight of weeds in the control plot are 281 (First) and 155 (Second) g m$^{-2}$.

Fujii, Y. Screening and future exploitation of allelopathic plants as alternative herbicides with special reference to hairy vetch, *J. Crop Prod.*, 4 (2) , 257-275 (2001)

日本農業新聞

1994年(平成6年) 5 25 水曜日

ヘアリーベッチ

# 牧草に雑草・木抑制の力

## 休耕田保全、果樹の下草にぴったり



農水省四国農業試験場（香川県善通寺市）は、植物のアレロパシーという雑草を抑制する力を利用し、耕作放棄地や農地を保全する技術を開発した。牧草のヘアリーベッチが、根から抑草物質を分泌し、雑草や雑木の生育を抑制することを突き止めた。場内で実証し三か所の現地でも試験している。耕作放棄地が荒れるのを防ぎ、復田を容易にすることができることから、休耕地や耕作放棄田の保全管理と、ミカンなど果樹園の下草に普及したいとしている。

四国の山間地では、高齢化で棚田などの耕作放棄が進み、「山が里に降りてくる」（農家）。耕作放棄地に雑草が繁茂するだけでなく、雑木も生え、五年も放置すれば、太さ数㌢の木になってしまい、水田なら根が耕盤を突き抜け、田は壊れ、復田で きなくなる。

同試験はこれまでに、三百五十種類、二千品種の植物のアレロパシー活性を調べた。実験室内で、レタスの根の伸びを、抑える程度（活性）を調べたもので、ヘアリーベッチは、ほとんどない。現地試験は同県仲多度郡内の三か所、十九㌃で行っている。

雑草が最も伸び、育つ夏になると、畢さに弱いヘアリーベッチは、自然に枯れてしまうが、敷き草になり、夏雑草の発生も抑制、栽培後の土壌に植物生育阻害作用がなく、後作に悪作用がないことも分かった。

試験の結果、ヘッチの種まき適期は十一月上旬で、種十㌃当たり三―四った。

場内の試験では、何も種を まかない試験区は雑草が繁茂しているが、同牧草をまいた試験区には、雑草がほとんどない。現地試験は同県仲多度郡内の三か所、十九㌃で行っている。

雑草が最も伸び、育つ夏になると、畢さに弱いヘアリーベッチは、自然に枯れてしまうが、敷き草になり、夏雑草の発生も抑制、栽培後の土壌に植物生育阻害作用がなく、後作に悪作用がないことも分かった。

試験の結果、ヘッチの種まき適期は十一月上旬で、種十㌃当たり三―四った。

さらに、ほ場を使って、抑草効果を試験。春まき緑肥は、強くて約六〇―八〇％の生育阻害だったが、秋まきのヘアリーベッチ、エン麦、ライ麦、大麦は、九〇％以上の強い抑草作用があった。

ヘアリーベッチは雑草だけでなく、雑木の芽が生えるのを防ぐ。同試験は、「ヘアリーベッチの利用で、数年後に畑や水田に戻すことができる」という。

ことば　アレロパシー　植物が根や葉から放出する化学物質が、他の植物、昆虫、微生物などの生育や行動に何らかの影響を及ぼす作用。マリーゴールドやクロタラリアが線虫の密度を抑える例があり、神奈川県内などで、農薬に利用している。

、コモンベッチ、ン麦の活性が高

Recommendation of Hairy Vetch In Newspaper, 1994

(Japan Agricultural News)

# Orange Farm


Local Government recommend (Minami-Ashigara city)

## No herbicide, no fertilizer, only Vetch (Kiwi Fruits)

Mr. Ishiwata
Odawara City

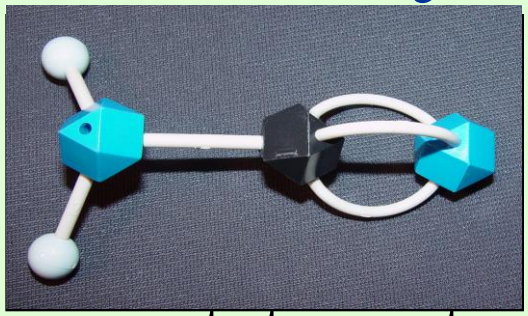
My Recommendation at 1991 →
Starting in his Fruit garden

after 10 years

No herbicide, No fertilizer, No organic materials than vetch →
now spreading all around Japan in Orchard ……


# Identification of Cyanamide as Allelochemical from Hairy vetch

★ **Cyanamide**



★ known as active constituents of synthetic fertilizer (Calcium cyanamide) **First finding from plants**

Kamo, T., Hiradate, S. and Fujii, Y.: First isolation of natural cyanamide as a possible allelochemical from hairy vetch *Vicia villosa* . *J. Chemical Ecol.* 29 (2), 275-283 (2003)


Horimoto, S., Araki, H., Itoh, H., & Fujii, Y.,Weed suppression and rice yield in the hairy vetch introduced paddy field. *Weed Sci. Tech.* 47, 168-174 (2002)

## Sustainable Rice production
## by Hairy vetch mulch


## Organic Rice with Hairy vetch

# Hairy Vetch used as cover crop in Japan

more than10,000 ha

(estimated from 300 tons seed)

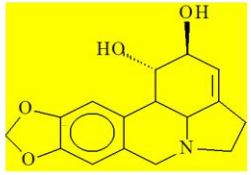
No.2 as cover crop

…after 18 years

# Other Promising Allelopathic Cover Plants

# Red Spider Lily
## *Lycoris radiate*

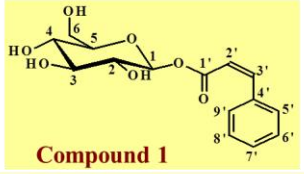
- Japanese traditional plants originally came from South China（Yunnan）
- Farmers notice allelopathy

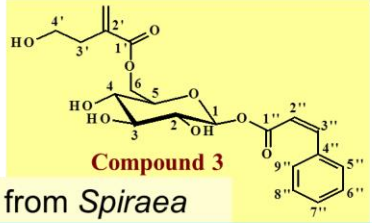



**Allelochemical: Lycorine**

Iqbal, Z., Nasir, H., Hiradate, S. and Fujii, Y. Plant growth inhibitory activity of Lycoris radiate Herb. and possible involvement of lycorine as an allelochemical. *Weed Biology and Management*, 6 (4), 221-227 (2006).

# Thunberg spiraea
## Yuki-yanagi 雪柳
## *(Spiraea thunbergii)*

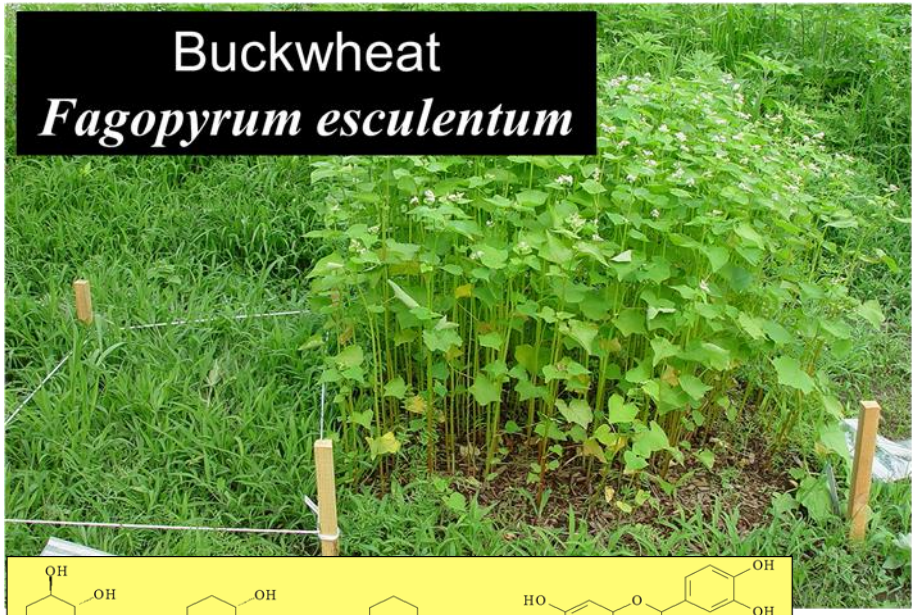



Isolation of *cis*-cinnamic acid from *Spiraea*

Hiradate, S., S. Morita, H. Sugie, Y. Fujii, and J. Harada, Phytotoxic *cis*-cinnamoyl glucosides from *Spiraea thunbergii*. Phytochemistry, 65(6), 731-739 (2004)

# Buckwheat
## *Fagopyrum esculentum*



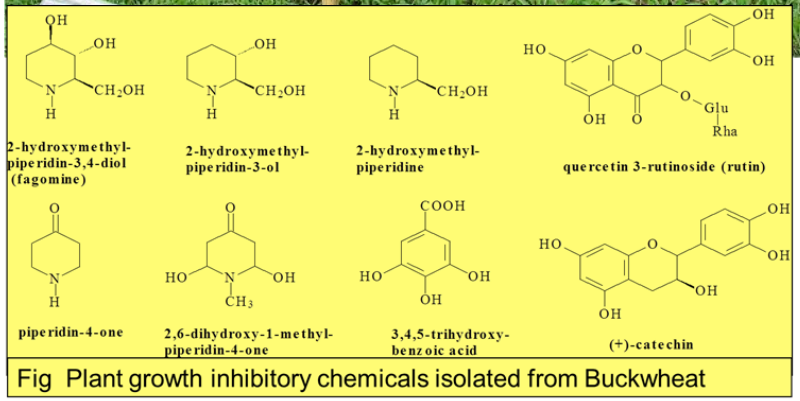
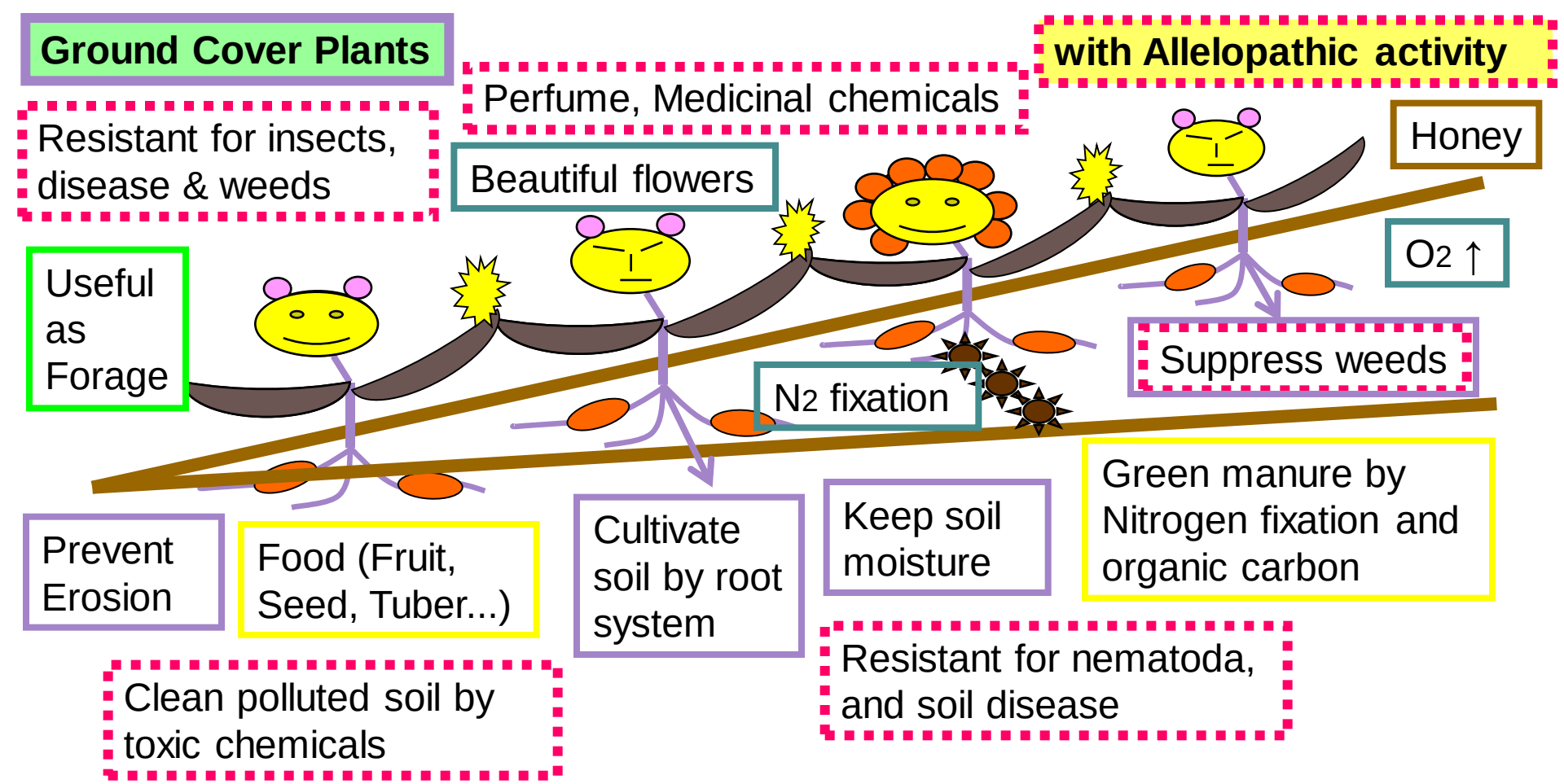



Fig Plant growth inhibitory chemicals isolated from Buckwheat

Iqbal, Z., Hiradate, S., Noda, A., Isojima, S. and Fujii, Y. : Allelopathy of buckwheat: Assessment of allelopathic potential of extract of aerial parts of buckwheat and identification of fagomine and other related alkaloids as allelochemicals. *Weed Biology and Management* **2,** 110-115 (2002)




**Phyto-Lark** : Ground Cover plants with allelopathy

# Three key messages

- **Specific bioassays for Allelopathy**, and evaluated about 4,000 plants.
- New Allelochemicals Isolated by new methodology, "**Total Activity Method**"
- **Ground Cover Plants with allelopathiy (= Phytolark )** provides natural and environmentally friendly way of managing weeds without herbicides.

Department of Agriculture and Food
GOVERNMENT OF WESTERN AUSTRALIA

GRDC Grains Research & Development Corporation
Your GRDC working with you

# Questions?

## Contact details

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CROP updates