ผลของกรด 3-ไนโทรซินนามิก และ 3,4-(เมทิลลีนไดออกซี)ซินนามิกต่อวัชพืชและพืชปลูก

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EFFECTS OF 3-NITROCINNAMIC ACID AND 3,4-(METHYLENEDIOXY) CINNAMIC ACID ON WEEDS AND CROPS

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Thesis Title	EFFECTS OF 3-NITROCINNAMIC ACID AND 3,4-(METHYLENEDIOXY)CINNAMIC ACID ON THE GROWTH OF WEEDS AND CROPS
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Field of Study	Biotechnology
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ได้สังเคราะห์กรด 3-ไนโทรซินนามิก, กรด 3,4-(เมทิลีนไดออกซี)ซินนามิก, โซเดียม 3-ไนโทรซินนาเมต และ โซเดียม 3,4-(เมทิลีนไดออกซี)ซินนาเมต เพื่อนำไปใช้ทดสอบกับพืชเศรษฐกิจและวัชพืชสำคัญของประเทศไทย สารเคมีทั้ง 4 ชนิดสังเคราะห์ขึ้นจากการทำปฏิกิริยาระหว่างกรดมาโลนิกกับอัลดีไฮด์ การทดสอบในระดับห้องปฏิบัติการพบว่าสารทั้ง 4 ชนิด สามารถยับยั้งการงอกและการเจริญเติบโตของวัชพืชได้มากกว่า 60% เมื่อใช้ที่ความเข้มข้น 100 ppm และมีผลกระทบต่อพืชปลูกด้วย การศึกษาผลของสารโซเดียม 3-ไนโทรซินนาเมต และโซเดียม 3,4-(เมทิลีนไดออกซี)ซินนาเมตต่อการเจริญของวัชพืช โดยใช้หญ้ารังนกและถั่วผีเป็นวัชพืชทดสอบในกระถาง พบว่าที่ความเข้มข้น 30000 ppm พืชทดสอบทั้ง 2 ชนิด ถูกยับยั้งการเจริญเติบโตมากกว่า 44% โดยพืชทดสอบที่ได้รับสารมีอาการ ใบไหม้ ใบม้วน แต่สามารถฟื้นกลับได้หลังจากได้รับสาร 12 วัน ในการศึกษาถึงความเป็นพิษต่อหอยเชอรี่ พบว่าสารทั้ง 4 ชนิดนี้แสดงความเป็นพิษต่อหอยเชอรี่น้อยกว่า 7%

สาขาวิชา…..…..เทคโนโลยีชีวภาพ…..... ลายมือชื่อนิสิต.....……

ปีการศึกษา….....2547……..... ลายมือชื่ออาจารย์ที่ปรึกษา…..……..

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3-Nitrocinnamic acid, 3,4-(methylenedioxy)cinnamic acid, sodium 3-nitrocinnamate and 3,4-(methylenedioxy)cinnamate were synthesized and tested on important economic crops and noxious weeds. All of tested chemicals synthesized from the condensation reaction between malonic acid and selected aromatic aldehyde. At 100 ppm all substances had more than 60% in germination inhibition and growth inhibition on tested weed species and crops, also. To find out the effective concentration of sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy) cinnamate, *Chloris barbata* Sw. and *Macroptilium lathyroides* (L.) Urb. were selected as target plant species in pot test. The result indicated that these chemicals have 44% inhibition on tested plants at 30000 ppm. According to pot test, these chemicals can merely inhibit all tested plants growth. Their leaves were burn and curly but can recover themselves within 12 days. For toxicity study on *Pomacea canaliculata* Lamarck., all tested chemicals have less than 7% toxicity.

Field of study ….. Biotechnology ….. Student's signature……
Academic year……2004…..……. Advisor's signature…….……..
Co-advisor's signature……..

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List of Abbreviations

br	broad (NMR)
°C	degree celsius
$CDCl_3$	deuterated chloroform
CH_2Cl_2	dichloromethane, methylene chloride
$CHCl_3$	chloroform
CIGAR	constant time inverse-detected gradient accordion rescaled long-rang heteronuclear multiple bond correlation
cm^{-1}	unit of wavelength
Conc.	concentration
DMSO	dimethylsulfoxide
DMSO-d_6	deuterated dimethylsulfoxide
EtOAc	ethyl acetate
EtOH	ethanol
g	gram (s)
GC	gas chromatography
Hz	hertz
HPLC	high performance liquid chromatography
IR	infrared
J	coupling constant
kg	kilogram (s)
L	liter (s)
LC_{50}	50% lethality concentration
m	multiplet (NMR)
M^+	molecular ion
MeOH	methanol
mg	milligram (s)
mL	milliliter (s)
MS	mass spectrometry
MW	molecular weight
m/z	mass to charge ratio
nm	nanometer

List of abbreviations (continued)

NMR	nuclear magnetic resonance
ppm	part per million
UV	ultraviolet
Vol.	volume
wt	weight
δ	unit of chemical shift
μg	microgram (s)
DAA	Day After Application
WBA	Week Before Application

CHAPTER I
INTRODUCTION

Since Thailand is one the most famous agricultural countries, so agricultural pests are the serious problems of the country. There are many serious problems to cultivated crops, such as weather, irrigation, insect or especially weed-derived problems. Weed is an unwanted plant that grows in the same cultivated area with crops. Weed can harm crops seriously such as reducing quality and quantity of crops, diminishing crops nutrition or even making crops die. For those reason, farmer has to eliminate them from their plantation by all means.

Nowadays, the tendency of herbicidal utility of Thai farmer depends mainly on chemical herbicides which cause many subsequent problems. Chemical herbicides are short-term-expecting products but have severely inverse effect in the long run to both nature and human. Chemical herbicides can pollute all nearby biological system such as soil, water and air by its toxic though this process continues little by little and may take a duration of time to expose its threaten. As for soil, its nourishment will be diminished slowly until all of its nutrition are gone that means farmers must pay for extra fertilizer. For water, the dissolved toxic substance of chemical herbicides can damage the ecological system of local and nearby water system seriously even kill fish and other water living beings. Air, above from its smell which can cause aspiratory diseases in human and animals, herbicidal gas also halt in the high atmosphere and will be dissolved in rain that following with the toxic rain and water pollution problems. In addition, the accumulation of toxic substance of chemical herbicides in crops makes the crops poisonous to all partaker and can cause cancer and another disease in human in long terms, and if the crops have high poisonous quality it may make death to those consumer. Furthermore, most of chemical herbicides that usually sold in market are imported goods and nearly all of them have a quite expensive price, this means the more Thai farmer used those imported chemical herbicides the more money we must pay to those producer countries which cause deficit trade value. Exempt from deficit trade value problem, the remaining of chemical herbicides toxic is one of the most often reason for blocking Thai agricultural exported products to the market of the high develop countries.

By all those reasons, it is clearly that the chemical herbicide utility has many undesirable effects in all dimensions of long terms except for the short terms benefit. However, the herbicide usage of Thai farmer is accustomed with chemical herbicides for a quite long time, and if the farmer would quit those chemical ones what will be replaced, this is a question that must be first answered.

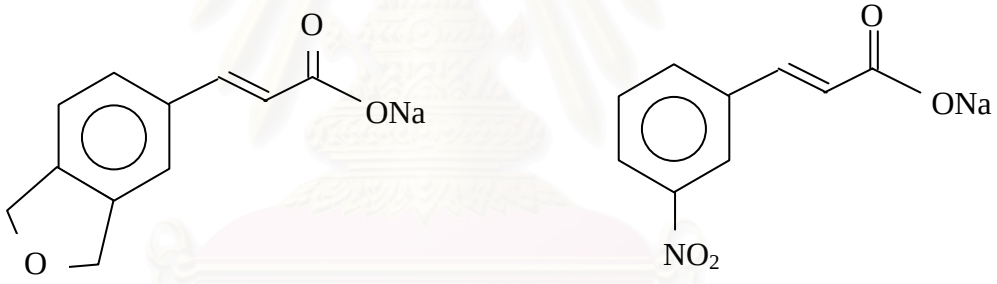
The solution for the answer is the natural herbicides, in deed, the natural herbicides are used for thousands years by human throughout the history and by its long time usage had proved that its properties, contrast to the chemical herbicides, often ineffective and lack of science base (1). The early herbicides in history can trace back to Greek period, Theophrastus reported that olive oil can use as herbicide by pouring it at the roots of trees, later, Latin philosopher Cato said that armuca; the watery residue left after the oil is drained from crushed olives, for weed control (2). Salt was also used as herbicides in the sack of Carthage and in England later. Though the lack of affection, natural herbicides still have many good aspects more than chemical herbicides, for example, it does not cause pollution to environment, has no harm to soil, does not make any toxic substance that may remain in the agriculture product, at least harm to ecological system.

However, the natural herbicides have weak points that make it hard to use. First of all, there is no any natural herbicides that can use as weed control effectively until now. Second, the natural herbicides have a short efficiency in general. Third, most of natural herbicides can extract in a little quantity per time, so it is difficult to make it for commercial purpose. Forth, some of natural herbicides can be destroy easily by light or temperature.

Concerning about the natural herbicides advantage, natural herbicides usually use local herbs as basic material that means it certainly cost cheaper than imported products as chemical herbicides. The natural herbicides can degrade easily, so it will not reserve in any crops then it is safe for consumer and also export easier. Friendly to environment, this is the most important reason for using natural herbicides, because natural herbicides make from natural components so it can use harmlessly.

Natural herbicides have both advantage and disadvantage but for the long run virtue it beat other herbicides completely, so it is the best choice for farmer of chemical herbicides replacement. However, the natural herbicides is still under

developing process for more contented properties such as more efficiency, much more last effect of the herbicides, all of these natural herbicides improvement needs more research in every dimension. One of the problems of the herbicides utility is its complicated procedure of extraction but a little outcome. Thanks to the chemistry advance, exempt from direct extraction from the natural sources of the natural herbicides, one can synthesize the substance like the natural one by the less complex chemical process which much quantity outcome refer to the direct extraction from the natural sources. The synthesis of cinnamic acid is one of the interesting groups of those synthesis substance especially to sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate. Those syntheses imitated the structure from cinnamic acid which can extract from cinnamon (*Cinnamomum cassia* Linn.). The structures of sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate are displayed below.



(a) (b)

Fig 1.1 Structures of two sodium cinnamate derivatives
(a) sodium 3,4-(methylenedioxy)cinnamate
(b) sodium 3-nitrocinnamate

From literature survey, cinnamate substances are aromatic compounds which is one of the main group of compounds which can use as weed-inhibitor (3, 4). Activities of sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate based on the allelopathic study. “Allelopathy” generally refers to the detrimental effects of higher plants of one species (the donor) on the germination or development or growth of plants of another plant (The recipient). Allelopathy can be separated from other mechanisms of plant interference because the detrimental effect is exerted through release of chemical inhibitors (allelochemicals) by the donor species. In 1974,

Rice (5) defines “allelopathy” as “any direct or indirect harmful effects of one plant (including microorganism)” on another through the production of chemicals that escape into the environment”. The term “allelopathy” should be extended to include the manifold mutual effects of metabolic of both plants and animals.

The study of allelopathy has a long history. According to Rice (3), Lee and Monis (4) found a report by Banzan Kumazawa in a Japanese document some 300 years old that rain or dew washing of the leaves of red pine (*Pinus densiflora*) was harmful to crops growing under the pine. This was substantiated by these workers in a series of experiments. Historically, this is considered to be the first report on allelopathy. Besides, Bonner (6) found that the residue of guayule (*Pathenium argentatum*) produced *trans*-cinnamic acid, which is toxic to young guayule plants. He also found that cinnamic acid was slowly decomposed in soil, so that the effect disappeared with time.

Several aromatic compounds, such as caffeic acid, chlorogenic acid, *trans*-cinnamic acid, *p*-coumaric acid, ferulic acid, gallic acid, vanillic acid, vanillin and *p*-hydroxybenzaldehyde have been found in crop residues and many of them have been isolated from field soil (3). Guenzi and McCalla (7) also isolated those compounds from residues of corn (*Zea mays* L.), wheat (*Triticum aestivum* L.), oats (*Avena fatua* L.) and sorghum (*Sorghum bicolor* L.). The same chemicals were found to inhibit the growth of sorghum, soybeans (*Glycine max*), sunflower (*Helianthus annuus* L.) and tobacco (*Nicotiana tabacum* L.) (8).

According to Deesamer (9) sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate exhibited good results as weed-inhibitor in laboratory test. Sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate are potentiality substances that can develop to weed-inhibitor referring to the laboratory experimental result. However, sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate needs pot test result to prove if the substances can really use as weed-inhibitor or not. Pot test process specifies on Swollen finger grass (*Chloris barbata* Sw.) and Phasey bean (*Phaseolus lathyroides* Linn.f.) because of it high ability of germination and its resisting. Swollen finger grass (*Chloris barbata* Sw.) and Phasey bean (*Phaseolus lathyloides* Linn.f.) were test to finding a suitable concentration of Sodium 3,4-(Methylenedioxy)Cinnamate and sodium 3-nitrocinnamate for best

herbicidal activity. Exempt form Swollen finger grass (*Chloris barbata* Sw.) and Phasey bean (*Phaseolus lathyloides* Linn.f.), there are other twenty plants examining to find out if sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate have the herbicidal effect, the list of all test-plant are swollen finger grass (*Choris barbata* Sw.), crowfoot grass (*Dactyloctenium aegyptium* (L.) P.B.), barnyard grass (*Echinochloa crus-galli* (L.) Beauv.), jointvetch (*Aeschynomene americana* Linn.), slender amaranth (*Amaranthus viridis* Linn.), wild caia (*Cleome viscosa* Linn.), swamp morning glory (*Ipomoea aquatica* Forsk.) , rice (*Oryza sativa* Linn.), giant mimosa (*Mimosa pigra* Linn.), phasey bean (*Phaseolus lathyroides* Linn. f.), chinese celery (*Apium graveolens* L.), hairy basil (*Ocimum americanum* Linn.), chinese cabbage (*Brassica campertris* var. chinensis), eggplant (*Solanum xanthocarpum* Schard & Wendl.), corn (*Zea mays* Linn.), mung bean (*Vigna radiata* Linn.), Wild spikenard (*Hyptis suavelonsis* (L.) Poit.), cock's-comb (*Celosia argentia* L.), ivy gourd (*Coccinia cordifolia* Cogn.), Strinking passion flower (*Passiflora foetida* L.), Popping pod (*Ruellia tuberosa* L.), red sprangle top (*Leptochloa chinensis* (L.) Nees), Glossy wild sorghum (*Sorghum nitidum* (Vahl) Pers.), Goat weed (*Ageratum conyzoides* L.), trichoxanthes (*Trichosanthes bracteata* (Lam.) Voigt.), Muskmelon (*Cucumis melo* Linn.), Wild daisy (*Tridax procumbens* L.), Chilli (*Capsicum frutescens* Linn.), Coriander (*Coriandrum sativum* Linn.), and Country mallow (*Abutilon indicum* (L.) Sweet.).

1.1 Synthesis of *trans*-cinnamic acid

Many methods have been reported to apply for the synthesis of *trans*-cinnamic acid. Utilizing benzaldehyde as a substrate, the synthesis of *trans*-cinnamic acid could be accomplished by various well-known reactions; for instance (10),

Perkin reaction: condensation between benzaldehyde and acid anhydride in the presence of sodium salt functioning as a catalyst.

Knoevenagel reaction: condensation between benzaldehyde, malonic acid and ammonia, piperidine or diethylamine with alcohol as solvent.

Doebner reaction: condensation between benzaldehyde and malonic acid with pyridine as solvent and trace of piperidine as catalyst.

Claisen reaction: condensation between benzaldehyde and ethyl acetate with metallic sodium and trace of alcohol.

Reformatsky reaction: condensation between benzaldehyde and ethyl bromoacetate with metallic zinc and benzene as solvent.

In this thesis uses Doebner reaction in *trans*-cinnamic acid synthesis process because of it easily to do the process.

1.2 Literature review

Natural herbicides have been used for a long time through out the history until World Wars II that the science development brought chemical herbicides into the agricultural system. Pokorny (11) first synthesized (2,4-dichlorophenoxy) acetic acid (2,4-D). It had no activity as a fungicide or insecticide. Accounts vary about when the first work on growth-regulator herbicides was done (12). Zimmerman and Hitchcock of the Boyce-Thomson Institute first described the substituted phenoxy acids (2,4-D is one) as growth regulators, but did not report herbicidal activity. They also worked with other compounds that eventually become herbicides (13). They were the first to demonstrate that these molecules had physiological activity in cell elongation, morphogenesis, root development, and parthenocarpy (14). The widespread utility of herbicides came from its most important property; the selectivity (15). Later the chemical herbicide blooming period many people felt its dangers, for example, some herbicides that remain in agricultural products can cause cancer in human, most of herbicides can do harm to ecological system around plantation area seriously. Bewaring of herbicides threatens called for searching more safety weed control and the solution is natural herbicides. Less harmful to environment, easily to degrade, less toxicity for human and cattle, these are advantages of natural herbicide but they are disadvantage in the same time too comparing to chemical herbicides because of those quality of natural herbicide which defective its ability on biological weed control.

Though many natural herbicides were invented, the less can really use in agricultural system as the natural herbicides needs serious study for its developing. In fact, the natural herbicide gaining process is a quite complex process and the out come is not valuable in the economic point of view. However, Searching for the natural herbicides will grant benefit to us all as describing above. The study of sodium

3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate is one of natural herbicide searching.

1.3 Bioassay species

To describe the herbicidal activity of sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate twenties plants were selected for bioassay.(16, 17, 18)

1.3.1 Monocotyledonous weeds

1) *Chloris barbata* Sw.

Fig 1.2 *C. barbata* Sw.

***Family* :** Poaceae

***Common Name* :** Swollen finger grass

***Synonyms* :** *C. inflata* LK.

***Thai Name* :** Yaa rangnok (หญ้ารังนก) (19)

***Picture from* :** (20)

Annual grass, tufted. Culms, erect and branching, 50-100 centimeters high. Leaves, linear, hairy, 5-30 centimeters long. Inflorescence, at terminal, composed of 5-10 digitately arranged purple spikes. Spikelets, subsessile, greenish purple, with purple hairs arising from petal apex. The life span is rather short. Heading and flowering all year round. Propagated by seeds.

This weed prefers dry condition and often grows in sunny areas along roadsides, in wastelands, grasslands, and upland and perennial crop fields, distributed throughout Thailand.

2) *Dactyloctenium aegyptium* Willd.

Fig 1.3 *D. aegyptium* Willd.

***Family* :** Poaceae

***Common Name* :** Crowfoot grass, Coast buttongrass, Beach wiregrass

***Synonyms* :** *D. aegyptium* (L.) P.B., *Eleusine aegyptia* (L.) Desf.

***Thai Name* :** Yaa paak khwaii (หญ้าปากควาย)

***Picture from* :** (21)

Annual grass, erect and spreading. Culms, stoloniferous, rooting and shooting at lower nodes, 40-50 centimeters high. Leaves, linear, about 20 centimeters long, with hairs in leaf margins. Inflorescence, 2 to 7 coarse spikes, arranged digitately, 2-4 centimeters long, with hairs at the central core. Spikelets, sessile. The life cycle is short and flowering all year round. Propagated by seeds and stolon.

This weed prefers dry condition, commonly found in upland crop and wastelands, distributed throughout Thailand.

3) *Echinochloa crus-galli* (L.) P. Beauv.

Fig 1.4 *E. crus-galli* (L.) P. Beauv.

***Family* :** Poaceae

***Common Name* :** Barnyard grass,
Water grass,
Baronet grass (22)

***Synonyms* :** *E. pungens* L.

***Thai Name* :** Yaa khaao nok (หญ้าข้าวนก)

***Picture from* :** (23)

Annual grass noxious narrow leaves. This plant is a damaging weed in the paddy field and other crops (24). Leaves are linear and acuminate with 10-30 centimeters long. Flowers are inflorescence, panicle 10-20 centimeters long. It's a vigorous, worm season annual grass reaching 1 to 5 feet in height with base of many stems reddish to dark purple (25). This weed is not an only noxious weed in Thailand, but also of the world. Holm (24) reported it as a top-ten world worst weed; distribute both in tropical and temperate zone of the world, both in paddy field and upland field. This weed cause harmful aspect to crop especially to rice (26).

This weed prefers moist lands, commonly grown in dry-seeded rice and wastelands. Distributed in Central Thailand.

1.3.2 Dicotyledonous weeds

1) *Amaranthus viridis* L.

Fig 1.5 *A. viridis* L.

***Family* :** Amaranthaceae

***Common Name* :** Slender amaranth

***Synonyms* :** *A. gracilis* Desf.

***Thai Name* :** Phak khom (ผักขม) (19)

***Picture from* :** (27)

Annual herb. Stems, erect, brownish, 30-70 centimeters high. Leaves, simple, alternate, triangular-ovate, with long petiole, 4-10 centimeters long. Inflorescence, terminal and axillary, dense spike disposed, brown, small floret about 1 millimeter long. Fruits, schene-like. Seeds, shiny black. Reproduced by seeds.

This weed prefers dry condition, commonly found in wastelands, along roadsides, and upland crop fields, distributed throughout Thailand.

2) *Celosia argentia* L.

Fig 1.6 *C. argentia* L.

***Family* :** Amaranthaceae

***Common Name* :** Cock's-comb

***Synonyms* :** -

***Thai Name* :** Ngon kai thai (หงอนไก่ไทย)

***Picture from* :** (28)

Annual herb. Stems, erect, branched, glabrous, strongly ribbed, up to 150 centimeters tall. Leaves, linear-lanceolate/ ovate-oblong, acute at both end, upper one subsessile. Inflorescence, dense spike, terete, white and pink-tipped, pallescent. Fruits, obovoid. Seeds, lenticular, black in color 1.3-1.5 millimeters long. Propagated by seeds.

This weed prefers dry localities, commonly found in upland fields, waste places, and roadsides.

3) *Cleome viscosa* L.

Fig 1.7 *C. viscosa* L.

***Family* :** Capparidaceae

***Common Name* :** Wild caia

***Synonyms* :** -

***Thai Name* :** Phak sian phi (ผักเสี้ยนผี) (19)

***Picture from* :** (29)

Annual herb. Stems, erect, hairy, branched, 20-140 centimeters tall. Leaves, compound, 3 to 5 foliolate, alternate. Leaflets, oblong to obovate, 5-10 millimeters wide and 2-5 centimeters long. Flowers, solitary, axillary, yellow in color. Fruit, capsules, silique, pubescent 6-8 centimeters long. Seeds, ribbed-rough. Reproduce by seeds.

This weed commonly found in paddy as well as upland crop fields, and wastelands.

4) *Ipomoea aquatica* Forsk.

Fig 1.8 *I. aquatica* Forsk.

***Family* :** Convolvulaceae

***Common Name* :** Swamp morning glory, Water spinach

***Synonyms* :** *I. reptans* (L.) Poir.

***Thai Name* :** Phak bung (ผักบุ้ง) (19)

***Picture from* :** (30)

Perennial herb, aquatic or amphibious. Stems, round, juicy, tailing or floating, several meters in length, branched and rooted at the nodes. Leaves, simple, alternate, saggitate, entire. Inflorescence, cymose, funnel shaped, corolla white at upper and violet at base or white. Fruits, capsule. Reproduced vegetatively and by seeds.

This weed prefers aquatic or wet condition, commonly found in aquatic area and paddy fallows.

5) *Macroptilium lathyroides* (L.) Urb.

***Family* :** Fabaceae

***Common Name* :** Phasey bean

***Synonyms* :** *Phaseolus lathyroides* Linn. f.
P. semi-erectus (L.) DC,
P. crotalaroides Mort.

***Thai Name* :** Thua phi (ถั่วผี) (19)

***Picture from* :** (31)

Fig 1.9 *M. lathyroides* (L.) Urb.

Perennial herb. Stems, erect, trailing at upper, pubescent, 1.0-1.5 meters tall. Leaves compound, trifoliate, lateral stipule. Leaflets, oblong, acute, glabrous, lateral stipule. Inflorescence, spike-like, scabrous peduncle, up to 40 centimeters long. Florets, zygomorphic, tubular calyx, dark red collora. Fruits, pods, pubescent, 8-10 centimeters long. Propagated by seeds

This weed prefers dry condition, commonly found along roadsides, fencerows and wastelands.

6) *Mimosa pigra* L.

***Family* :** Fabaceae

***Common Name* :** Giant mimosa

***Synonyms* :** *Mimosa pellita*

***Thai Name* :** Maiyaraap yak (ไมยราพยักษ์)

***Picture from* :** (32)

Fig 1.10 *M. pigra* L.

Perennial woody shrub, rapidly growing. It is noxious broad leaf weeds that grows rapidly and widely distribute all regions in Thailand. It infests both agricultural and non-agricultural area, cause serious problem for irrigation and transportation (33). The plant has strong stem with spine, 2-4 meters tall. Leaves, bipinnate, more than 20 centimeters long, less sensitive to the touch. Inflorescence, head, pink. Pods, hairy, slightly curved, 5-10 centimeters long. Reproduced by seeds.

This weed prefers wet and swamp condition, commonly found and widely spread in Northern Thailand, recently invading to the Central. Occasionally found in the Northeast and South Thailand.

7) *Ruellia tuberosa* L.

Fig 1.11 *R. tuberosa* L.

***Family* :** Acanthaceae

***Common Name* :** Popping pod

***Synonyms* :** -

***Thai Name* :** Toi ting (ต้อยติ่ง) (19)

***Picture from* :** (34)

Perennial herb.stems, erect up to 3 centimeters. Leaves, opposite, oblong or oblong-obovate, repend. Inflorescence, cymes, long peduncle, corolla tube, 5-lobes, sinuate-dentate, bright violet. Fruits, capsule, fusiform 2-3 centimeters. Seeds suborbicular, compressed, dark brown. Reproduced by seeds.

This weed commonly distributes in dry regions, slightly shaded localities, crop fields, wastelands and roadside. It sometimes becomes a weed in plantation area.

1.3.3 Monocotyledonous crops

1) *Oryza sativa* L.

Fig 1.12 *O. sativa* L.

***Family* :** Poaceae

***Common Name* :** Rice

***Synonyms* :** -

***Thai Name* :** Khao (ข้าว) (19)

***Picture from* :** (35)

Oryza sativa L., the most important economic crops of Thailand (36), an annual crop with erect culms 1.33 meters tall usually with four to five tillers. Inflorescence a loose terminal panicle of perfect flowers each panicle branch bearing a number of spikelets, each with a single floret. Each flower is surrounded by a lemma and palea at

the base of which are two small glumes. The lemmas may be awn less or variously awned. The rice grain enclosed by the lemma and palea (hull) varies in size, texture and color. Each panicle holds 100-150 seeds. Reproduced by seeds.

Rice is one of the world's two major human food crops, the other being wheat. Rice straw is retained for feeding draught animals in most rice-producing countries in the tropics. Rice bran is fed to domestic animals when not required for human consumption in dry years. Paddy straw provides 80 percent of the organized roughage for India and a large part of the roughage for animals in other rice-producing countries where draught animals are used.

2) *Zea mays* L.

Fig 1.13 *Z. mays* L.

***Family* :** Poaceae

***Common Name* :** Maize, Corn, Sweet corn

***Synonyms* :** -

***Thai Name* :** Khao phot (ข้าวโพด) (19)

***Picture from* :** (37)

Zea may L., an annual economic cereal and forage crop. Culms 60-80 centimeters high, straight, internodes cylindrical in the upper part, alternately grooved on the lower part with a bud in the groove. The stem is filled with pith. Leaf-blades broad. Has separate staminate (male) and pistillate (female) inflorescences. The staminate inflorescence is a tassel borne at the apex, the pistillate flowers occur as spikes (cobs) rising from axils of the lower leaves. The ovary develops a long style or silk which extends from the cob and receives the pollen from the tassel. Reproduced by seeds.

1.3.4 Dicotyledonous crops

1) *Apium graveolens* L.

Fig 1.14 *A. graveolens* L.

***Family* :** Apiaceae

***Common Name* :** Celery

***Synonyms* :** -

***Thai Name* :** Khuen-chai (ขึ้นฉ่าย) (19)

***Picture from* :** (38)

Apium graveolens L., annual herb, this plant can grow in any areas and used as vegetable. Perennial caulescent herb, erect to ascending, 5-12 decimeters tall, stems not rooting at nodes; basal leaves. pinnate, 1-6 decimeters long, petioled,the upper much reduced. Leaves, 5-9, 2.5-7 centimeters long, the divisions ovate to suborbicular or cuneate; petioles 3-25 centimeters. Flowers white in compound umbels which are sessile or short-peduncled, involucels none; rays 7-16; pedicels 1-6 millimeters long. Fruit, subglobose to ellipsoid, notched at tip 1.5 millimeters long.

This plant prefers a rich moist soil in sun or semi-shade, but with some shade in the summer. It is tolerant of saline soils. The plants are fairly hardy, though they can be damaged by hard frosts.

2) *Brassica chinensis* L. var. ***chinensis***

Fig 1.15 *B. chinensis* L.

***Family* :** Cruciferae

***Common Name* :** Pak choi cabbage,
Chinese cabbage,
Pe-Tsai cabbage

***Synonyms* :** -

***Thai Name* :** Phakkat khao kwangtung
(ผักกาดขาวกวางตุ้ง),
Phakkat bai (ผักกาดใบ) (19)

***Picture from* :** (39)

Annual herb, growing to 0.75 meters high. It is in flower from May to August. The flowers are hermaphrodite (have both male and female organs) and are pollinated by Bees. The plant is self-fertile. Reproduced by seeds.

The plant prefers sandy soils, loamy soils and clay soils, requires well-drained soil and can grow in heavy clay soil. The plant prefers acid, neutral and alkaline soils and can grow in very alkaline soil. It can grow in semi-shade (light woodland) or no shade. It requires moist soil.

This plant succeeds in full sun in a well-drained fertile preferably alkaline soil. Succeeds in any reasonable soil but prefers one on the heavy side. Tolerates a pH in the range 4.8 to 8.3.

3) *Capsicum frutescens* Linn. var. ***frutescens***

Fig 1.16 *C. frutescens* Linn.

***Family* :** Solanaceae

***Common Name* :** Chili

***Synonyms* :** *C. minimum* Roxb.

***Thai Name* :** Phrik khinu (พริกขี้หนู) (19)

***Picture from* :** (40)

Perennial growing to 1 meter. It is in flower from August to September. The flowers are hermaphrodite (have both male and female organs). Reproduced by seeds.

The dried fruit is a powerful local stimulant with no narcotic effect, it is most useful in atony of the intestines and stomach. It has proved efficacious in dilating blood vessels and thus relieving chronic congestion of people addicted to drink. It is sometimes used as a tonic and is said to be unequalled in warding off disease (probably due to the high vitamin C content). Some caution should be employed, however, since large doses are extremely irritating to the gastro-intestinal system. Used externally, the fruit is a strong rubefacient stimulating the circulation, aiding the removal of waste products and increasing the flow of nutrients to the tissues. It is applied as a cataplasm or liniment. It has also been powdered and placed inside socks as a traditional remedy for those prone to cold feet. A weak infusion can be used as a gargle to treat throat complaints. The fruit is also antihaemorrhoidal, antirheumatic,

antiseptic, carminative, diaphoretic, digestive, sialagogue and stomachic. These pungent fruited peppers are important in the tropics as gastrointestinal detoxifiers and food preservatives. The fruits contain 0.1 - 1.5% capsaicin. This substance stimulates the circulation and alters temperature regulation. Applied to the skin it desensitizes nerve endings and so has been used as a local anaesthetic. The seed contains capsicidins. These are thought to have antibiotic properties.

The plant prefers sandy, loamy and clay soils and requires well-drained soil. The plant prefers acid, neutral and alkaline soils and can grow in very acid and very alkaline soils. It cannot grow in the shade. It requires moist soil.

4) *Coriandrum sativum* Linn.

Fig 1.17 *C. sativum* Linn.

***Family* :** Apiaceae

***Common Name* :** Coriander

***Synonyms* :** -

***Thai Name* :** Phak chi (ผักชี) (19)

***Picture from* :** (41)

Annual growing to 0.45 meters. It is in flower from June to July, and the seeds ripen from August to September. The scented flowers are hermaphrodite (have both male and female organs) and are pollinated by Insects. The plant is self-fertile. It is noted for attracting wildlife. Reproduced by seeds.

Leaves - raw or cooked. They are used as a flavoring in salads, soups etc. and the fresh leaves are probably the most widely used flavoring herb in the world. The leaves have an aromatic flavor. It is foetid according to another report, whilst another says that the fresh leaves have a strong bedbug-like smell. The leaves should not be eaten in large quantities. The fresh leaves contain about 0.012% oxalic acid and 0.172% calcium.

Seed - cooked. It is used as a flavoring in many dishes including cakes, bread and curries, it is also widely used to flavor certain alcoholic liquors. The fresh seed has a disagreeable and nauseous smell, but when dried it becomes fragrant, the longer it is kept the more fragrant it becomes. Plants yield about 1.75 tones per acre of seed.

The root is powdered and used as a condiment. An essential oil from the seed is used as a food flavoring.

The plant prefers sandy and loamy soils and requires well-drained soil. The plant prefers acid, neutral and alkaline soils and can grow in very alkaline soil. It can grow in semi-shade (light woodland) or no shade. It requires dry or moist soil.

5) *Cucumis melo* Linn.

Fig 1.18 *C. melo* Linn.

Family **:** Cucurbitaceae

Common Name **:** Melon, Musk melon

Synonyms **:** -

Thai Name **:** Taeng thai (แตงไทย) (19)

Picture from **:** (42)

Annual Climber growing to 1.5 meter high. It is in flower from July to September, and the seeds ripen from August to October. The flowers are monoecious (individual flowers are either male or female, but both sexes can be found on the same plant) and are pollinated by Insects. The plant is self-fertile. Propagated by seeds.

This plant prefers sandy soils, loamy soils and clay soils and requires well-drained soil. The plant prefers acid, neutral and alkaline soils. It cannot grow in the shade. It requires moist soil.

Fruit, very watery but with a delicate flavor, it is very refreshing. Rich in vitamins B and C. The flesh of the fruit can be dried, ground into a powder and used with cereals when making bread, biscuits etc.. The size of the fruit varies widely between cultivars but is up to 10 centimeters long and 7 centimeters wide.

6) *Ocimum americanum* L.

Fig 1.19 *O. americanum* L.

***Family* :** Labiatae

***Common Name* :** Hoary basil

***Synonyms* :** *O. canum* Sims.

***Thai Name* :** Maeng lak (แมงลัก) (19)

***Picture from* :** (43)

Perennial herb, growing to 0.45 meters high. It is in flower from August to September, and the seeds ripen in September. The scented flowers are hermaphrodite (have both male and female organs) and are pollinated by Bees. Reproduced by seeds.

The plant prefers light sandy and medium loamy soils and requires well-drained soil. The plant prefers acid, neutral and alkaline soils. It cannot grow in the shade. It requires moist soil. Prefers a rich light well-drained to dry soil.

Requires a sunny sheltered position if grown outdoors. Tolerates a pH in the range 5 to 8. Sweet basil is commonly grown as an aromatic culinary and medicinal herb in warm temperate and tropical climates.

7) *Solanum aculeatissimum* Jacq.

Fig 1.20 *S. aculeatissimum* Jacq.

***Family* :** Solanaceae

***Common Name* :** Cockroach berry

***Synonyms* :** *Solanum xanthocarpum* Schard&Wendl.

***Thai Name* :** Ma khua khuen (มะเขือขื่น), Ma khua phroa (มะเขือเปราะ) (19)

***Picture from* :** (44)

Perennial herb growing to 1 meter. It is in leaf from May to October, in flower from July to September, and the seeds ripen from August to October. The flowers are hermaphrodite (have both male and female organs) and are pollinated by Insects. Reproduced by seeds.

Fruit - raw or cooked. The fruit should not be eaten raw. It can be baked, stewed or added to soups, curries etc. The fruit is said to be very nutritious. It is a good source of vitamin C and potassium. The fruit can be up to 20centimeters long in cultivated plants.

This plant is used mainly as a food crop, but it does also have various medicinal uses that make it a valuable addition to the diet. In particular the fruit helps to lower blood cholesterol levels and is suitable as part of a diet to help regulate high blood pressure. The fruit is antihaemorrhoidal and hypotensive. It is also used as an antidote to poisonous mushrooms. It is bruised with vinegar and used as a poultice for cracked nipples, abscesses and haemorrhoids. The leaves are narcotic. A decoction is applied to discharging sores and internal haemorrhages. A soothing and emollient poultice for the treatment of burns, abscesses, cold sores and similar conditions can be made from the leaves.

The plant prefers sandy, loamy and clay soils and requires well-drained soil. The plant prefers acid, neutral and alkaline soils. It cannot grow in the shade. It requires moist soil.

8) *Vigna radiata* L.

Fig 1.21 *V. radiata* L.

***Family* :** Leguminoceae

***Common Name* :** Mung bean, Green gram

***Synonyms* :** *Phaseolus aureus* Roxb.

***Thai Name* :** Thua khiao (ถั่วเขียว) (19)

***Picture from* :** (45)

Vigna radiata L. is one of economic crops. This plant has nitrogen fixation ability and can used as manure. Especially this plant can use as raw material in some industrial. An upright annual legume ranging in height from 15 centimeters to 1 meters average height of mature plant, 0.9 meters. Branches freely, but not heavily foliaged. Leaves, stems and pods are slightly hairy. Junctions of branches and stems are stipuled. The first flowers appear seven to eight weeks after planting and the crop reaches maturity

in 12 to 14 weeks. Pods borne at top of plant. Seeds, green and almost globular. Pods clothed in long, spreading, deciduous silky hairs. Propagated by seeds.

1.3.5 Snails

1) *Pomacea canaliculata* Lamarck. (46)

Fig 1.22 *P. canaliculata* Lamarck.

***Family* :** Ampullariidae

***Common Name* :** Golden apple anail, Apple snail, Chanelled apple snail, Golden miracle snail, Golden snail, Jumbo snail, Miracle snail, South American apple snail

***Synonyms* :** *Ampullaria canaliculata* Lamarck., *Ampullarius canaliculata* Lamarck., *Ampullarius insularum* Hamada & Matsumoto, *Ampullarius insularus* Chang, *Pila canaliculata* (Lamarck.), *Pomacea canaliculate* (Lamarck.), *Pomacea lineate*, GAS

***Thai Name* :** Hoi cherry (หอยเชอรี่)

***Picture from* :** (47)

This species comes in different colors from brown to albino or yellow and even blue, with or without banding. The body of these snails also shows great variation from black to yellow and grey. When taken good care of some apple snail species can reach a large size. Apple snails are in fact the biggest living freshwater snails on earth.

The shell of this apple snail species is globosely and relatively heavy (especially in older snails). The 5 to 6 whorls are separated by a deep, indented suture (hence the name ‘canaliculata’ or ‘channeled’). The shell opening (aperture) is large and oval to round. Males are known to have a rounder aperture than females. The umbilicus is large and deep. The overall shell shape is similar to that of *P. lineata* E., except the deeper sutures and more globose shape in canaliculata. The size of these snails varies from 40 to 60 millimeters wide and 45 to 75 millimeters high depending

on the conditions. The color varies from completely yellow and green (cultivated forms) to brown with or without dark spiral bands (wild form). The shell growth of this species occurs mainly in spring and summer, while it stagnates in fall and winter.

The operculum is moderately thick and corneous. The structure is concentric with the nucleus near the centre of the shell. The color varies light (in young snails) to dark brown. The operculum can be retracted in the aperture (shell opening). The color of the body varies from yellow (cultivated), brown to nearly black, with yellow spots on the siphon, but not as much on the mouth as in *P. bridgesi*. When at rest, the tentacles is curled under the shell.

The reddish (due to the high carotenoid content) eggs are loosely attached to each other. They are attached on object above the waterline and their size varies from 2.20 to 3.5 millimeters (0.5 to 0.9 inch) diameter. An average clutch contains 200 to 600 eggs.

When apple snails from the genus Pomacea were introduced in Taiwan in the 1980's, they were also able to transfer the *Angiostrongylus cantonensis* (rat lungworm) parasite just like the native apple snail population. This parasite spends a part of its life cycle in apple snails and can infect humans when the snail isn't cooked long enough before consumption. Apple snails became a serious pest, posing a real threat to the taro and rice production and the environment in general. Apple snails are also introduced in several regions in Africa and Asia to control snails (Planorbidae: *Bulinus* sp. and *Biophalaria* sp.) which serves as an intermediate host for trematoda parasites. These parasites can cause swimmers itch and schistosomiasis, a disease that affects over 200 million people in tropical regions. Despite the fact these tremadote parasites do not complete their life cycle in apple snails, apple snails themselves can carry these parasites and nematodes of the genus Angiostrongylus. *Angiostrongylus cantonensis* can afflict humans.

In spite the fact that many snail species are hermaphrodite apple snails are definitely not hermaphroditic: they have separated sexes (gonochoristic) and a male and a female are needed for reproduction. *P. canaliculata* is sexual mature at the size of 2.5 centimeters. The reproductive rate of this snail varies with the temperature and partly by the availability of food. During fall and winter, the reproduction rate is at its

lowest point, while with the raising temperatures in spring their reproduction rate increases.

Eats almost all types of plants; can also be fed with fish food; it is not suited for planted aquaria at all; to be avoided unless you do not have plants or other vegetation in your aquarium.

Amphibious animal; submerged during the day, hidden in the vegetation near the border and the surface. More active during the night, also leaves the water in search for fresh vegetation. The activity rate of this snail varies highly with the water temperature. At 18°C they hardly move around, this in contrast with higher temperatures (25°C).

The natural habitat of apple snails is quite various: from ponds, swamps to rivers and although they occasionally leave the water, they are mainly spending their time in the water. Apple snails are exceptionally well adapted to tropical regions with periods of drought alternated with periods of excessive rainfall. This adaptation is reflected in their life style: moderately amphibious and being equipped with a shell door enabling the snail to close its shell (to prevent drying out while hiding in the mud during dry periods).

P. canaliculata Lamarck. (golden apple snail) *P. canaliculata* are extremely polyphagous snails, feeding on vegetal, detrital and animal matter, and they also show quite flexible methods of food acquisition. In contrast with most freshwater snails, they are primarily macrophytophagous, preferring floating or submersed plants over emergent ones. Young snails feeding on detritus and algae; they begin to attack higher plants when they reach 15 millimeters.

1.4 Goal of this research

This research is designed to study on herbicidal activity in pot test with various of serious problem weed and crops. The approach is based on the assumption sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate that the imitation of natural herbicidal substances should have activities in pot test as well as in the laboratory test, though the quantity and concentration of the substances may variant. Furthermore, to study the toxicity on golden apple snail (*Pomacea canaliculata* Lamarck.) of sodium 3-nitrocinnamate and sodium 3,4-

(methylenedioxy)cinnamate. In addition, this research may suggest the alternative herbicide for Thai farmer if sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate can cause all test-weed die. Therefore, the target of this research can be summarized as follows:

1. To study the effectiveness of sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate as herbicide on weed and crop.

2. To study the herbicidal activities of sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate on different age of plant.

3. To study the toxicity of sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate on golden apple snail (*Pomacea canaliculata* Lamarck.).

CHAPTER II
MATERIALS AND METHODS

2.1 Materials

Tesed weeds seeds were collected from Amphur Banmi, Lopburi Province. Those weed species were

1. *A. viridis* Linn.
2. *C. barbata* Sw.
3. *C. viscosa* Linn.
4. *E. crus-galli* (L.) Beauv.
5. *I. aquatica* Forsk.
6. *M. lathyroides* (L.) Urb.
7. *R. tuberosa* L.

Some weeds seeds were received from Dr.Siriporn Zungsontiporn, Weed Science Sub-Division, Botany and Weed Science Division, Department of Agriculture, Ministry of Agriculture and Cooperatives. Those weed species were

8. *C. argentia* L.
9. *D. aegyptium* (L.) P.B.
10. *M. pigra* Linn.

The available crop seeds were collected from local market in Amphur Banmi, Lopburi province. They are:

11. *A. graveolens* L.
12. *B. campertris* L.
13. *C. frutescens* L.
14. *C. sativum* Linn.
15. *C. melo* Linn.
16. *O. americanum* Linn.
17. *O. sativa* Linn.
18. *S. xanthocarpum* Schard & Wendl.
19. *V. radiata* Linn.
20. *Z. mays* Linn.

According to agrochemicals, there were two types that used in this experimental. There were

1. Round up, active ingredients: N-(phosphonomethyl)glycine and isopropylamine salt 48% w/v.
2. Fixer 600, active ingredients: Blend of alkyl aryl polyethoxylate and sodium salt of dialkylsulfosuccinated 60%

2.2 Synthesis of substituted *trans*-cinnamic acids

General procedure (48)

Malonic acid 6.24 g (0.03 mol) was dissolved in 10.4 mL of anhydrous pyridine, selected aromatic aldehyde (0.03 mol) and 0.56 mL of piperidine were added. The solution was refluxed approximately 1.5 hours, cooled to room temperature, then poured into a mixture of 32 g of ice, 16 mL of conc HCl and 52 mL of H_2O, precipitating the acid as a colorless solid. The product was filtered, washed with ice water and recrystallized with dilute ethanol.

Two substituted *trans*-cinnamic acids, 3,4-(methylenedioxy)cinnamic acid and 3-nitrocinnamic acid were selected for further bioassay because of effect on tested weeds.

2.3 Preparation of sodium cinnamate derivatives

General Procedure (49)

Selected *trans*-cinnamic acids (0.03 mol), 0.03 mol of sodium hydroxide and 24 mL of toluene were put into a round bottom flask and stirred under reflux for 5 hours. The reaction solution was cooled, and then 24 mL of acetone was added thereto. The precipitate was collected by filtration; the obtained crude crystals were washed with acetone and then dried at room temperature to obtain the desirable compound.

Two sodium cinnamate derivatives, sodium 3,4-(methylenedioxy)cinnamate and Sodium 3-nitrocinnamate were selected from other sodium cinnamate derivatives because of their highly inhibitory effect on tested weeds.

2.4 Bioassay on Herbicidal Activity

2.4.1 General procedure for plant germination inhibition test (50)

A tested compound was dissolved in a proper solvent (acetone for acid form and distilled water for salt form) at concentration of 1000, 100, 10, and 1 ppm, respectively. The 3.0 mL of solution was poured in a plate (diameter 90 millimeters) which contained a filter paper. The controlled set was prepared by the same method but without any test compound. All plates were dried up for 10-12 hours, followed by the addition of 3.0 mL of distilled water to each plate (concentrations of tested

compound were 1000, 100, 10 and 1 ppm, respectively). The available seeds of tested plant species were vary by seeds size and placed in a plate, 3 plates for each concentration. All plates were covered and left at room temperature. The germinated seed numbers were recorded at 7 days after planting and calculated for germination inhibition percentage by:

$$\%\text{Germination Inhibition} = \{1 - (T/C)\} \times 100\%$$

where 'T' is germination number of treated and 'C' is germination number of controlled set.

Germination inhibition 100% means completely inhibitory effect.

2.4.2 General procedure for plant growth inhibition test (50)

Tested plant seeds were placed in to a plate (diameter 90 millimeters) which contained a filter paper. After the seeds germinated, prepared the tested compound by dissolving in a proper solvent (acetone for acid form and distilled water for salt form) at concentration of 1000, 100, 10, and 1 ppm, respectively. The 3.0 mL of solution was poured in a plate (diameter 90 millimeters) which contained with a filter paper and seedlings. The controlled set was prepared using the same method with out tested compound. All plates were covered and left at room temperature. Root length and shoot height of 10 randomly pick up were recorded after planting for 7 days. The inhibitory effect was calculated by:

$$\%\text{Growth Inhibition} = \{1 - (T/C)\} \times 100\%$$

where 'T' is average value of the index in treatment and 'C' is average value of the index in control.

Germination inhibition 100% means completely inhibitory effect.

The number of seeds used in these experiments was showed in Table 2.1.

Table 2.1 The usage number of tested seeds in laboratory scale

Plant species	Number of seeds			
	Plate 1	**Plate 2**	**Plate 3**	**Total**
Monocotyledonous weeds				
D. aegyptium Willd.	50	50	50	150
Dicotyledonous weeds				
A. viridis L.	50	50	50	150
C. argentia L.	50	50	50	150
C. viscosa L.	50	50	50	150
I. aquatica Forsk.	40	40	40	120
M. lathyroides (L.) Urb.	50	50	50	150
M. pigra L.	30	30	30	90
R. tuberosa L.	40	40	40	120
Monocotyledonous crops				
O. sativa L.	30	30	30	90
Z. mays L.	30	30	30	90
Dicotyledonous crops				
A. graveolens L.	50	50	50	150
B. chinensis L. var. *chinensis*	40	40	40	120
C. frutescens Linn. var. *frutescens*	30	30	30	90
C. sativum Linn.	30	30	30	90
C. melo Linn.	30	30	30	90
O. americanum L.	50	50	50	150
S. aculeatissimum Jacq.	30	30	30	90
V. radiata L.	30	30	30	90

2.5 Pot Experimental on the Effects of Tested Chemical

To study the effects of tested chemicals: 3,4-(methylenedioxy)cinnamic acid, 3-nitrocinnamic acid, sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate the experiment was separated into 4 experiments as describe below:

2.5.1 Effects of sodium 3-nitrocinnamate, sodium 3,4-(methylenedioxy) cinnamate and commercial herbicide, round up at different concentration

The experiment was done during June 1, 2002 to August 31, 2002. Swollen finger grass (*C. barbata* Sw.) and Phasey bean (*M. lathyroides* (L.) Urb.) were selected as bioassay species because of their high germination. Each experiment has 5 replications done in a natural condition. The seeds of bioassay species were sowed in 5×7 inches pots which contained natural soil, collected from rice field in plantation area of Amphur Banmi, Lopburi Province. 7 Days after the seeds germinated eliminated them out of the pots until each pot contained with 5 seedlings. Took care of them for 3 weeks then tested chemicals were applied at the concentrations of 30,000 ppm, 10,000 ppm, 5,000 ppm and 1,000 ppm. Shoot length was collected every 3 days after application, started at 3 days after application until 15 days after application. The results were summarized and calculated for plant growth inhibition percentage.

2.5.2 Effects of sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy) cinnamate on plant growth at different age

This experimental was carried out during January 1, 2003 to January 15, 2004. The experimental was designed to study the effect of sodium 3,4-(methylenedioxy) cinnamate and sodium 3-nitrocinnamate in different concentrations on variety species and ages of plant. The experimental has 5 replications done in a natural condition. 12 plant species were selected and sowed in 5×7 inches pots which coatained natural soil. 7 Days after the seeds germinated eliminated them out of the pots until each pot contained with 5 seedlings. After the first series were 7 days, sowed the new series of experimental and took care of them. Following to the experiment after sowing for the 4^{th} series tried to sprayed tested chemicals on tested plants. Shoot length was collected 15 days after application.

2.6 Effect of tested chemicals on golden apple snail (51)

P. canaliculata Lamarck., a snail of family Pilidae, common name golden apple snail. This snail causes severe effect on rice fields. It is very patient to every nature. Precious report rewarded that it can survive although in very dry areas. To get rid of it was difficult to do because of vitallity.

Preparation of *P. canaliculata* Lamarck. or golden apple snail

The uniform size of *P. canaliculata* Lamarck. (diameter of shell ~3.5 centimeters) was used. For each test, three snails were placed in 1000 mL of dechlorinated water overnight at room temperature.

Preparation of sample for testing

Tested compounds were prepared at concentration of 1000 ppm and diluted to 100, 10 and 1 ppm, respectively. 3 mL of each concentration was poured into a plate (diameter 90 millimeters) containing a filter paper. The controlled plate was prepared by using the same method but without sample. All plates were dried up overnight. Then, the dried filter paper was cut to small pieces and put in each tested beaker, 3 beakers for each concentration. All beakers were covered and left at room temperature. The dead numbers of snail were recorded at 24 hours for 4 days after application. The percentage mortality of snail was calculated by

$$\% \text{ mortality} = \{(O-C)/T\} \times 100$$

where ‘O’ is mortality number of snail in tested set

‘C’ is mortality number of snail in controlled set

‘T’ is total number of tested snail

LC_{50} values were calculated by probit analysis program.

CHAPTER III
RESULTS AND DISCUSSION

3.1 Synthesis of substituted *trans*-cinnamic acids

Two substituted *trans*-cinnamic acids, 3,4-(methylenedioxy)cinnamic acid and 3-nitrocinnamic acid were synthesized by using Doebner condensation between one mole equivalent of malonic acid and one equivalent of selected aromatic aldehydes (3-nitrobenzaldehyde for 3-nitrocinnamic acid and 3,4-methylenedioxybenzaldehyde for 3,4-(methylenedioxy)cinnamic acid). The comparative results of the synthetic substituted *trans*-cinnamic acid are tabulated in Table 3.1.

Table 3.1 Physical properties and % yield of synthesized substituted *trans*-cinnamic acids

compounds	**Physical Properties**		**% yield**
	Appearance	**m.p.(°C)**	
3-nitrocinnamic acid	Yellow needle crystal	204-206	49
3,4-(methylenedioxy)cinnamic acid	Pale yellow mirror-like crystal	244-245	50

3,4-(methylenedioxy)cinnamic acid: Pale yellow mirror-like crystal (49%), m.p. 244-245 °C (ethanol) (lit. (52, 53) 242-244 °C), R_f 0.62 (ethanol); IR (KBr, cm^{-1}): 3650-3320, 1696, 1629, 1611, 1496, 1450, 1427, 1310, 1250, 1210 1100 and 1125; ^{1}H-NMR (DMSO-d_6) δ (ppm): 7.49 (*d, J* = 15.99 Hz, 1H, Ar-C**H**=), 6.91-7.45 (Ar-H, 2H) and 6.37 (*d, J* = 15.92 Hz, 1H, =C**H**-COOH); ^{13}C-NMR (DMSO-d_6) δ (ppm): 167.8 (-**C**OOH), 149.1, 148.0, 128.6, 124.6, 108.4 and 106.6 (aromatic carbons), 143.8 and 117.1 (olefinic carbons) (9).

3-nitrocinnamic acid: Yellow needle crystal (50%), m.p. 204-206 °C (ethanol) (lit. (52) 200-201 °C), R_f 0.70 (ethanol); IR (KBr, cm^{-1}): 3625-3358, 1690, 1634, 1529, 1442, 1419, 1364, 1300 and 1210; ; ^{1}H-NMR (DMSO-d_6) δ (ppm): 7.70 (*d, J* = 16.06 Hz, 1H, Ar-C**H**=), 7.64-8.48 (Ar-H, 4H) and 6.72 (*d, J* = 16.09 Hz, 1H, =C**H**-COOH); ^{13}C-NMR (DMSO-d_6) δ (ppm): 167.1 (-**C**OOH), 148.2, 136.1, 134.0, 130.3, 124.4 and 122.8 (aromatic carbons), 141.5 and 122.2 (olefinic carbons) (9).

3.2 Preparation of sodium cinnamate derivatives

Two sodium cinnamate derivatives, sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate were synthesized by Doebner condensation. The *trans*-cinnamic acids, 3,4-(methylenedioxy)cinnamic acid and 3-nitrocinnamic acid were used as substrate to receive the desirable compounds. The comparative results of sodium cinnamate derivatives are tabulated in Table 3.2.

Table 3.2 Physical properties and % yield of synthesized sodium cinnamate derivatives

compounds	**Physical Properties**		**% yield**
	Appearance	**m.p.(°C)**	
Sodium 3-nitrocinnamate	Pale brown solid	300 up	49
Sodium 3,4-(methylenedioxy)cinnamate	White solid	300 up	50

Sodium 3-nitrocinnamate: Pale brown solid (58%), m.p. at least 300 °C; IR (KBr, cm^{-1}): 1650, 1567, 1541, 1480, 1439, 1408, 1352 and 1075 (9).

Sodium 3,4-(methylenedioxy)cinnamate: White solid (90%), m.p. at least 300 °C; IR (KBr, cm^{-1}): 1645, 1616, 1553, 1456, 1413, 1359, 1250, 1100 and 1050 (9).

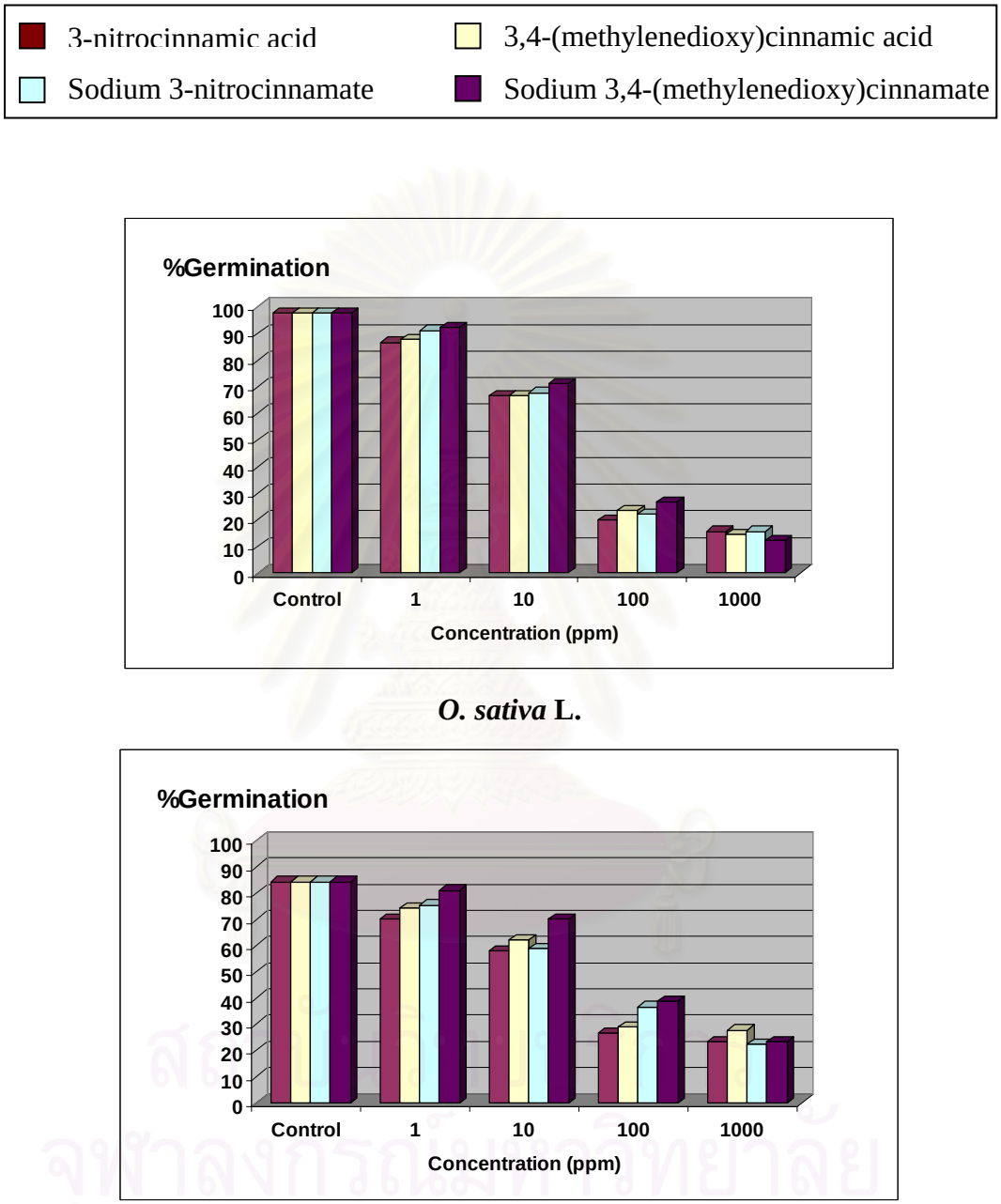
3.3 Bioassay on herbicidal activity

3.3.1 General procedure for plant germination inhibition test

This experiment was conducted to find out the germination inhibition percentage of tested chemicals, 3-nitrocinnamic acid, 3,4-(methylenedioxy)cinnamic acid, sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate on common weeds and crops in Thailand.

To clarify that the high herbicidal potential compounds could inhibit plant germination or not: 8 common weed species were selected to test are: *R. tuberosa* L., *M. lathyroides* (L.) Urb., *A. viridis* L., *M. pigra* L., *C. viscosa* L., *I. aquatica* Forsk., *D. aegyptium* Willd. and *C. argentia* L., and 10 crops: *Z. may* L., *V. radiata* L., *O. sativa* L., *S. aculeatissimum Jasq.*, B. *chinensis* var.*chinensis* L., *A. graveolens* L., *O. americanum* Linn., *C. melo* Linn., C. *frutescens* Linn. var. *frutescens* and *C. sativum* Linn. were selected.

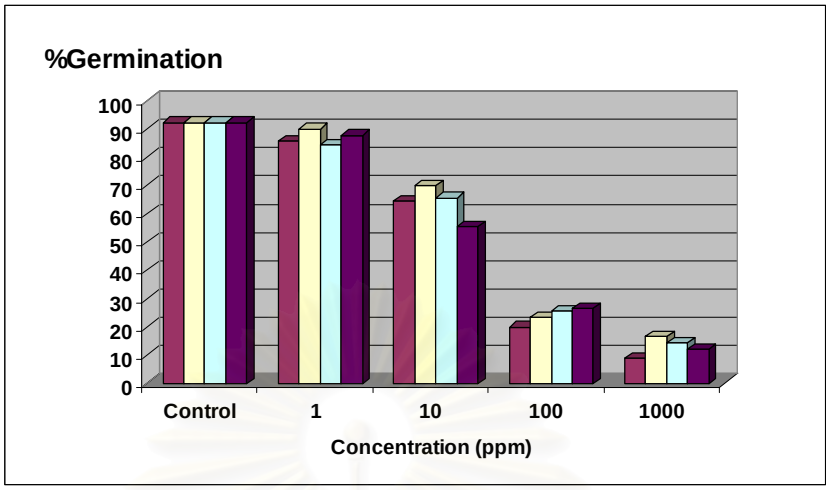
The germination percentage of all tested plants was test and shown in Fig 3.1.



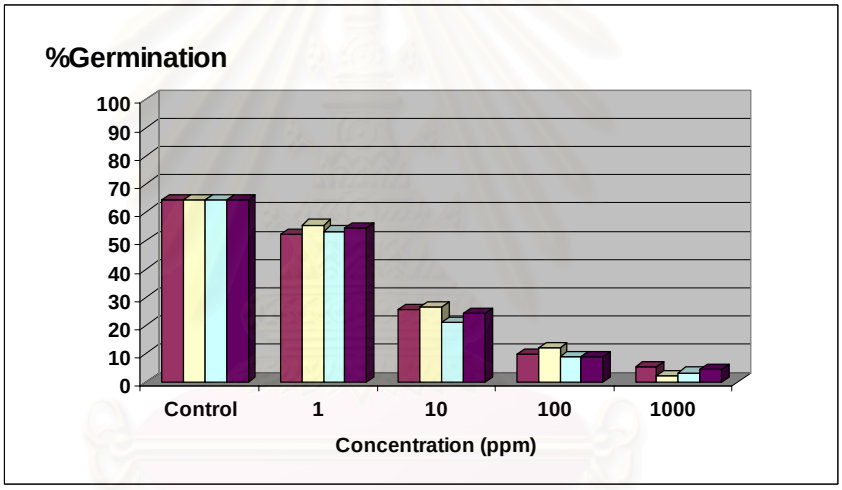
***O. sativa* L.**

***Z. mays* L.**

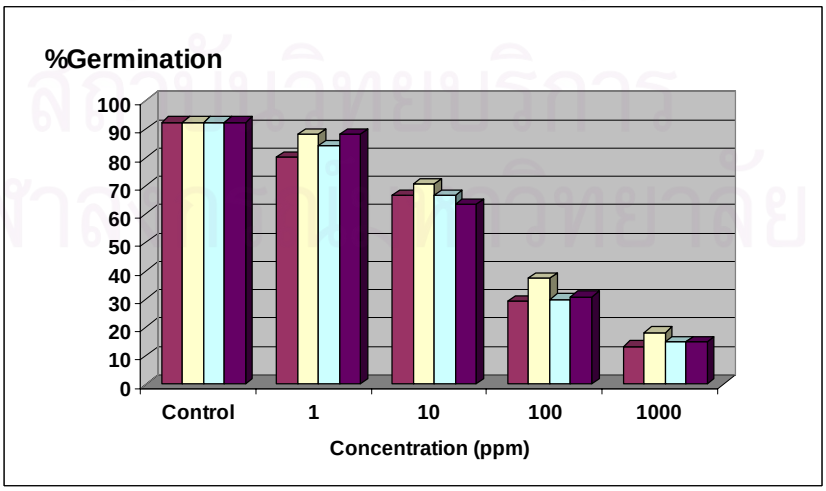
Fig 3.1 Germination percentage of tested plants



***V. radiata* L.**

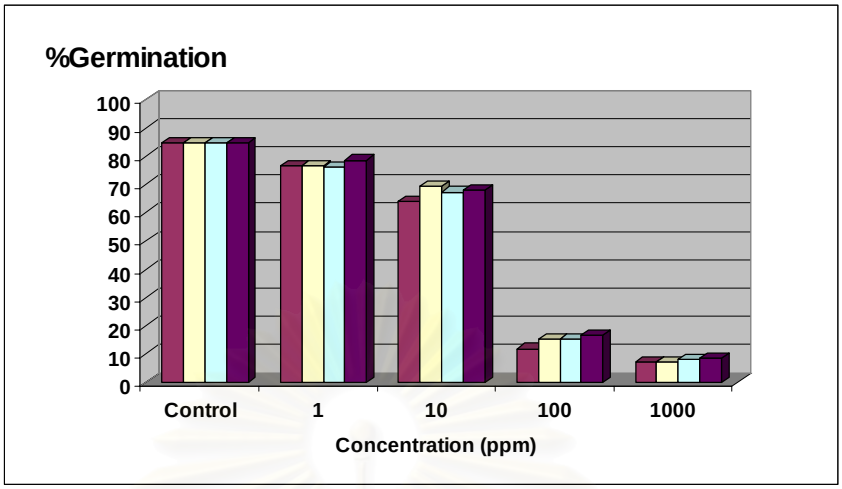


***S. aculeatissimum* Jasq.**

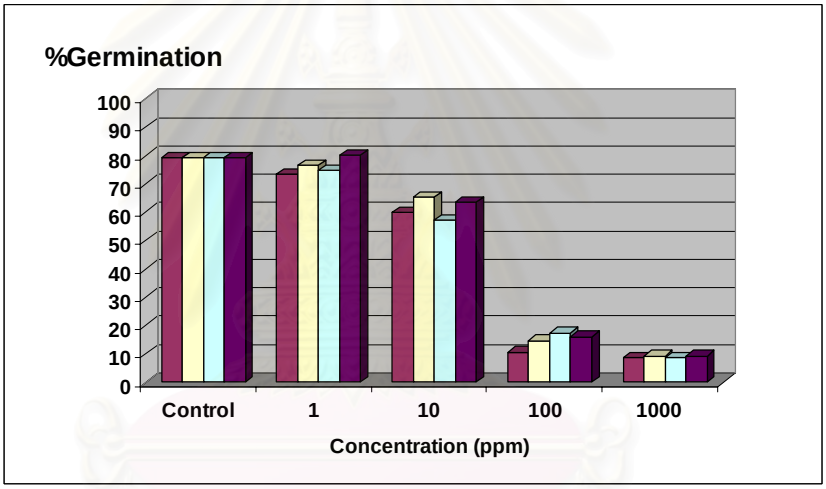


B. chinensis* L.** var.chinensis***

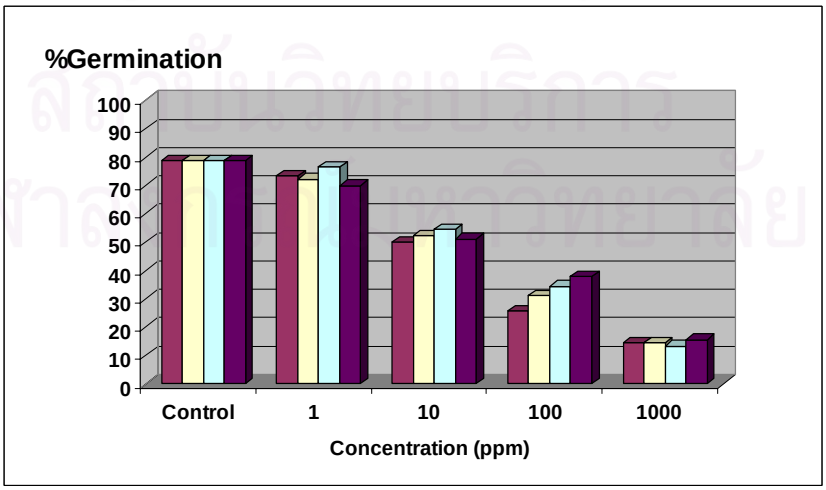
Fig 3.1 (cont.)



***O. americanum* Linn.**

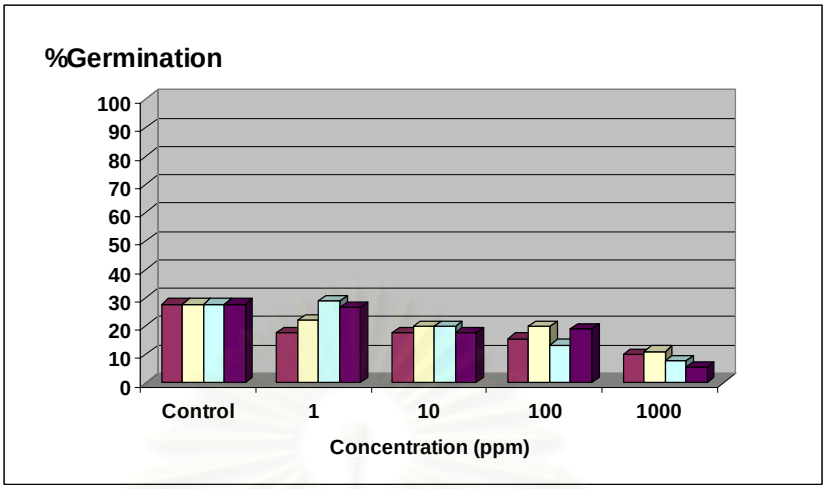


***A. graveolens* L.**

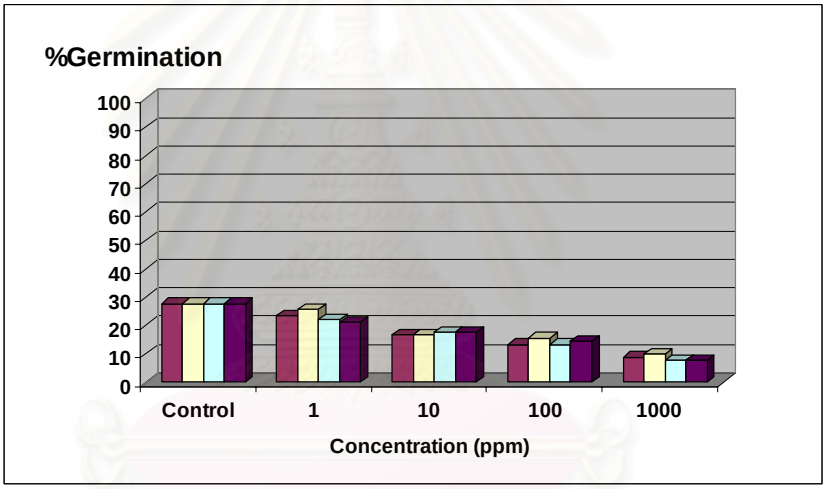


***C. melo* Linn.**

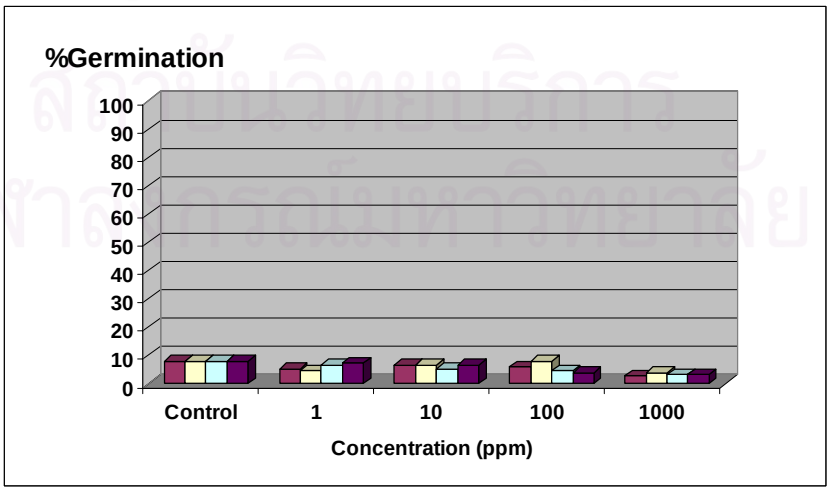
Fig 3.1 (cont.)



C. frutescens* Linn.** var. ***frutescens

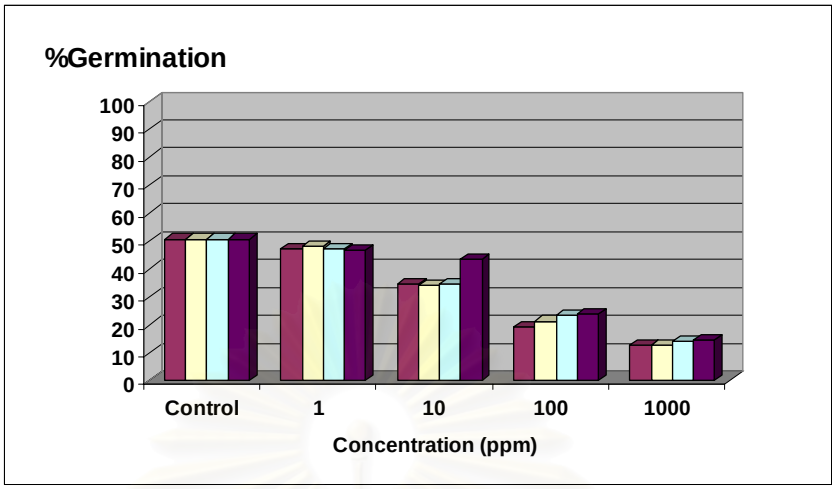


***C. sativum* Linn.**

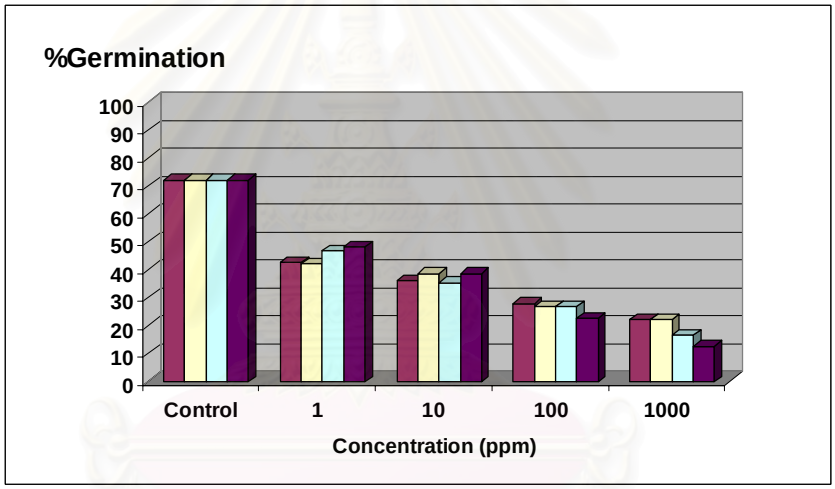


***D. aegyptium* Willd.**

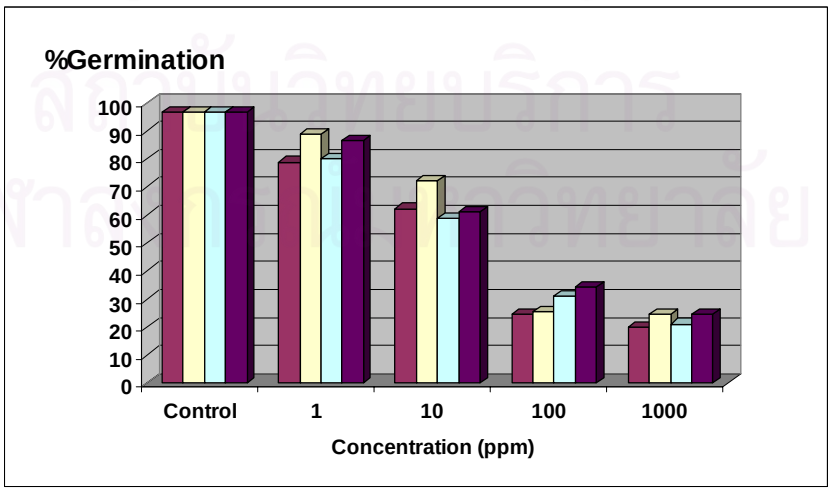
Fig 3.1 (cont.)



***M. lathyroides* (L.) Urb.**

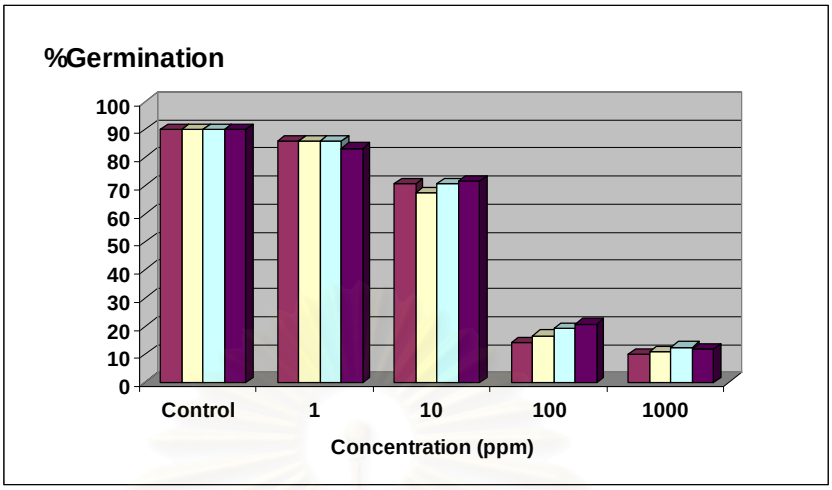


***A. viridis* L.**

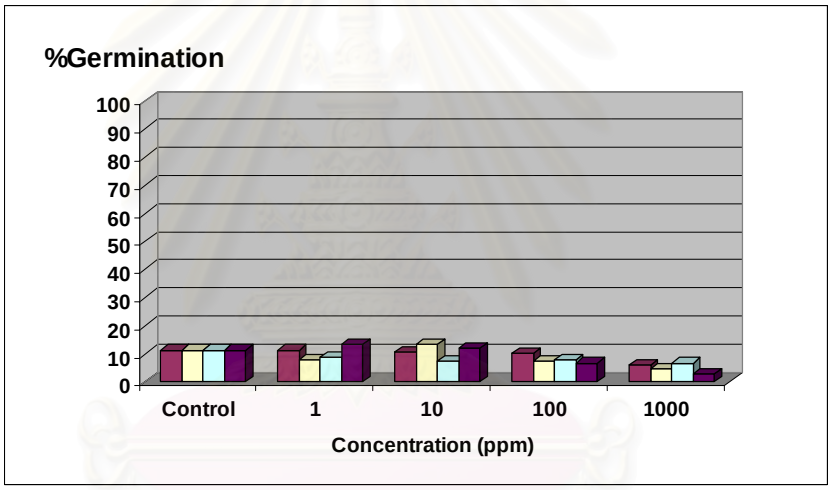


***M. pigra* L.**

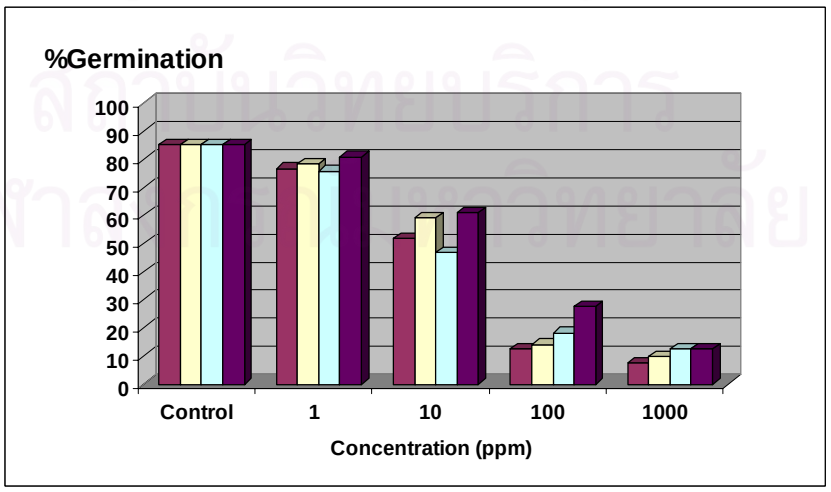
Fig 3.1 (cont.)



***R. tuberosa* L.**

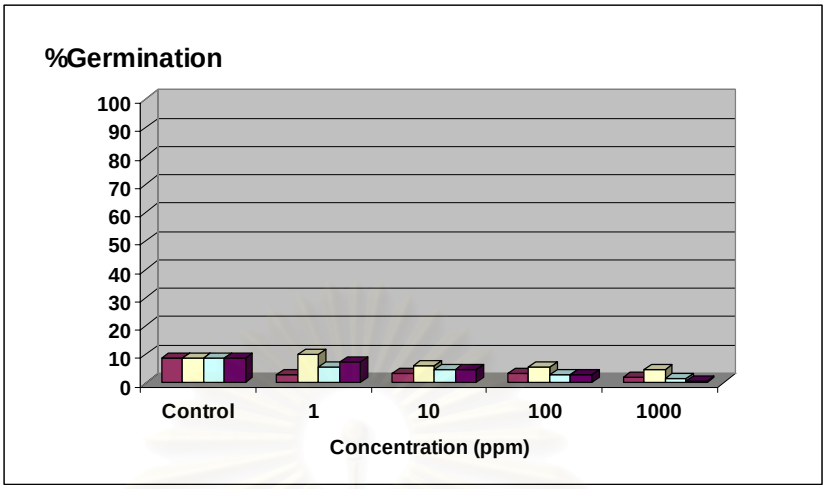


***C. viscosa* L.**



***I. aquatica* Forsk.**

Fig 3.1 (cont.)



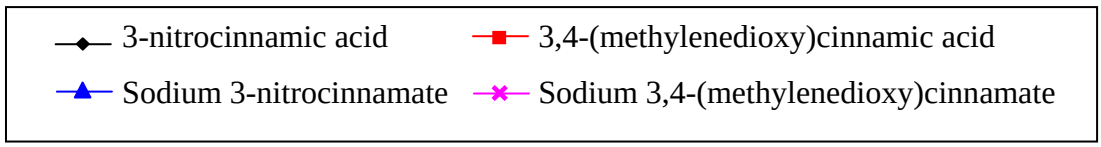
***C. argentia* L.**

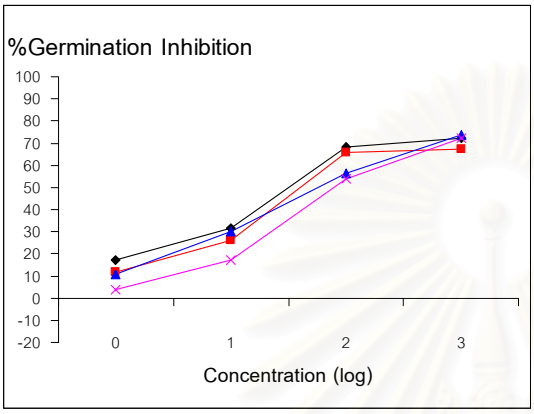
Fig 3.1 (cont.)

From Fig 3.1, most of tested plant species had highly germination percentage. The germination percentage of them were 60% up to 98% except for *C. argentia* L., *C. sativum* Linn., C. *frutescens* Linn. var. *frutescens*, *D. aegyptium* Willd. and *C. viscosa* L.

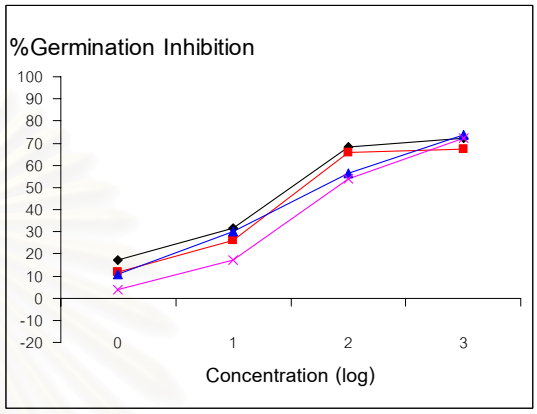
Referring to this result, the germination percentage of control set of tested plant species, *O. sativa* L., *Z. mays* L., *V. radiata* L., *S. aculeatissimum* Jasq., B. *chinensis* var.*chinensis* L., *O. americanum* Linn., *A. graveolens* L., *C. melo* Linn., C. *frutescens* Linn. var. *frutescens*, *C. sativum* Linn., *D. aegyptium* Willd., *M. lathyroides* (L.) Urb., *A. viridis* L., *M. pigra* L., *R. tuberosa* L., *C. viscosa* L., *I. aquatica* Forsk. and *C. argentia* L. were 97.78, 84.44, 92.22, 64.44, 92.50, 84.67, 79.33, 78.89, 27.78, 27.78, 8.00, 50.67, 72.00, 96.67, 90.00, 11.33, 85.00 and 8.67, respectively. The germination percentage was exhaustive displayed in Appendix A.

According to the germination percentage, all tested plant species were response to all chemicals. The germination of tested plant species was greatly decreased while the concentration of tested chemicals was increased. To indicate about these results the germination inhibition percentage were calculated and displayed in Fig 3.2.

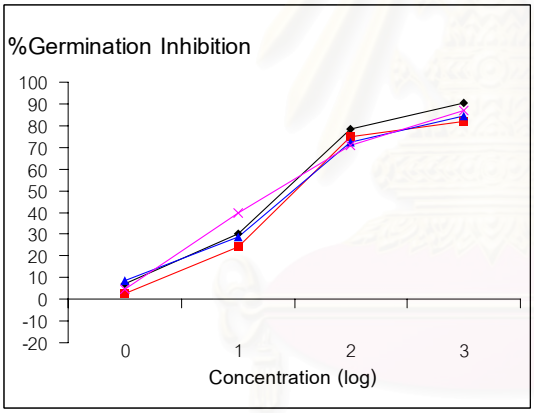




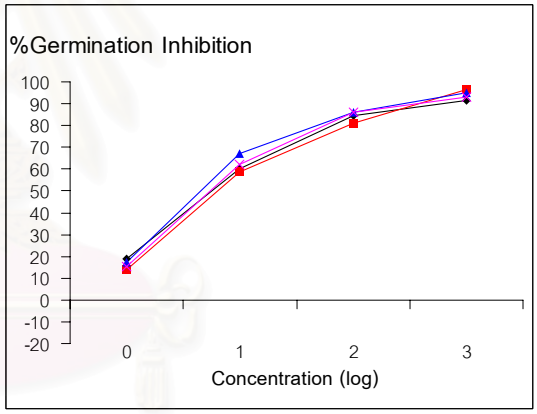
***O. sativa* L.**



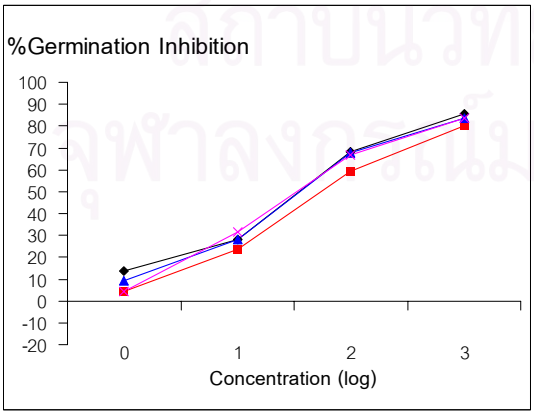
***Z. mays* L.**



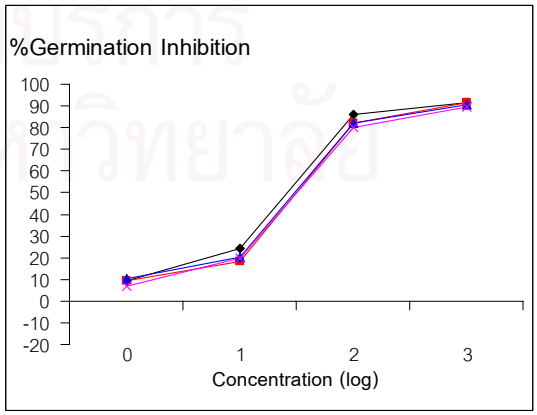
***V. radiata* L.**



***S. aculeatissimum* Jasq.**

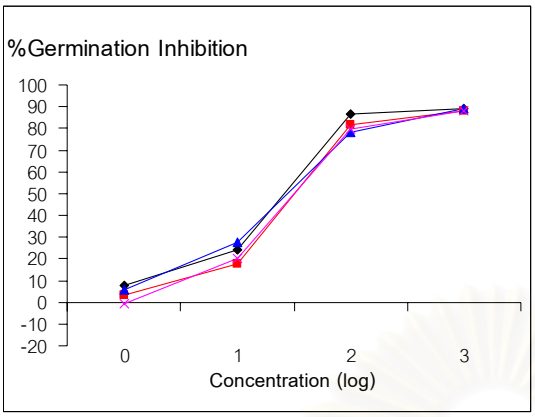


B. *chinensis* var.*chinensis* L.

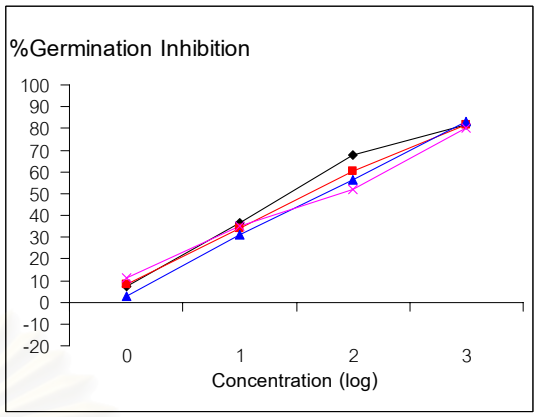


***O. americanum* Linn.**

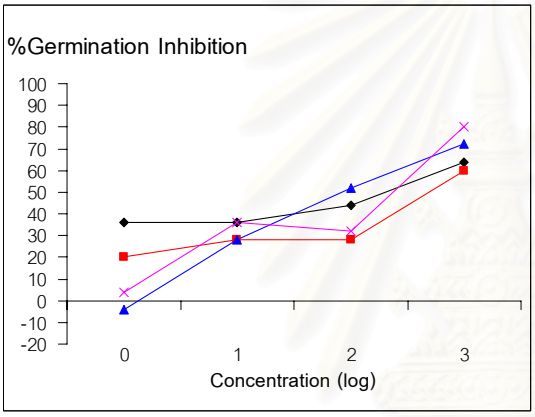
Fig 3.2 Plants germination inhibition effects of tested chemicals



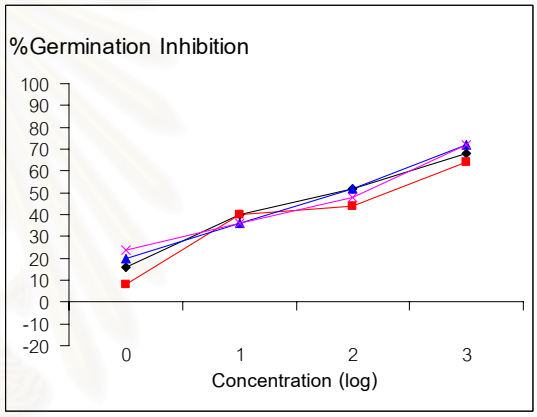
***A. graveolens* L.**



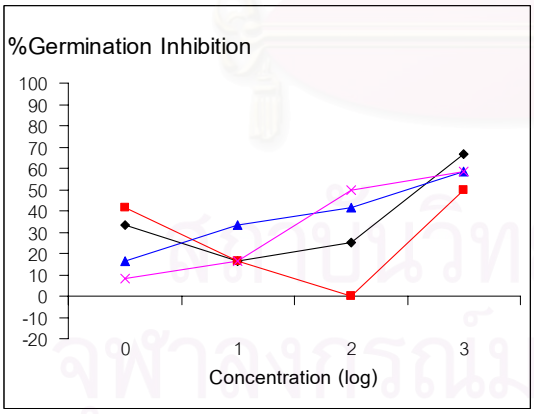
***C. melo* Linn.**



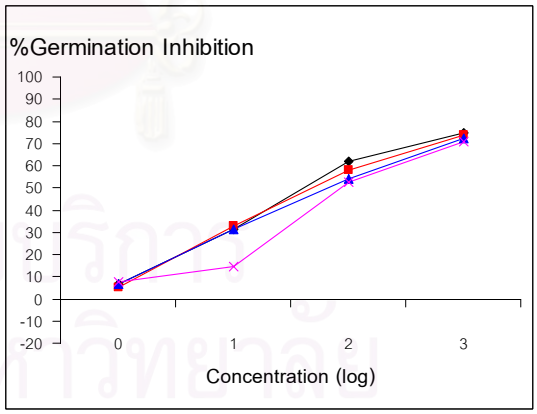
C. *frutescens* Linn. var. ***frutescens***



***C. sativum* Linn.**

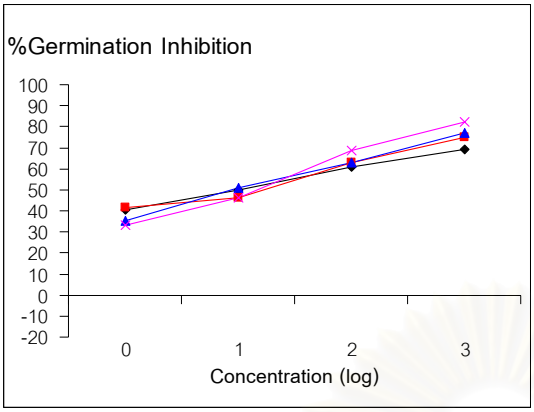


***D. aegyptium* Willd.**

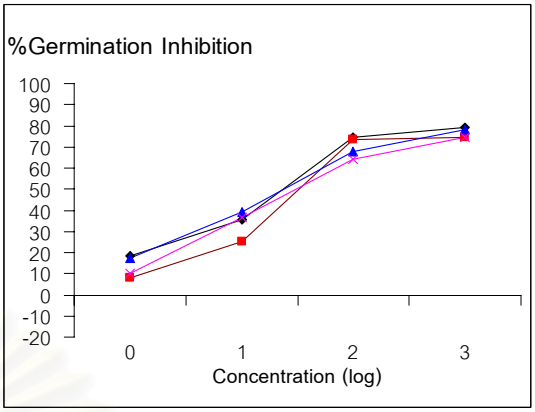


***M. lathyroides* (L.) Urb.**

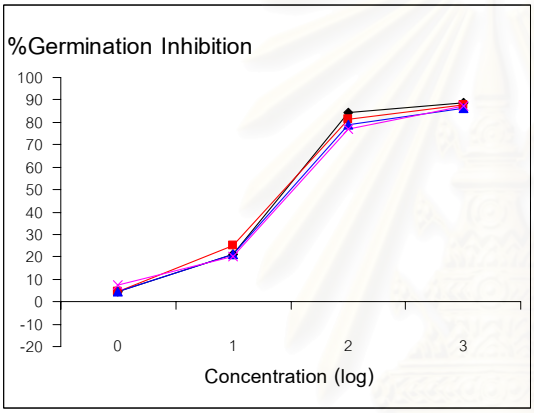
Fig 3.2 (cont.)



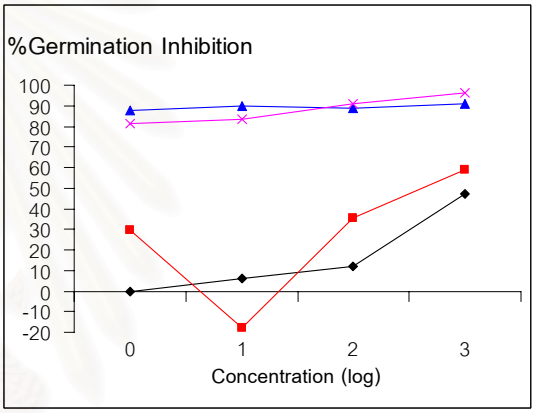
***A. viridis* L.**



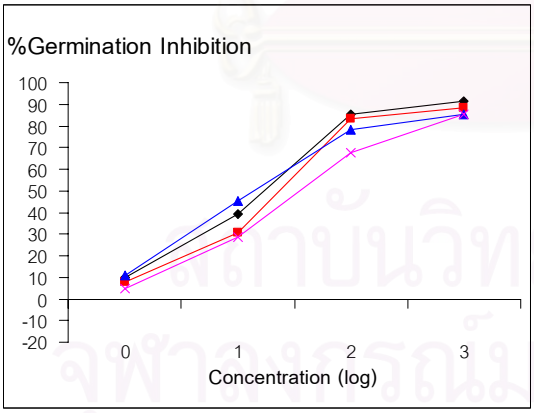
***M. pigra* L.**



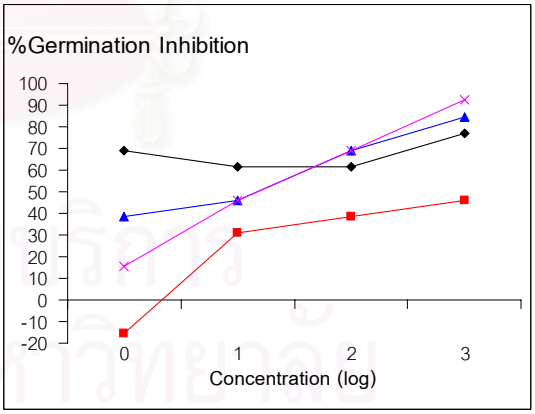
***R. tuberosa* L.**



***C. viscosa* L.**



***I. aquatica* Forsk.**



***C. argentia* L.**

Fig 3.2 (cont.)

According to Fig 3.2, the results show that all of tested chemicals also have severely effect on germination inhibition. Most plants that were used in this experiment have highly germination percentage except for C. *frutescens* Linn. var. *frutescens*, *C. sativum* Linn., *C. viscosa* L., *D. aegyptium* Willd. and *C. argentia* L. but these plants also show the same response.

At 10 ppm. these chemicals still have a little effect on plants germination. Some plants cannot be germinated. For 3-nitrocinnamic acid, the germination inhibition percentage was around 5.88 to 61.54. The most sensitive plants were *S. aculeatissimum Jasq.* > *A. viridis* L. > *I. aquatica* Forsk. > *C. melo* Linn. > *M. pigra* L., respectively. According to 3,4-(methylenedioxy)cinnamic acid, this chemical also show moderately effect on plant germination inhibition when treat at 10 ppm, too. The germination inhibition percentage was about 16.67 to 58.62. The most sensitive plants were *S. aculeatissimum* Jasq. > *A. viridis* L. > *C. melo* Linn. > *M. lathyroides* (L.) Urb. > *O. sativa* L., respectively. Considering for sodium 3-nitrocinnamate, the germination inhibition percentage was between 21.30 and 67.24. The most sensitive plants were *S. aculeatissimum Jasq.* > *I. aquatica* Forsk. > *M. pigra* L. > *M. lathyroides* (L.) Urb. > *C. melo* Linn., respectively. Referring to sodium 3,4-(methylenedioxy)cinnamate, the plant germination inhibition percentage was around 14.47 to 62.07. The most sensitive plants were *S. aculeatissimum* Jasq. > *A. viridis* L. > *V. radiata* L. > *M. pigra* L. > *C. melo* Linn., respectively. In case of C. *frutescens* Linn. var. *frutescens, C. sativum* Linn., *D. aegyptium*Willd., *C. viscosa* L. and *C. argentia* L., these plants also show moderately germination inhibition percentage but they had very low germination percentage indicated that the results of these plants were misgiving. To describe these results see Appendix A.

At 100 ppm. The plant germination inhibition percentage was rapidly increased from 10 ppm. All tested chemicals were shown rather high inhibitory effect. As for 3-nitrocinnamic acid, the germination inhibition percentage was around 61.11 to 86.55. The most sensitive plants were *A. graveolens* L. > *O. americanum* Linn. > *I. aquatica* Forsk. > *S. aculeatissimum* Jasq. > *R. tuberosa* L., respectively. According to 3,4-(methylenedioxy)cinnamic acid, this chemical also show rather high inhibitory effect. The germination inhibition percentage was around 57.89 to 83.33. The most sensitive plants were *I. aquatica* Forsk. > *O. americanum* Linn. > *A. graveolens* L. >

R. tuberosa L. > *S. aculeatissimum* Jasq., respectively. Referring to sodium 3-nitrocinnamate, the plant germination inhibition was between 53.95 and 86.21. The most sensitive plants were *S. aculeatissimum* Jasq. > *O. americanum* Linn. > *R. tuberosa* L. > *I. aquatica* Forsk. > *A. graveolens* L., respectively. Considering for sodium 3,4-(methylenedioxy)cinnamate, this chemical still show rather high germination inhibition percentage, too. The germination inhibition percentage was around 52.63 to 86.21. The most sensitive plants were *S. aculeatissimum* Jasq. > *A. graveolens* L. > *R. tuberosa* L. > *O. sativa* L. > *V. radiata* L., respectively. In addition, C. *frutescens* Linn. var. *frutescens, C. sativum* Linn., *D. aegyptium*Willd., *C. viscosa* L. and *C. argentia* L., these plants also show moderately germination inhibition percentage but they had very low germination percentage indicated that the results of these plants were doubt. To describe these results see Appendix A.

Considering about 1000 ppm., the highest concentration, was show the highly germination inhibitory effect to any case. All of tested chemicals also show the same results as the others. To describe the results see the plants germination inhibition percentage in Appendix A.

From these results reveal that these chemicals were show highly effective on dicotyledonous plants than monocotyledonous plants. Comparing the effect of these chemicals on weeds and crops indicated that these chemicals show the toxicity on crops higher than weeds. In addition, to comparing each sodium salt from its parent cinnamic acid indicated that sodium salt has lower effective than parent cinnamic acid in any case. For instance, sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy) cinnamate showed the germination inhibition activity more than 3-nitrocinnamic and 3,4-(methylenedioxy)cinnamic acid, respectively. The comparison of germination inhibition percentage of sodium cinnamate derivatives and their parent compounds against *M. pigra* L. at 100 ppm are shown in Fig 3.3.

A = 3-nitrocinnamic acid

B= Sodium 3-nitrocinnamate

C = 3,4-(methylenedioxy)cinnamic acid

D = Sodium 3,4-(methylenedioxy)cinnamate

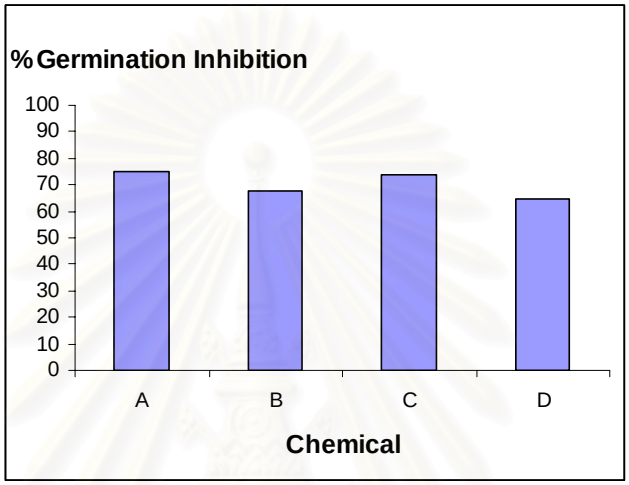


Fig 3.3 Germination inhibitory effect of sodium cinnamate derivatives and their parent compounds on *M. pigra* L. at 100 ppm (%)

3.3.2 General procedure for plant growth inhibition test

This experimental section was prepared to test about plant growth inhibitory effect. The results of this experiment was separated in to four parts with different tested chemicals and described below:

3.3.2.1 Plant growth inhibitory effect of 3-nitrocinnamic acid

To described the herbicidal activity of 3-nitrocinnamic acid. 8 common weed and 10 crops species were selected to test.

Following to the effect of 3-nitrocinnamic acid, this chemical exhibit highly inhibition. Considering for 10 ppm, this chemical show moderately effect. The root inhibition percentage was around 17.67 to 65.42 and the shoot inhibition percentage was around 22.39 to 54.30. The most sensitive plants were *S. aculeatissimum* Jasq. > *M. pigra* L. > *V. radiata* L. > *M. lathyroides* (L.) Urb. > *C. melo* Linn., respectively. According to 100 ppm, 3-nitrocinnamic acid was show very highly effect on tested plant species. The root inhibition percentage was 68.96 up to 93.86 and the shoot inhibition percentage was 57.74 up to 91.00. The most sensitive plant species were

S. aculeatissimum Jasq. > *O. sativa* L. > *R. tuberosa* L. > *I. aquatica* Forsk. ≅ *A. graveolens* L. ≅ *V. radiata* L., respectively. The plant growth inhibition of 3-nitrocinnamic acid was displayed in Table3.3.

Table 3.3 Plant growth inhibitory effect of 3-nitrocinnamic acid at 1, 10, 100 and 1000 ppm

Plant species	Plant growth inhibitory effect at (ppm)							
	Root				Shoot			
	1	10	100	1000	1	10	100	1000
Monocotyledonous weeds								
D. aegyptium Willd.	4.12	42.27	67.01	73.20	1.14	21.02	53.41	67.04
Dicotyledonous weeds								
A. viridis L.	18.20	32.54	83.48	90.31	18.52	27.60	73.87	84.65
C. argentia L.	84.81	81.01	91.14	96.83	79.78	78.93	86.24	96.07
C. viscosa L.	45.36	77.32	92.78	94.84	31.10	73.78	90.24	88.41
I. aquatica Forsk.	-17.95	32.72	89.60	97.15	3.90	35.62	84.19	95.89
M. lathyroides (L.) Urb.	21.37	46.6	68.96	87.85	14.69	32.62	57.74	81.90
M. pigra L.	-10.50	54.02	83.90	91.00	-0.75	22.39	74.33	88.81
R. tuberosa L.	-0.70	38.41	90.50	96.93	5.37	33.78	84.61	94.94
Monocotyledonous crops								
O. sativa L.	-1.45	41.72	91.28	96.66	7.65	34.29	81.43	94.69
Z. mays L.	27.03	17.67	74.15	92.07	10.77	27.08	59.00	87.30
Dicotyledonous crops								
A. graveolens L.	-20.24	35.15	89.88	95.74	0.00	29.01	77.68	92.92
B. chinensis L.	5.00	36.14	78.00	95.43	8.70	35.83	67.41	91.85
C. *frutescens* Linn.	39.30	61.57	84.87	93.04	38.16	50.00	72.42	88.29
C. sativum Linn.	-6.25	62.95	76.34	87.95	-16.35	37.27	64.61	82.04
C. melo Linn.	-3.73	44.60	90.36	97.04	-2.97	33.13	78.22	94.17
O. americanum Linn.	-3.51	31.70	84.57	97.02	3.32	27.15	71.57	93.96
S. aculeatissimum Jasq.	1.20	65.42	93.86	98.80	3.23	54.30	91.00	97.78
V. radiata L.	10.16	52.97	89.84	97.08	6.31	39.50	81.33	94.19

To described the growth inhibitory effect of 3-nitrocinnamic acid. The results are calculated and summarized as shown in Fig 3.4.

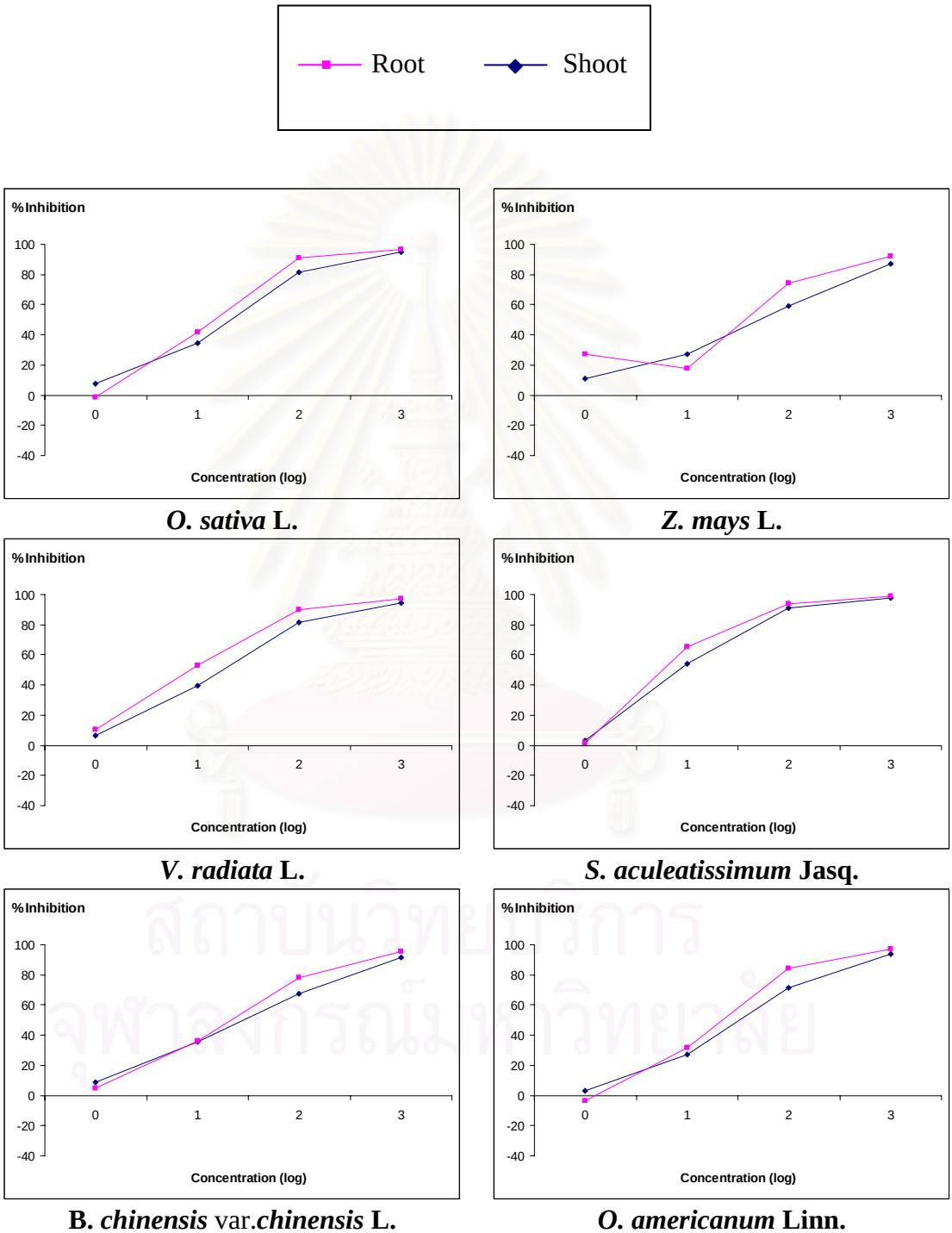
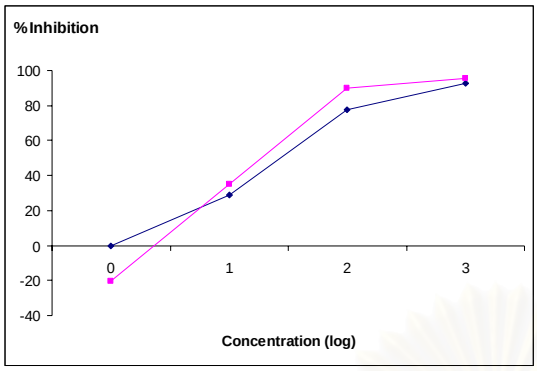
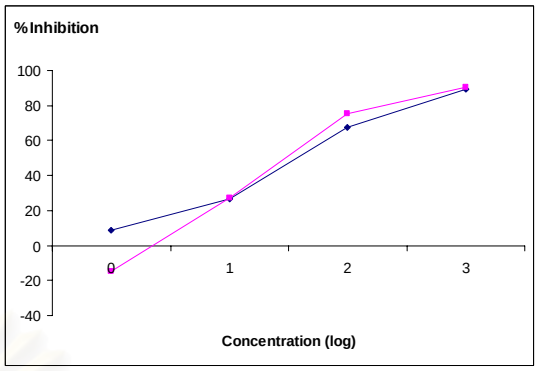


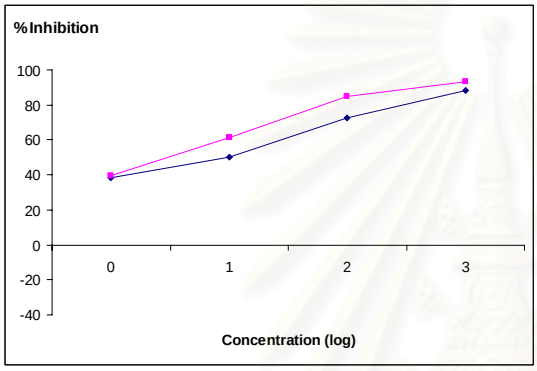
Fig 3.4 Inhibitory effect of 3-nitrocinnamic acid on root and shoot growth of noxious weeds and crops (%)



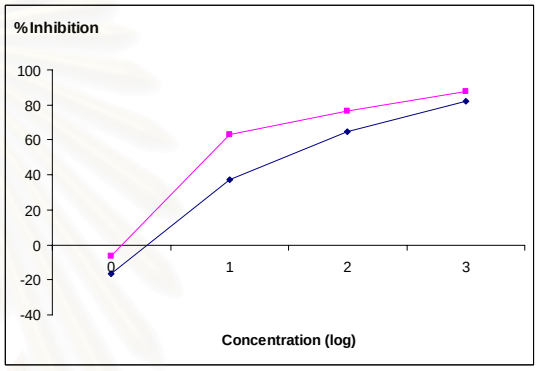
***A. graveolens* L.**



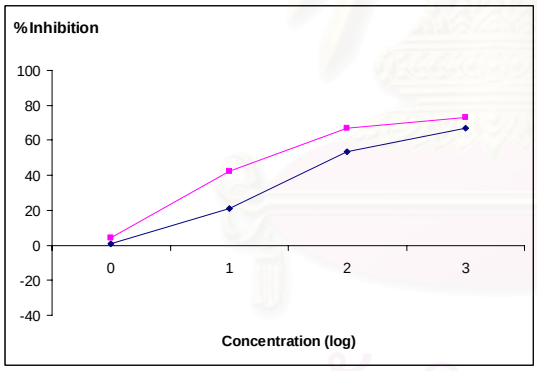
***C. melo* Linn.**



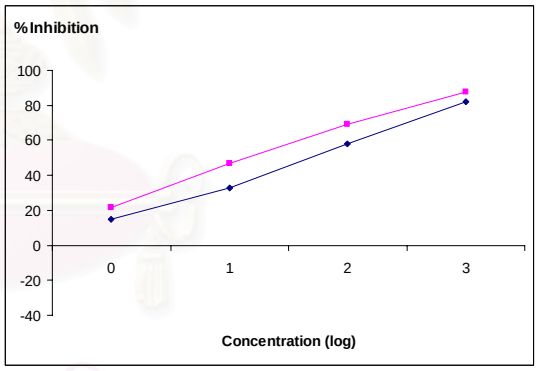
C. *frutescens* Linn. var. ***frutescens***



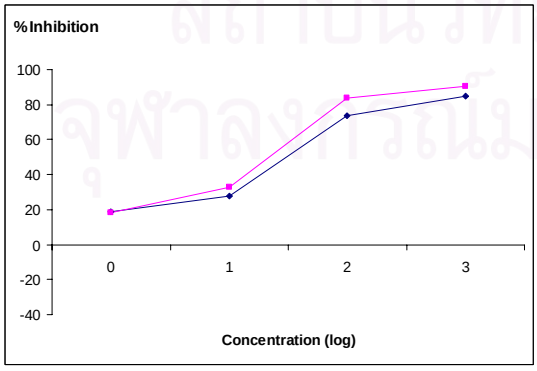
***C. sativum* Linn.**



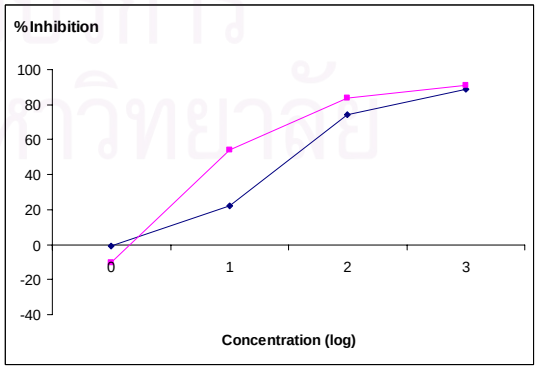
***D. aegyptium* Willd.**



***M. lathyroides* (L.) Urb.**

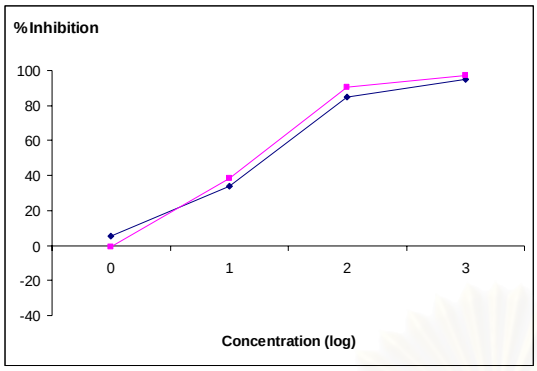


***A. viridis* L.**

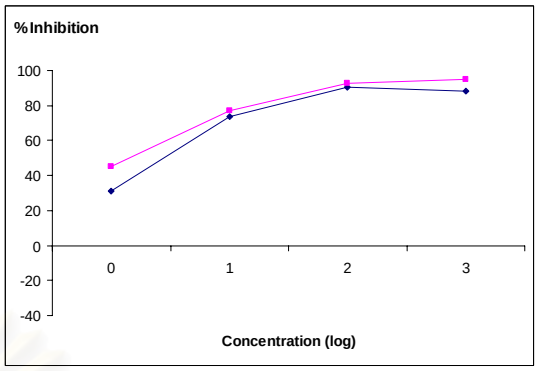


***M. pigra* L.**

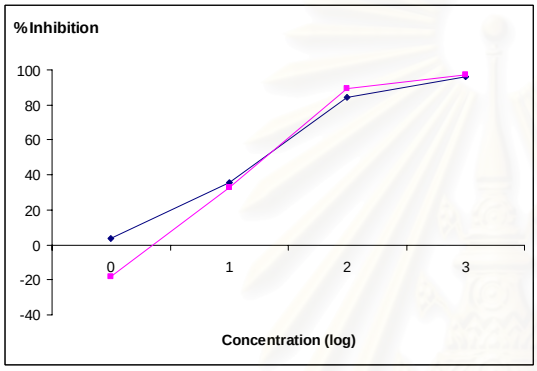
Fig 3.4 (cont.)



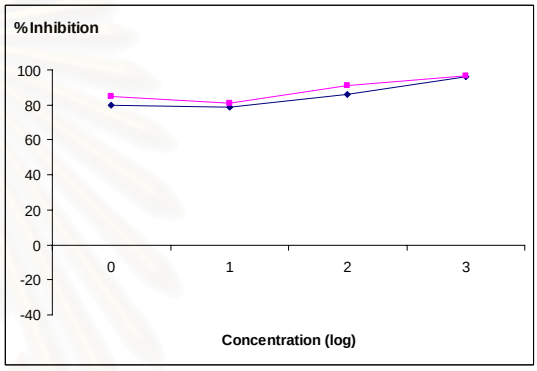
***R. tuberosa* L.**



***C. viscosa* L.**



***I. aquatica* Forsk.**



***C. argentia* L.**

Fig 3.4 (cont.)

The above graphs revealed the correlation between 3-nitrocinnamic acid in the range of 1-1000 ppm and inhibitory effect on root and shoot growth of common weeds, *R. tuberosa* L., *M. lathyroides* (L.) Urb., *A. viridis* L., *M. pigra* L., *C. viscosa* L., *I. aquatica* Forsk., *D. aegyptium* Willd. and *C. argentia* L. in Thailand. The substance possessing high activity should give a slope as increasing function in semi-logarithm graph (higher activity of each increase 1 unit of logarithm concentration of dose) and higher percent at 100 ppm. The inhibition of root is thought to be more essential for considering than that of percentage shoot growth inhibition because of the root would be directly contacted to the tested chemical, 3-nitrocinnamic acid in tissue paper. While the shoot growth is contributed from root and attributed to accumulated food from seed. For that reason, the profound effect of 3-nitrocinnamic acid in this plant part might be misinterpreted. Root growth inhibition percentage at 100 ppm was selected to be mainly meditated. By the way, low root growth inhibition always divulged by chemical with low concentration (1 or 10 ppm). Apart from its herbicidal activity, this chemical has highly inhibitory effect to other economic crops,

too. To attest about crops toxicity effect 10 crops, *O. sativa* L., *V. radiata* L., C. *frutescens* Linn. var. *frutescens*, B. *chinensis* L. var.*chinensis*, *S. aculeatissimum* Jasq., *O. americanum* Linn., *A. graveolens* L., *Z. mays* L., *C. melo* Linn., and *C. sativum* Linn. were choose to test for toxicity. The results were indicated in Table 3.3.

Considering for Fig 3.4, there are some plant species as C. *frutescens* Linn. var. *frutescens*, *C. sativum* Linn., *D. aegyptium*Willd., *C. viscosa* L. and *C. argentia* L., these plants also show moderately growth inhibition percentage but they had very low germination percentage indicated that the results of these plants were doubt.

3.3.2.2 Inhibitory effect of 3,4-(methylenedioxy)cinnamic acid

3,4-(methylenedioxy)cinnamic acid could be synthesized by Doebner reaction and once used to test for herbicidal activity. This chemical has been reported because it has highly inhibitory effect against some various weeds, *R. tuberosa* L., *M. lathyroides* (L.) Urb., *A. viridis* L., *M. pigra* L., *C. viscosa* L., *I. aquatica* Forsk., *D. aegyptium* Willd. and *C. argentia* L. in Thailand. In this research, 3,4-(methylenedioxy)cinnamic acid was choose to test again for herbicidal activity on various weeds and toxicity to economic crops. The results were found that this chemical has highly herbicidal activity and also has toxicity to economic crops, too. The results are summarized as shown in Table 3.4.

Table 3.4 Plant growth inhibitory effect of 3,4-(methylenedioxy)cinnamic acid at 1, 10, 100 and 1000 ppm.

Plants	Plant growth inhibitory effect at (ppm)							
	Root				Shoot			
	1	10	100	1000	1	10	100	1000
Monocotyledonous weeds								
D. aegyptium Willd.	13.40	26.80	45.36	90.72	2.84	18.75	32.95	89.20
Dicotyledonous weeds								
A. viridis L.	12.26	37.88	88.53	92.38	13.43	32.84	79.78	87.45
C. argentia L.	-10.13	64.56	81.65	89.87	3.09	59.55	79.78	89.61
C. viscosa L.	12.37	34.02	85.57	97.94	9.15	20.73	81.10	95.73
I. aquatica Forsk.	-19.30	34.40	88.26	92.95	3.27	34.46	80.82	94.31

Table 3.4 Plant growth inhibitory effect of 3,4-(methylenedioxy)cinnamic acid at 1, 10, 100 and 1000 ppm. (cont.)

Plants	Plant growth inhibitory effect at (ppm)							
	Root				Shoot			
	1	10	100	1000	1	10	100	1000
Dicotyledonous weeds								
M. lathyroides (L.) Urb.	26.42	50.07	71.34	89.74	19.46	45.91	63.68	84.87
M. pigra L.	7.23	48.02	78.85	86.00	-2.01	21.04	74.63	84.25
R. tuberosa L.	-1.96	40.78	88.83	95.67	3.30	34.19	77.69	93.80
Monocotyledonous crops								
O. sativa L.	0.44	45.06	89.10	96.37	3.57	33.57	77.76	93.67
Z. mays L.	12.73	29.98	62.48	87.62	23.59	46.01	59.93	81.89
Dicotyledonous crops								
A. graveolens L.	-19.44	23.97	86.42	96.54	-0.88	28.42	69.32	93.02
B. chinensis L.	4.143	42.86	77.43	93.14	9.63	36.02	66.30	90.00
C. *frutescens* Linn.	15.48	54.78	84.87	96.17	22.80	51.76	73.05	93.45
C. sativum Linn.	-20.98	37.95	73.66	93.30	-37.26	12.33	57.64	90.88
C. melo Linn.	-6.30	46.79	89.72	96.85	0.20	32.82	76.18	93.56
O. americanum Linn.	-3.72	28.51	82.13	97.34	2.21	28.09	66.13	94.30
S. xanthocarpum S.&W.	0.90	59.28	92.81	99.55	2.93	51.87	88.68	99.19
V. radiata L.	12.11	52.32	88.22	94.92	10.95	38.92	75.44	88.63

Following to the effect of 3,4-(methylenedioxy)cinnamic acid, this chemical exhibit highly inhibition. As for 10 ppm, this chemical show moderately effect on tested plant species. The root inhibition percentage was around 23.97 to 59.28 and the shoot inhibition percentage was around 21.04 to 51.87. The most sensitive plants were *S. aculeatissimum* Jasq. > *V. radiata* L. > *M. lathyroides* (L.) Urb. > *M. pigra* L. > *C. melo* Linn., respectively. According to 100 ppm, 3,4-(methylenedioxy)cinnamic acid was show very highly effect on tested plant species. The root inhibition percentage was 62.48 up to 92.81 and the shoot inhibition percentage was 59.93 up to 88.68. The most sensitive plant species were *S. aculeatissimum* Jasq. > *C. melo* Linn. ≅ *O. sativa* L. ≅ *V. radiata* L. ≅ *R. tuberosa* L. ≅ *I. aquatica* Forsk., respectively.

The plant growth inhibition of 3,4-(methylenedioxy)cinnamic acid was displayed in Table3.4.

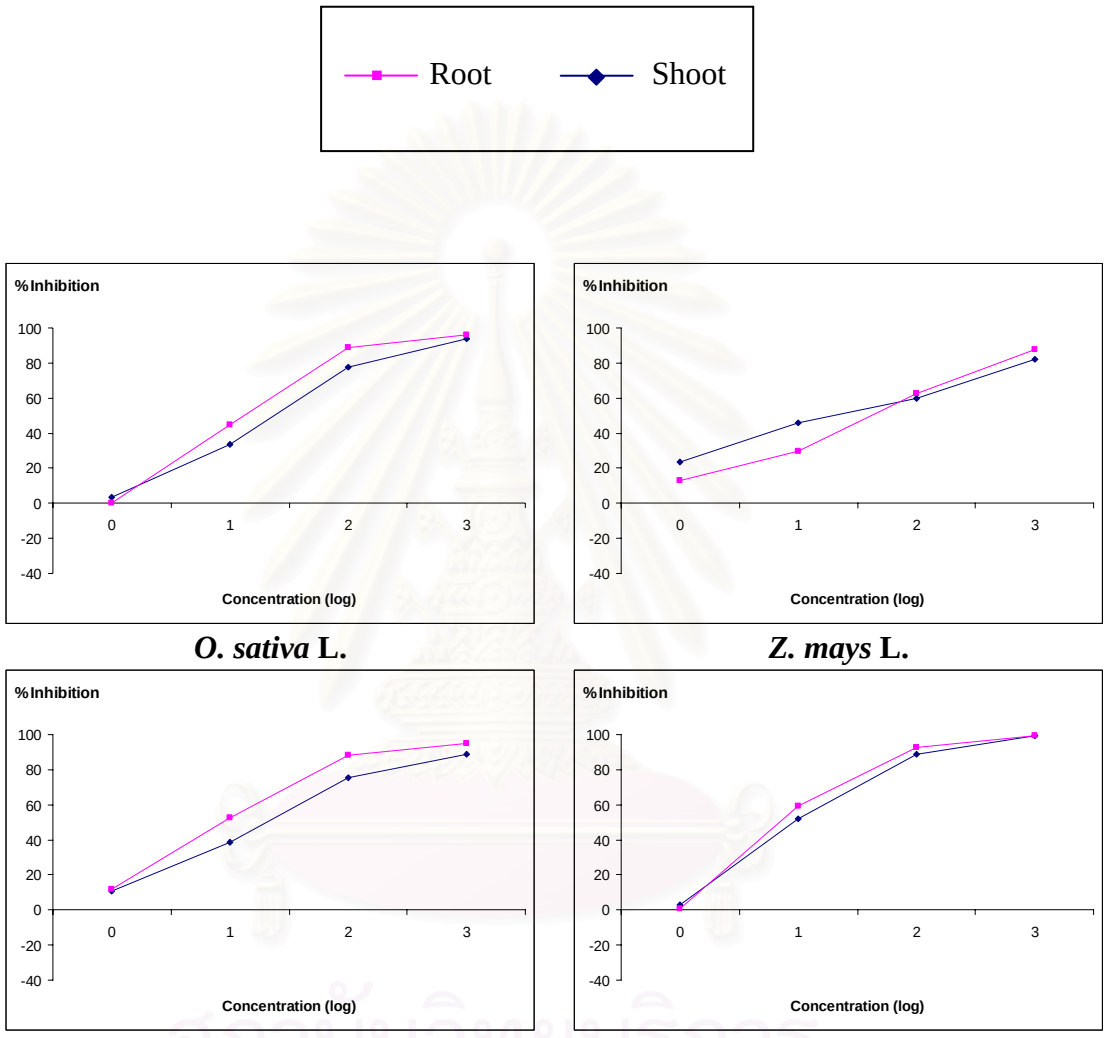
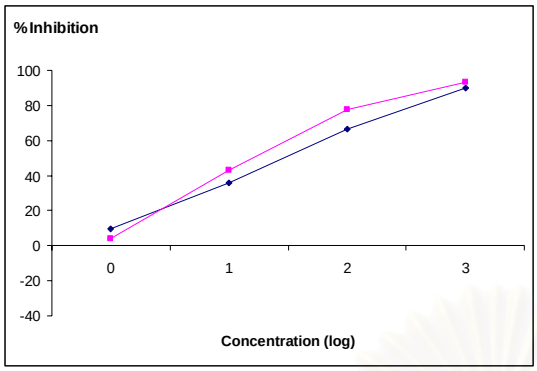
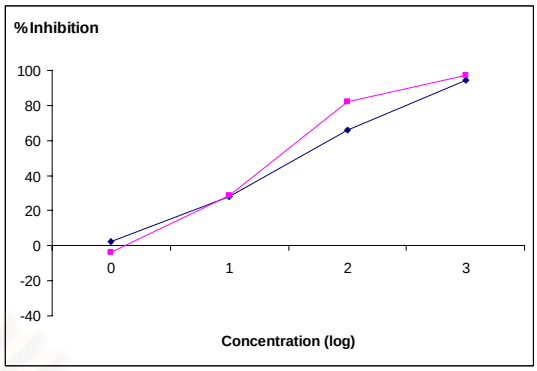


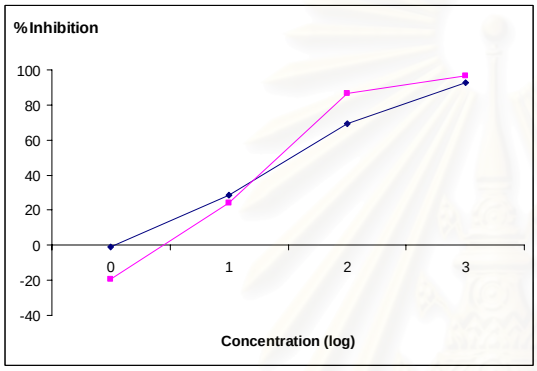
Fig 3.5 Inhibitory effect of 3,4-(methylenedioxy)cinnamic acid on root and shoot growth of noxious weeds and crops (%)



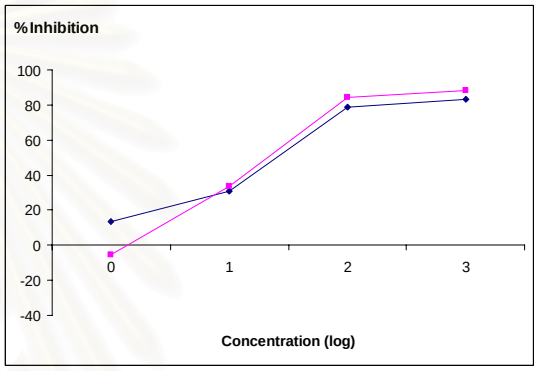
B. *chinensis* var.***chinensis* L.**



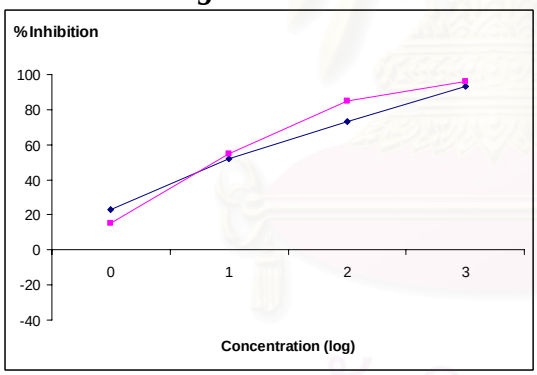
***O. americanum* Linn.**



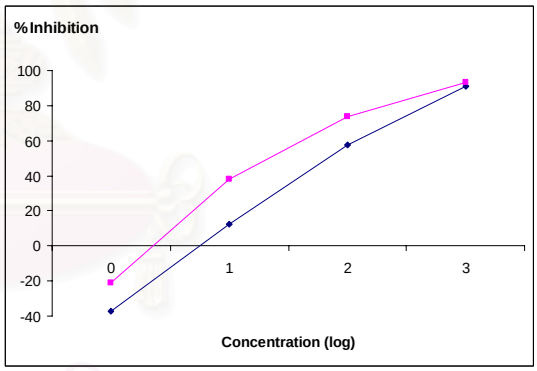
***A. graveolens* L.**



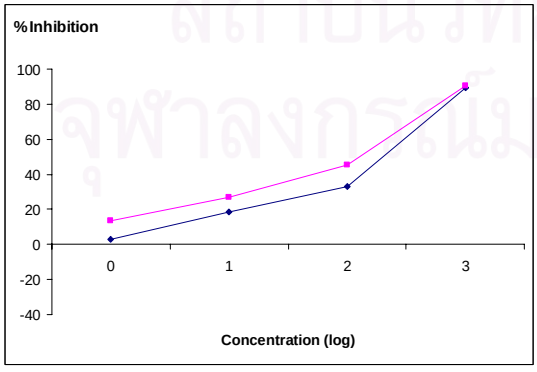
***C. melo* Linn.**



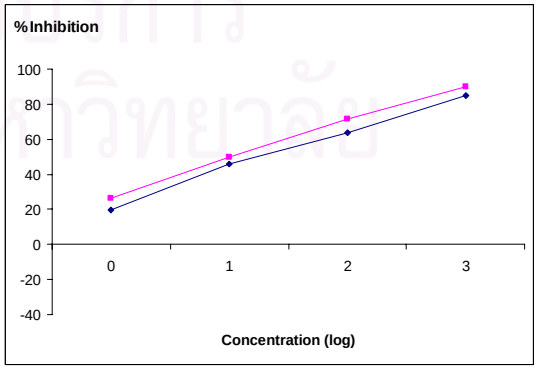
C. *frutescens* Linn. var. ***frutescens***



***C. sativum* Linn.**

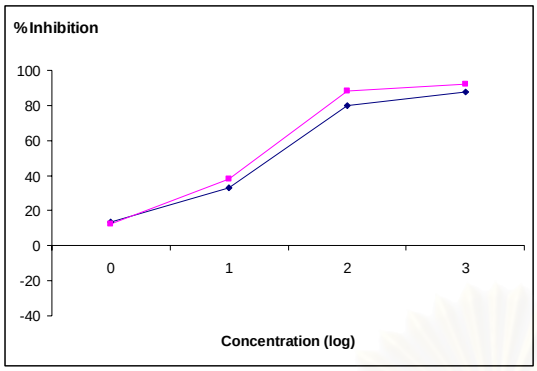


***D. aegyptium* Willd.**

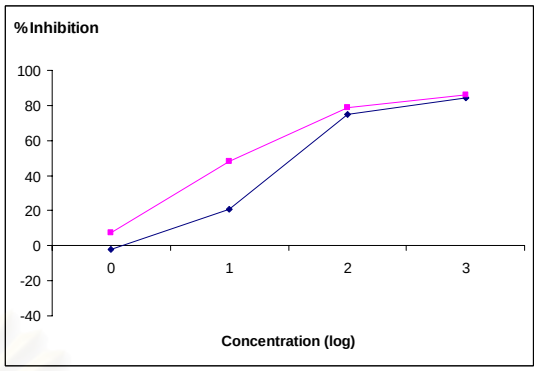


***M. lathyroides* (L.) Urb.**

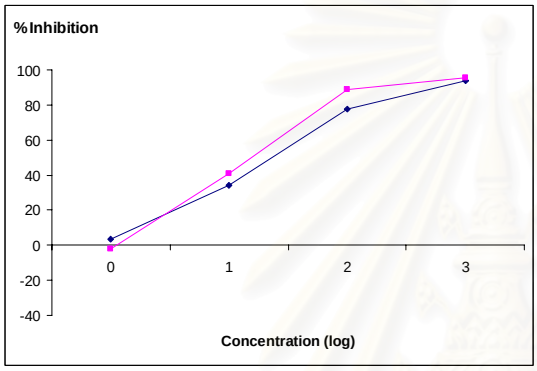
Fig 3.5 (cont.)



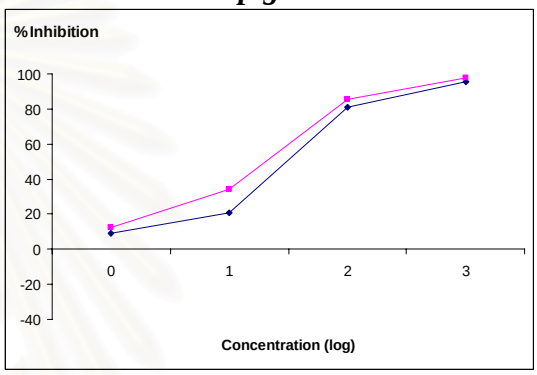
***A. viridis* L.**



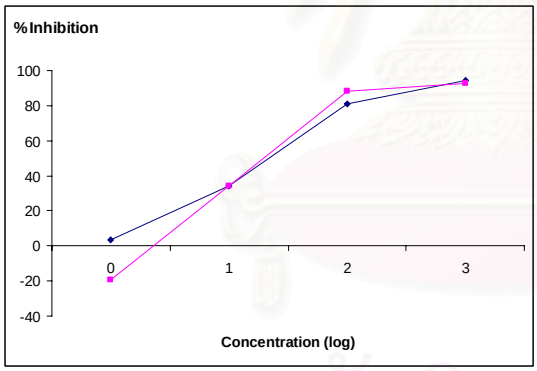
***M. pigra* L.**



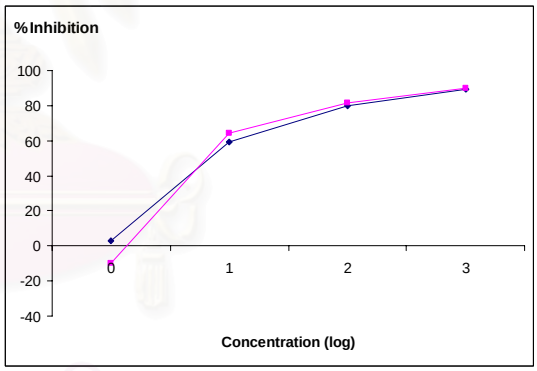
***R. tuberosa* L.**



***C. viscosa* L.**



***I. aquatica* Forsk.**



***C. argentia* L.**

Fig 3.5 (cont.)

All graphs in Fig 3.5 indicated the correlation between tested chemical, 3,4-(methylenedioxy)cinnamic acid in the range of 1-1000 ppm and inhibitory effect on root and shoot growth of major weeds in Thailand. The substance possessing high activity should give a slope as increasing function in semi-logarithm graph (higher activity of each increase 1 unit of logarithm concentration of dose) and higher percent at 100 ppm. The inhibition of root is thought to be more essential for considering than that of percentage shoot growth inhibition because of the root would be directly contacted to the tested chemical, 3,4-(methylenedioxy)cinnamic acid in tissue paper.

While the shoot growth is contributed from root and attributed to accumulated food from seed. For that reason, the profound effect of 3,4-(methylenedioxy)cinnamic acid in this plant part might be perverted. Root growth inhibition percentage at 100 ppm was selected to be mainly purposed. By the way, low root growth inhibition always related by chemical with low concentration (1 or 10 ppm). Apart from its herbicidal activity, this chemical has highly inhibitory effect to other economic crops, too. To verify about crops toxicity effect and were choose to test for toxicity effect of 3,4-(methylenedioxy)cinnamic acid the results are indicated in Fig 3.5.

Considering for Fig 3.5, there are some plant species as C. *frutescens* Linn. var. *frutescens, C. sativum* Linn., *D. aegyptium*Willd., *C. viscosa* L. and *C. argentia* L., these plants also show moderately growth inhibition percentage but they had very low germination percentage indicated that the results of these plants were distrust.

3.3.2.3 Plant growth inhibitory effect of sodium 3-nitrocinnamate

Referring to herbicidal activity of 3-nitrocinnamic acid test dedicated that this chemical has highly inhibitory effect on weeds. Because of this result this experimental could be done in laboratory scale and easily to use solvent, acetone. But in field study, it was very hard to apply that chemical or might be impossible. Beside the way, 3-nitrocinnamic acid must be transform in to other structure; sodium 3-nitrocinnamate is the most useful because it's easy to dissolve. In case of plant growth inhibitory effect, this chemical was choosing to test, too. The results dedicated that sodium 3-nitrocinnamate has highly inhibitory effect on weeds and crops, too.

According to the results, to measure the growth inhibition percentage of tested plant species with 10 ppm of tested chemical, sodium 3-nitrocinnamate the root growth inhibition percentage was between 26.35 and 50.59. Determining with shoot growth inhibition percentage, the plant growth inhibition percentage was around 23.55 to 41.22. The most sensitive plants were *S. aculeatissimum* Jasq. > *O. americanum* Linn. ≅ *R. tuberosa* L. > *V. radiata* L. > *O. sativa* L. ≅ B. *chinensis* L. var.*chinensis,* respectively.

Considering to 100 ppm of sodium 3-nitrocinnamate usage, this chemical also show highly inhibitory effect on the growth of tested plant species. According to root

and shoot growth inhibition percentage, it was around 67.46 to 83.84 and 55.22 to 80.02, respectively. The most sensitive plant species were *Z. mays* L. > *I. aquatica* Forsk. ≅ *S. aculeatissimum* Jasq. > *R. tuberosa* L. > B. *chinensis* L. var. *chinensis*, respectively.

Appeal with 1000 ppm, the plant growth inhibitory effect of sodium 3-nitrocinnamate was very high. The root growth inhibition percentage of tested plant species were about 90.73 up to 96.22. The shoot growth inhibition percentage was about 89.12 up to 93.76. the most sensitive plant species were *Z. mays* L. > *I. aquatica* Forsk. ≅ *R. tuberosa* L. > *M. pigra* L. > *M. lathyroides* (L.) Urb., respectively.

In the case of this result, sodium 3-nitrocinnamate was highly effective against monocotyledonous crops and dicotyledonous weeds. All of the results also showed in Table 3.5.

Table 3.5 Plant growth inhibitory effect of sodium 3-nitrocinnamate at 1, 10, 100 and 1000 ppm.

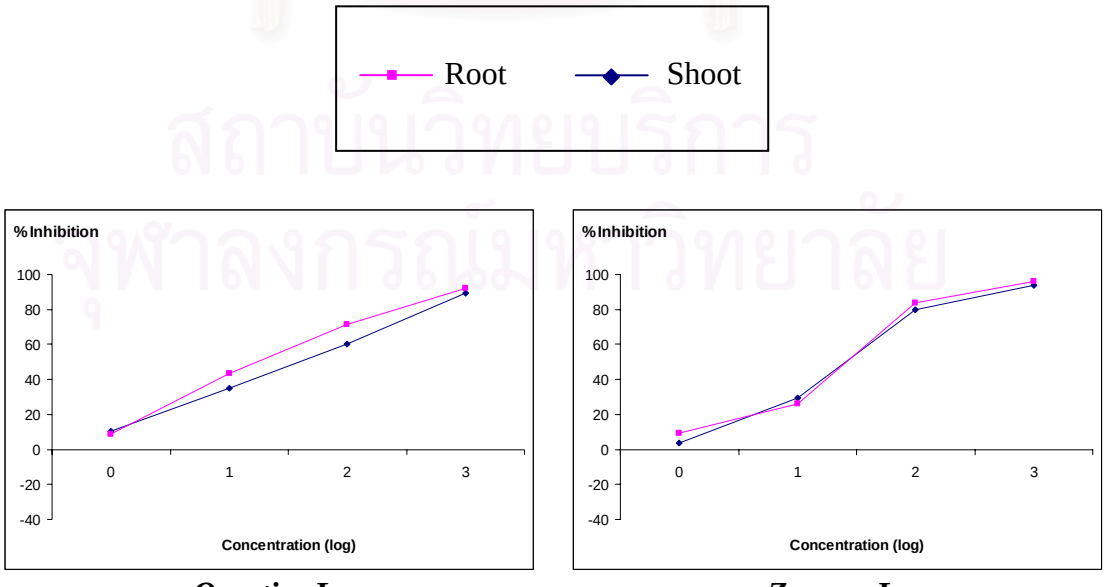
Plants	**Plant growth inhibitory effect at (ppm)**							
	Root				**Shoot**			
	1	**10**	**100**	**1000**	**1**	**10**	**100**	**1000**
Monocotyledonous weeds								
D. aegyptium Willd.	16.39	50.84	78.15	84.03	10.79	36.15	72.01	78.42
Dicotyledonous weeds								
A. viridis L.	10.33	36.26	78.41	93.35	8.12	34.63	67.32	90.13
C. argentia L.	84.81	81.01	91.14	96.84	79.78	78.93	86.24	96.07
C. viscosa L.	67.80	66.56	76.47	89.47	37.66	46.31	65.65	84.48
I. aquatica Forsk.	8.69	41.47	78.92	95.34	14.08	32.57	68.19	93.31
M. lathyroides (L.) Urb.	13.73	38.21	68.14	93.65	11.54	27.28	58.43	91.52
M. pigra L.	3.21	35.27	81.22	94.72	3.94	34.91	74.51	91.82
R. tuberosa L.	10.91	48.83	76.86	95.26	9.99	39.98	66.94	93.12
Monocotyledonous crops								
O. sativa L.	8.56	43.38	71.40	92.28	10.12	34.90	60.32	89.12

Z. mays L.	9.56	26.35	83.84	96.22	3.59	29.19	80.02	93.76

Table 3.5 Plant growth inhibitory effect of sodium 3-nitrocinnamate at 1, 10, 100 and 1000 ppm. (cont.)

Plants	**Plant growth inhibitory effect at (ppm)**							
	Root				**Shoot**			
	1	**10**	**100**	**1000**	**1**	**10**	**100**	**1000**
Dicotyledonous crops								
A. graveolens L.	-4.15	28.78	67.46	92.58	-0.64	23.55	55.22	91.32
B. chinensis L.	10.76	43.26	75.98	92.63	11.26	33.60	66.83	89.74
C. *frutescens* Linn.	25.59	57.00	79.83	89.01	17.95	46.26	72.25	85.02
C. sativum Linn.	16.05	56.56	84.74	89.82	15.42	45.52	76.06	88.10
C. melo Linn.	14.73	27.04	75.39	90.73	8.67	26.81	67.77	89.37
O. americanum Linn.	9.10	49.94	73.63	91.48	8.78	38.60	64.95	88.91
S. aculeatissimum Jasq.	35.18	50.59	78.79	93.15	24.37	41.22	67.80	90.56
V. radiata L.	18.14	47.88	75.73	93.14	16.14	40.35	65.59	89.69

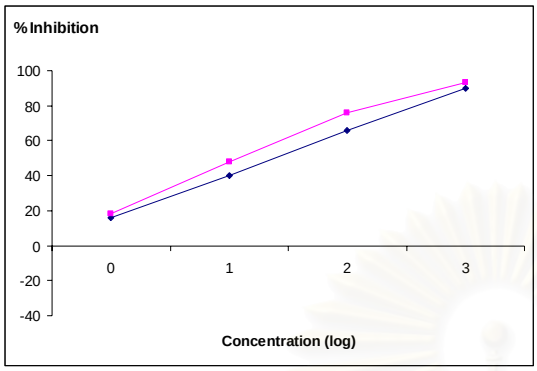
To verified plant growth inhibitory effect of sodium 3-nitrocinnamate. It was easy to reform the data in Table 3.5. All of the results are reformation and describing in Fig 3.6.



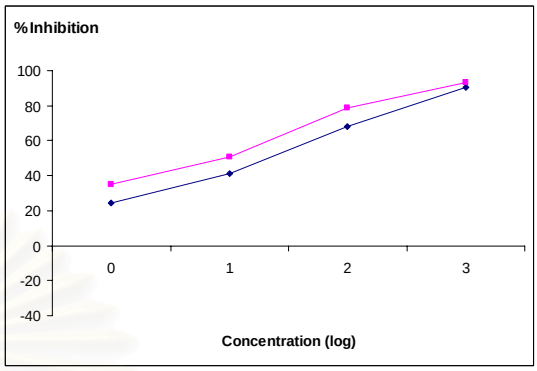
***O. sativa* L.** ***Z. mays* L.**

Fig 3.6 Inhibitory effect of sodium 3-nitrocinnamic acid on root and shoot

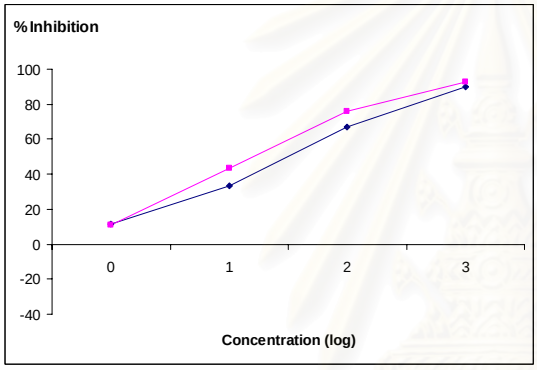
growth of noxious weeds and crops (%)



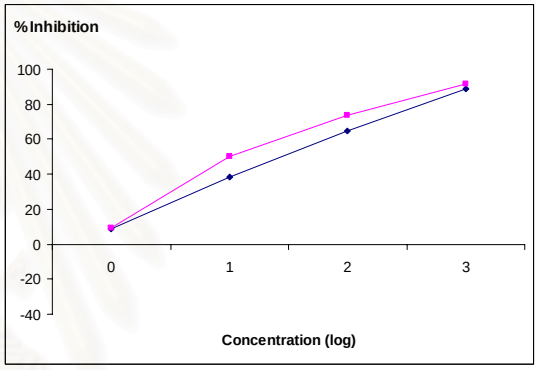
***V. radiata* L.**



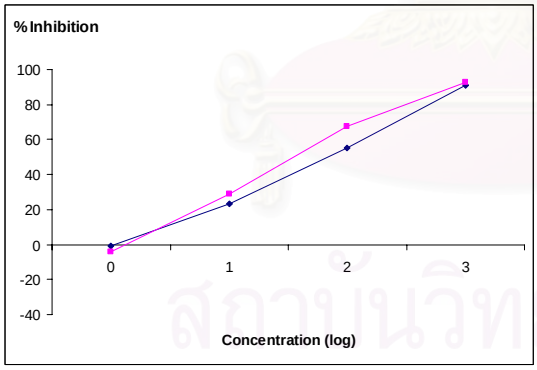
***S. aculeatissimum* Jasq.**



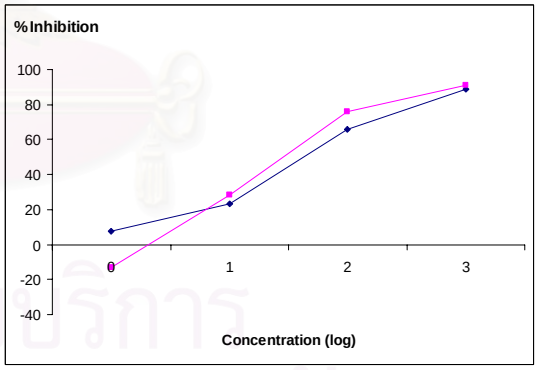
B. *chinensis* var.*chinensis* L.



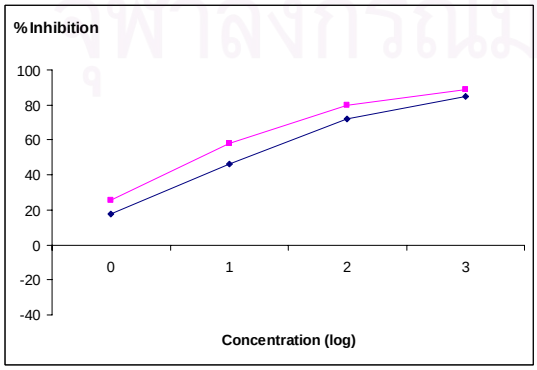
***O. americanum* Linn.**



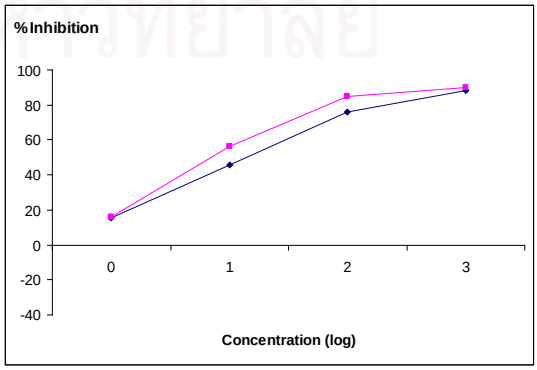
***A. graveolens* L.**



***C. melo* Linn.**

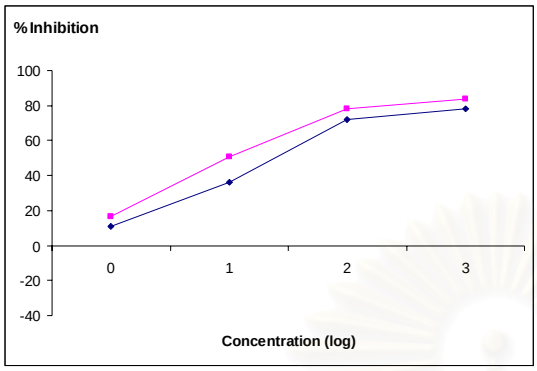


C. *frutescens* Linn. var. ***frutescens***

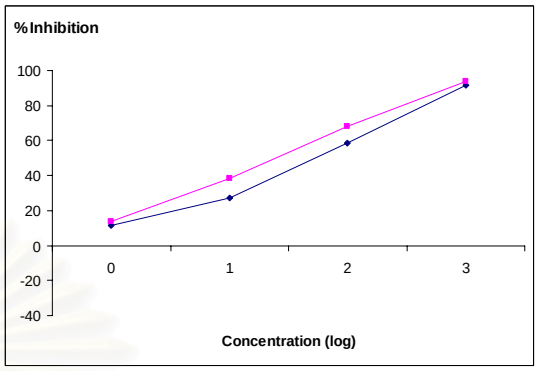


***C. sativum* Linn.**

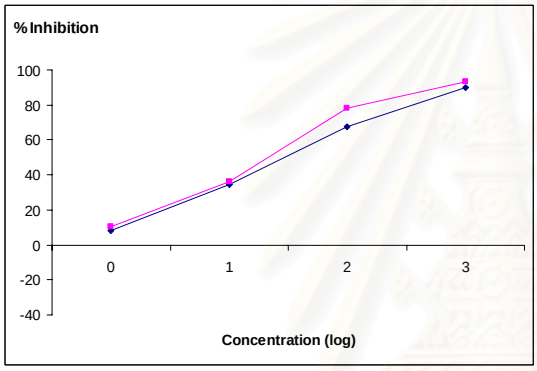
Fig 3.6 (cont.)



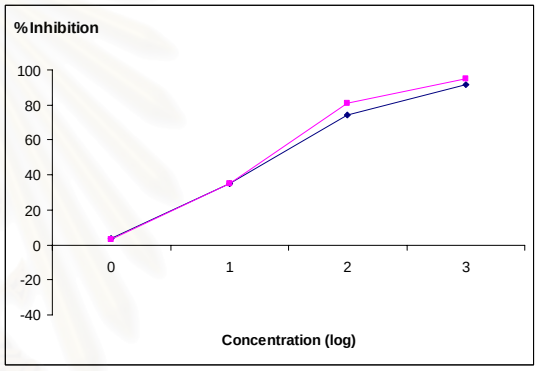
***D. aegyptium* Willd.**



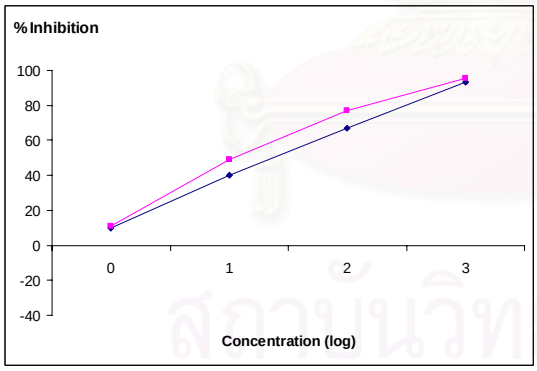
***M. lathyroides* (L.) Urb.**



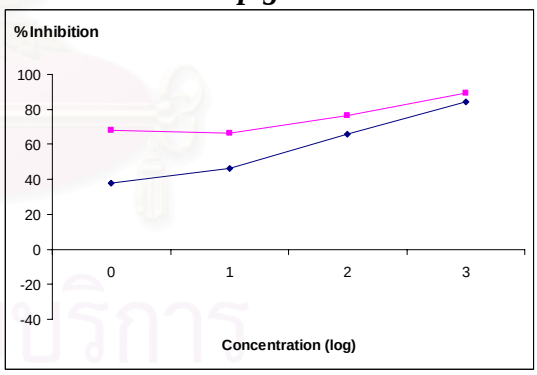
***A. viridis* L.**



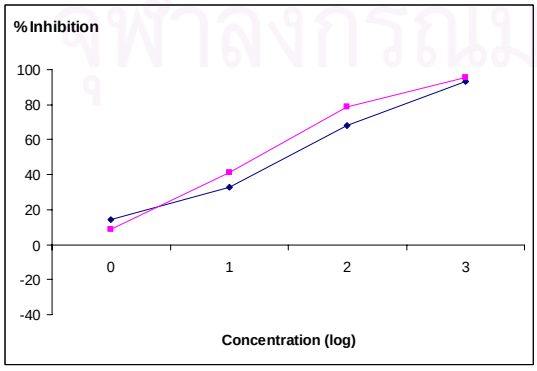
***M. pigra* L.**



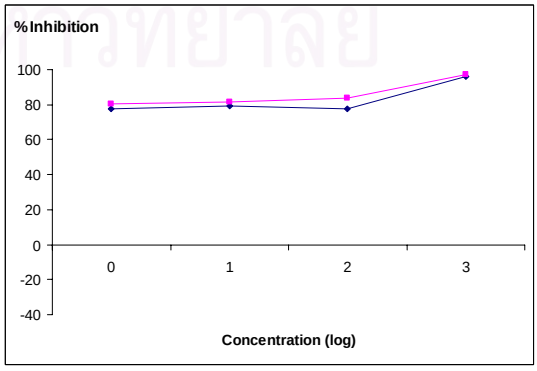
***R. tuberosa* L.**



***C. viscosa* L.**



***I. aquatica* Forsk.**



***C. argentia* L.**

Fig 3.6 (cont.)

From the above graphs, sodium 3-nitrocinnamate has highly inhibitory effect on any plant including crops, too. In that way this chemical can use as herbicide for the screening but at lower concentration the effect may be opposite call promoter effect, which promote the growth rate of tested plant species. For example: the root growth of *C. melo* Linn. when treat with 1 ppm of sodium 3-nitrocinnamate.

In case of *C. frutescens* Linn. var. *frutescens*, *C. sativum* Linn., *D. aegyptium* Willd., *C. viscosa* L. and *C. argentia* L., these plants also show moderately growth inhibition percentage when treat with sodium 3-nitrocinnamate at moderately concentration but these plant species also had very low germination percentage indicated that the results of these plants were distrust.

3.3.2.4 Plant growth inhibitory effect of sodium 3,4-(methylenedioxy) cinnamate

In the other way, sodium 3,4-(methylenedioxy)cinnamate were choose as the last chemical to test about herbicidal activity, regarding from the high inhibition effect of 3,4-(methylenedioxy)cinnamic acid. This chemical still have a highly inhibitory effect on plant growth. This experimental was indicated that this chemical has highly effective on weeds and crops, both. The results are described in Table 3.6.

Table 3.6 Plant growth inhibitory effect of sodium 3,4-(methylenedioxy)cinnamate at 1, 10, 100 and 1000 ppm.

Plants	Plant growth inhibitory effect at (ppm)							
	Root				Shoot			
	1	10	100	1000	1	10	100	1000
Monocotyledonous weeds								
D. aegyptium Willd.	38.66	53.36	73.11	84.03	27.11	44.02	63.56	80.47
Dicotyledonous weeds								
A. viridis L.	11.98	63.24	79.23	96.21	13.33	38.52	69.60	94.36
C. argentia L.	-10.13	64.56	81.64	89.87	3.09	59.55	79.78	89.61
C. viscosa L.	69.35	74.30	89.16	93.50	61.07	65.90	84.99	92.62
I. aquatica Forsk.	2.33	41.10	82.10	96.61	2.381	31.81	72.09	95.44

M. lathyroides (L.) Urb.	6.65	38.46	70.06	94.28	9.927	40.88	62.95	91.81

Table 3.6 Plant growth inhibitory effect of sodium 3,4-(methylenedioxy)cinnamate at 1, 10, 100 and 1000 ppm. (cont.)

Plants	**Plant growth inhibitory effect at (ppm)**							
	Root				**Shoot**			
	1	**10**	**100**	**1000**	**1**	**10**	**100**	**1000**
Dicotyledonous weeds								
M. pigra L.	3.81	28.90	68.10	94.07	0.49	19.55	60.25	90.92
R. tuberosa L.	6.88	40.98	77.06	93.32	1.706	35.84	63.29	90.54
Monocotyledonous crops								
O. sativa L.	-3.50	41.63	70.95	93.00	7.50	33.86	61.55	90.40
Z. mays L.	5.78	28.20	84.59	95.56	2.964	28.42	77.99	93.89
Dicotyledonous crops								
A. graveolens L.	2.67	33.83	68.45	89.61	2.65	26.85	54.26	86.25
B. chinensis L.	11.72	40.24	74.94	92.11	11.52	33.48	66.27	88.74
C. *frutescens* Linn.	40.19	64.67	76.77	89.57	33.48	55.84	66.30	86.45
C. sativum Linn.	-3.33	48.53	77.30	86.69	-1.17	36.71	70.04	84.58
C. melo Linn.	-5.20	33.71	84.49	88.04	13.34	30.80	78.88	83.14
O. americanum Linn.	-19.95	41.31	71.06	84.01	-0.98	37.36	63.35	82.08
S. aculeatissimum Jasq.	12.65	46.64	83.33	93.02	17.02	35.30	75.63	89.25
V. radiata L.	7.71	51.03	74.27	93.14	12.10	42.53	63.79	89.69

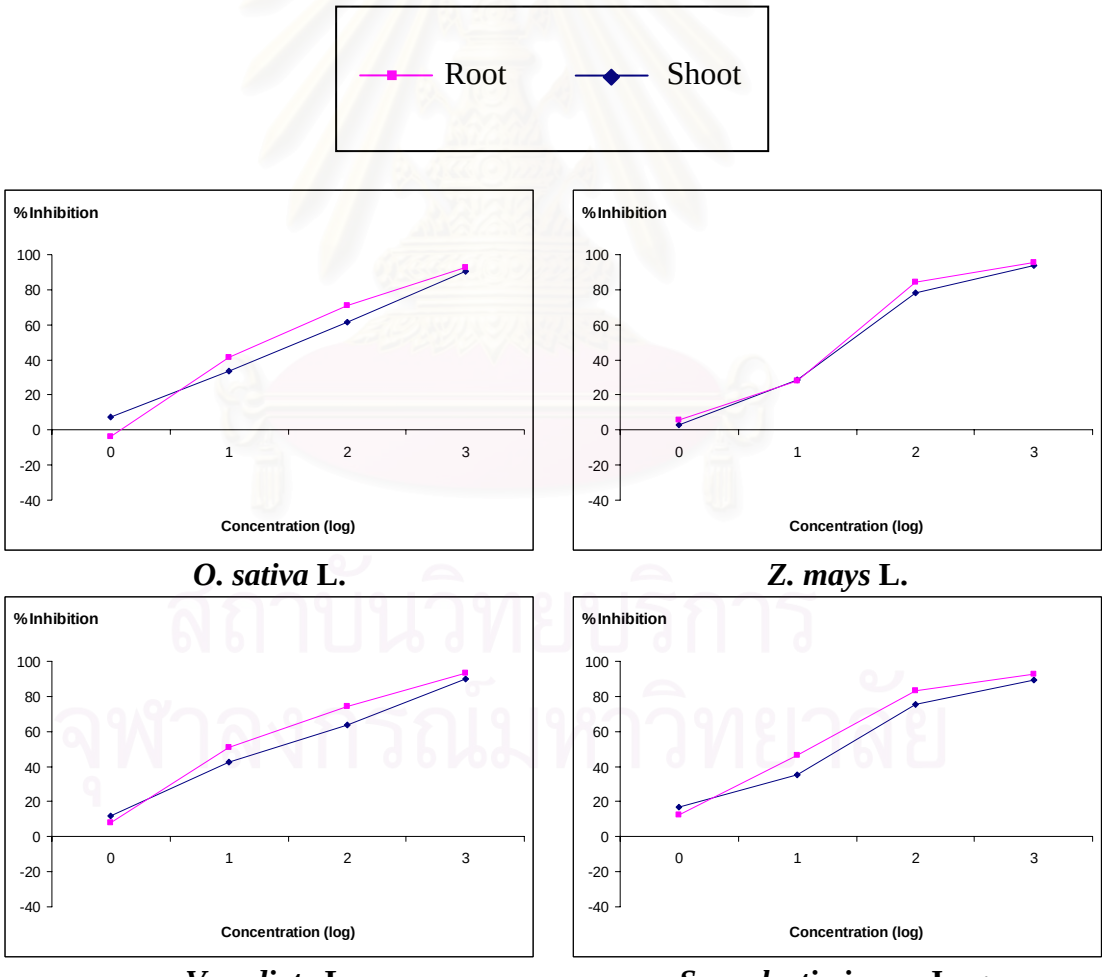
According to Table 3.6, the effect of 10 ppm sodium 34-(methylenedioxy) cinnamate was concluded for the root growth inhibition and the shoot growth inhibition. The root growth inhibition percentage of tested plant species were 28.20 up to 51.03 and the shoot growth inhibition percentage were 19.55 up to 42.53. The most sensitive plant species were *V. radiata* L. > *S. aculeatissimum Jasq.* > *O. sativa* L. > *I. aquatica* Forsk. > *R. tuberosa* L., respectively.

Referring to 100 ppm chemical usage, the root growth inhibition percentage and the shoot growth inhibition percentage were rapidly increased compared with 10 ppm. the growth inhibition percentage were around 68.10 to 84.59 and 54.26 to 78.88, respectively. considering for the most sensitive plant species, they were *Z. mays* L. ≅

C. melo Linn. > *S. aculeatissimum* Jasq. > *I. aquatica* Forsk. > *A. viridis* L., respectively.

Considering for 1000 ppm dosage, there were severely effect on plant growth inhibition percentage. For the root growth inhibition percentage, the values were 84.01 to 96.61. For the shoot growth inhibition percentage, the values were around 82.08 to 95.44. the most sensitive plant species were *I. aquatica* Forsk. > *A. viridis* L. > *Z. mays* L. > *M. lathyroides* (L.) Urb. > *M. pigra* L., respectively.

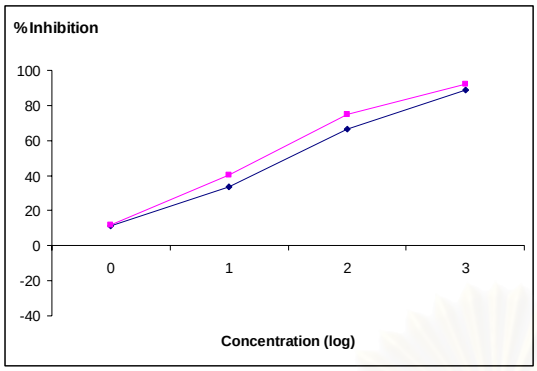
In case of C. *frutescens* Linn. var. *frutescens*, *C. sativum* Linn., *D. aegyptium* Willd., *C. viscosa* L. and *C. argentia* L., these plants also show highly growth inhibition percentage when treat with sodium 3,4-(methylenedioxy)cinnamate but these plant species also had very low germination percentage.



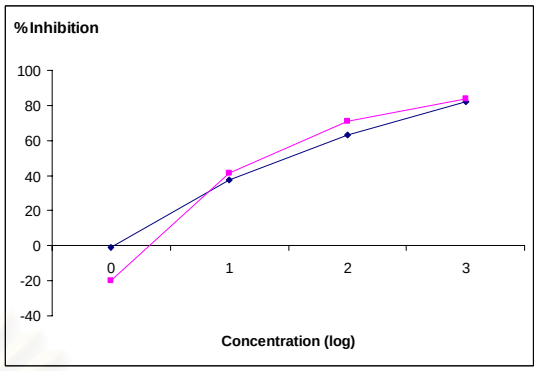
***O. sativa* L.** **Z. *mays* L.**

***V. radiata* L.** ***S. aculeatissimum* Jasq.**

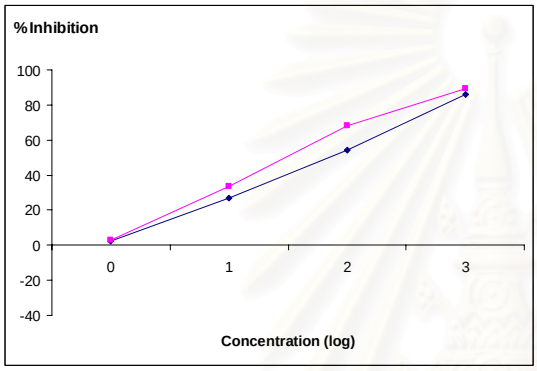
Fig 3.7 Inhibitory effect of sodium 3,4-(methylenedioxy)cinnamate on root and shoot growth of noxious weeds and crops (%)



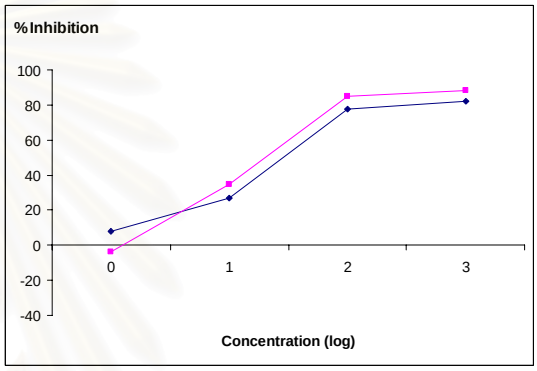
B. *chinensis* var.***chinensis* L.**



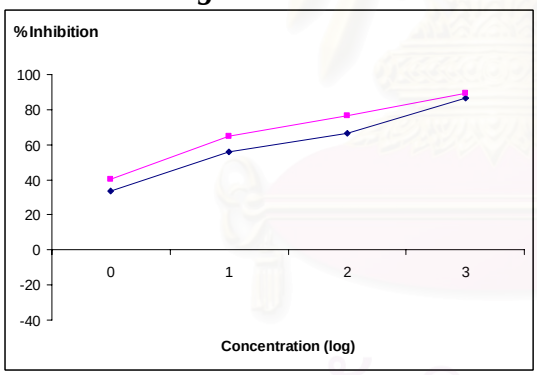
***O. americanum* Linn.**



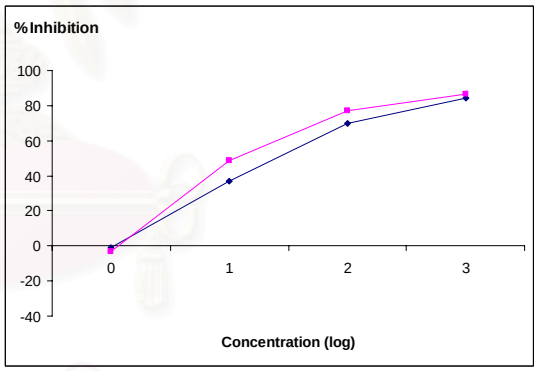
***A. graveolens* L.**



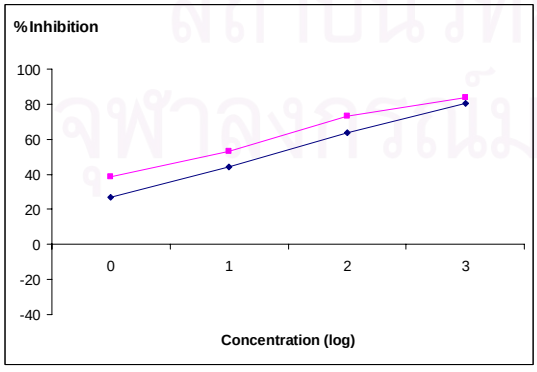
***C. melo* Linn.**



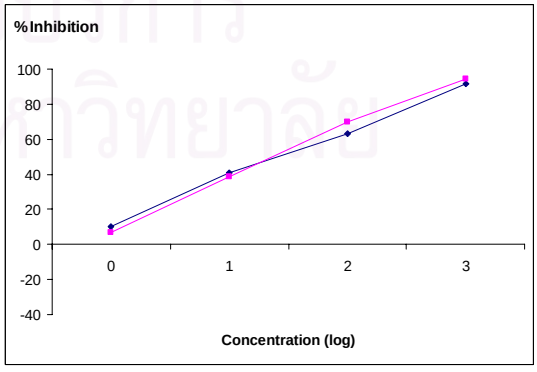
C. *frutescens* Linn. var. ***frutescens***



***C. sativum* Linn.**

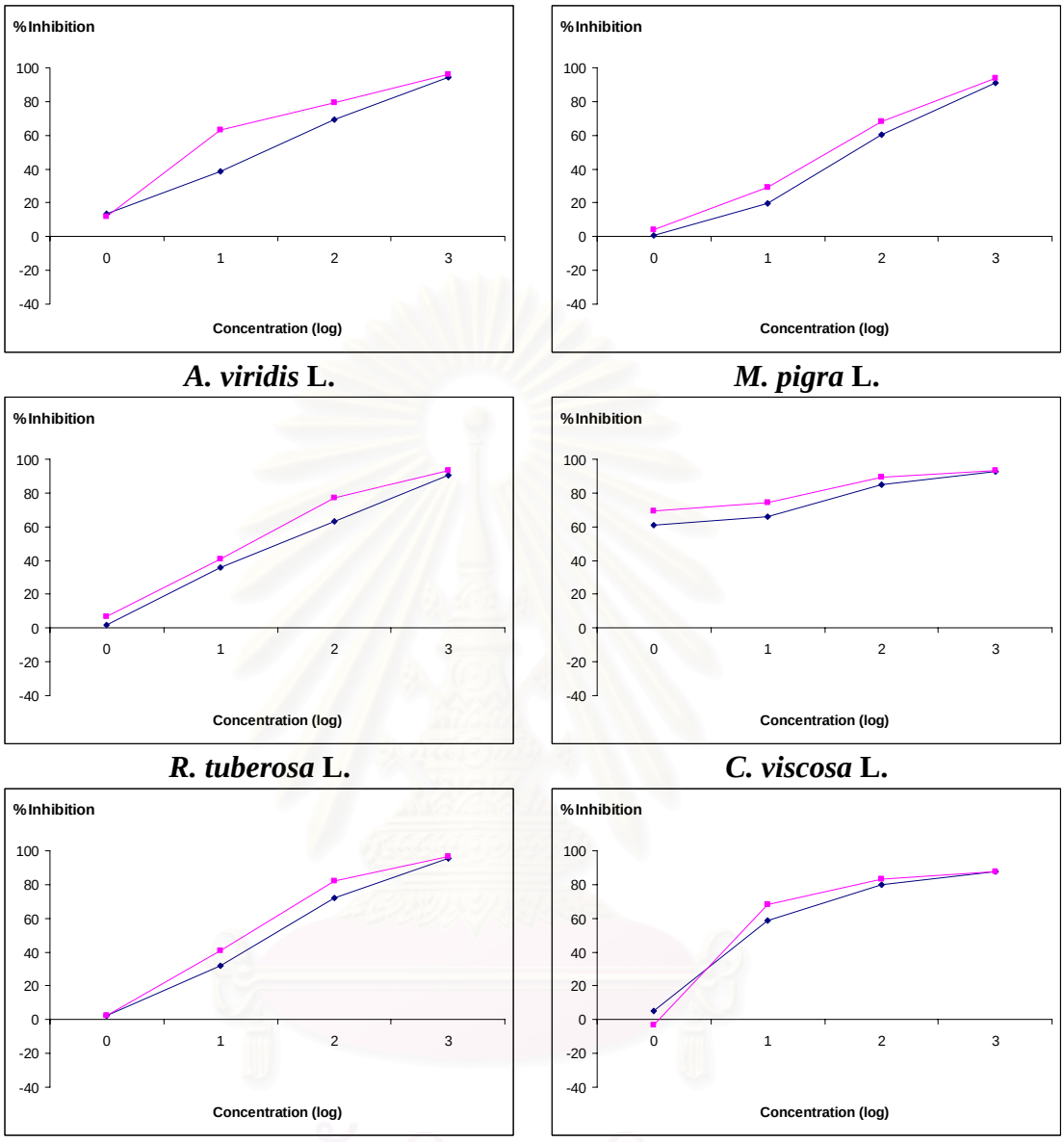


***D. aegyptium* Willd.**



***M. lathyroides* (L.) Urb.**

Fig 3.7 (cont.)



***A. viridis* L.** ***M. pigra* L.**

***R. tuberosa* L.** ***C. viscosa* L.**

***I. aquatica* Forsk.** ***C. argentia* L.**

Fig 3.7 (cont.)

The results indicated that sodium 3,4-(methylenedioxy)cinnamate still has highly inhibitory effect same as the beginning structure, 3,4-(methylnedioxy)cinnamic acid. At high level concentration all tested plants were almost be destroy. By the way, the results were displayed as plant growth inhibitory effect percentage in Table 3.7.

Referring the results from all parts of this experimental, 3-nitrocinnamic acid, 3,4-(methylenedioxy)cinnamic acid, sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate also show the highly inhibitory effect on plant growth both root and shoot growth. Compared with their effect on root and shoot growth, these

chemicals show higher effective on root growth than shoot growth. Determined with sodium cinnamate, sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy) cinnamate and their parent structures, 3-nitrocinnamic acid and 3,4-(methylenedioxy) cinnamic acid, the growth inhibitory effects of sodium cinnamate were closely to their parent structure, *trans*-cinnamic acid.

According to the effective of *trans*-cinnamic acid and sodium cinnamate, the inhibitory effect of *trans*-cinnamic acid was closely up to the effect of sodium cinnamate indicated that the next experimental can use only sodium cinnamate because this structure can easily dissolves in water.

3.4 Effects of sodium 3- nitrocinnamate, sodium 3,4-(methylenedioxy)cinnamate, and commercial herbicide, round up at different concentration

Apart from it highly inhibitory effect on laboratory scale, 2 chemicals as sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate were selected to test for herbicidal activity in pot test.

Firstly, to test for finding the effective concentration 2 plants, *C. barbata* Sw. and *M. lathyroides* (L.) Urb. were select as indicator because it was highly germination percentage. The result has been separated as the subject below:

3.4.1 Effects of sodium 3,4-(methylenedioxy)cinnamate at 1000 ppm, 5000 ppm, 10000 ppm and 30000 ppm on *M. lathyroides* (L.) Urb.

M. lathyroides (L.) Urb. was choose as an indicator for dicotyledonous. To find the effective concentration, 20 seeds were placed in each pot. After germinated for 7 days eliminated them out until the seedlings per pot equal to 5. Take care of them for 3 weeks and then sprayed the tested chemical, sodium 3,4-(methylenedioxy)cinnamate at the different concentration. The responses of tested plant species were show in Table 3.7. This chemical was show moderate effect on *M. lathyroides* (L.) Urb.

The inhibition percentage were around 47.96 to 58.61 when use at 30000 ppm. The best time that can show highly effect was 9 days after application. The result was summarized in Fig 3.8.

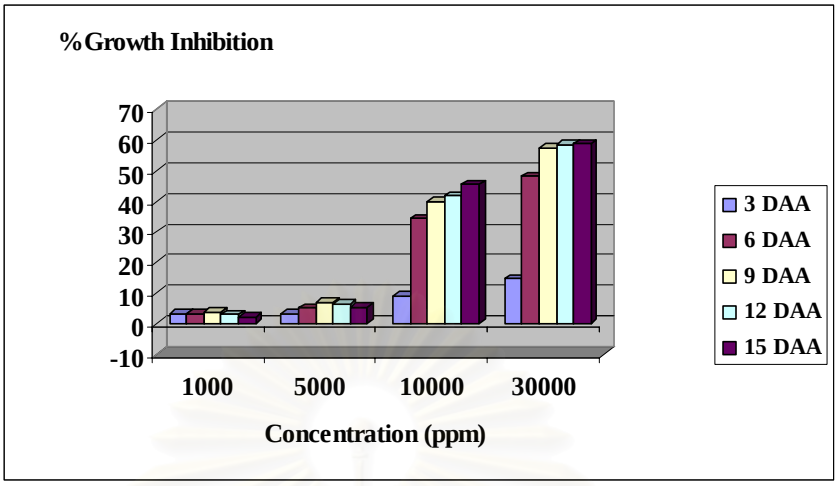


Fig 3.8 Effect of sodium 3,4-(methylenedioxy)cinnamate on *M. lathyroides* (L.) Urb.

3.4.2 Effects of sodium 3-nitrocinnamate at 1000 ppm, 5000 ppm, 10000 ppm and 30000 ppm on *M. lathyroides* (L.) Urb.

According to this experiment, was designed to found the effective concentration of tested chemical, sodium 3-nitrocinnamate. The responded of tested plant were show in Table 3.7. This chemical also show moderate effect as sodium 3,4-(methylenedioxy)cinnamate, too. The results indicated that inhibition percentage were around 45.94 to 61.02 when applied at 30000 ppm. The best time to indicate its activity was 9 day after application. The result was summarized in Fig 3.9.

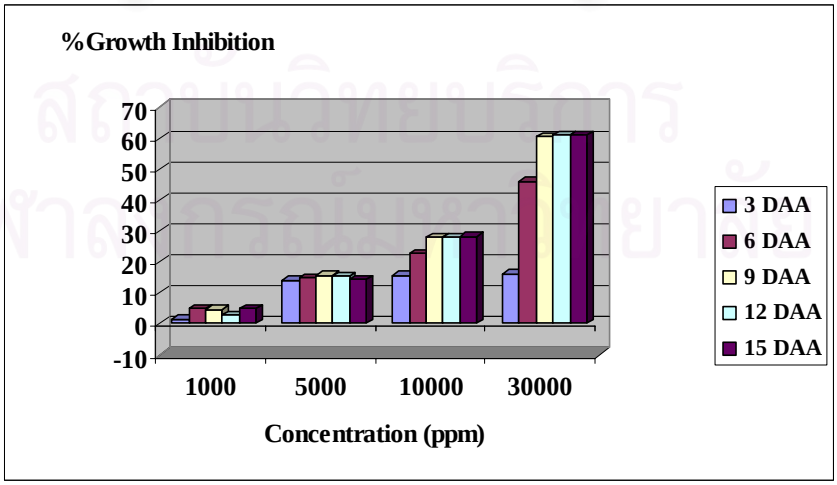


Fig 3.9 Effect of sodium 3-nitrocinnamate on *M. lathyroides* (L.) Urb.

3.4.3 Effects of commercial herbicide, round up at 1000 ppm, 5000 ppm, 10000 ppm and 30000 ppm on *M. lathyroides* (L.) Urb.

To study the possibly to take tested chemicals up to newly herbicide. It's very necessary to find out the commercialized herbicide that can use as reference. In this experiment choosing round up, *N*-(poosphonomethyl)glycine 36%w/v. This chemical once widely used by farmers in agricultural areas of Thailand. It's very effective against many varieties of weeds. This herbicide was choosing to test the herbicidal activity and indicated the result as Table 3.7. The result elucidated that this chemical shows very highly inhibitory effect. According to Table 3.7, the inhibition percentage was around 81.92 to 100 when applied only at 1000 ppm. It's also mean completely inhibitory effect on plants. The time can count the result was 3 days after application. The result was showed in Fig 3.10.

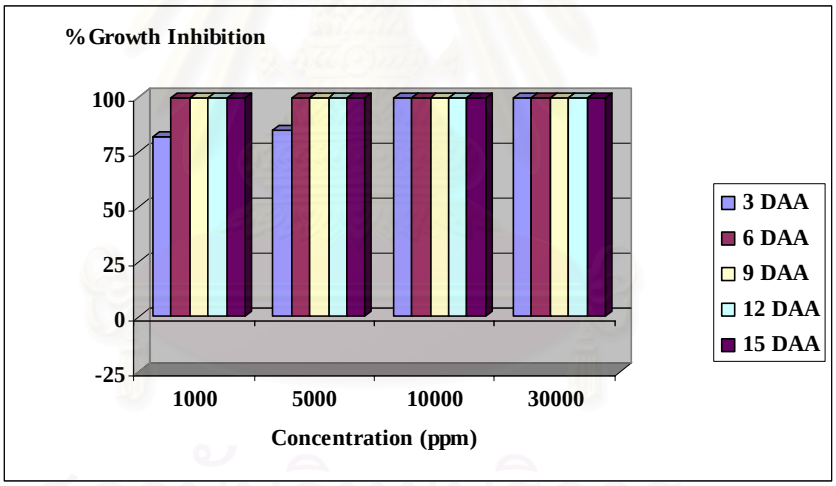


Fig 3.10 Effect of commercial herbicide, Round up on *M. lathyroides* (L.) Urb.

Referring to Fig. 3.8-3.9 contain herbicidal activity of tested chemicals on *M. lathyroides* (L.) Urb. The graphs indicated that tested chemicals had moderately effect on *M. lathyroides* (L.) Urb. when used at high concentration (10000 and 30000 ppm). the growth inhibition percentage was calculated and summarized in Table 3.7.

Table 3.7 Affects of tested chemical on the growth of *M. lathyroides* (L.) Urb.

Treatments	Conc. (ppm)	%Growth Inhibition (DAA)				
		3	6	9	12	15
1. sodium 3,4-(methylenedioxy)cinnamate	1000	3.14	3.27	3.96	2.95	2.27
2. sodium 3,4-(methylenedioxy)cinnamate	5000	3.39	5.19	6.96	6.40	5.43
3. sodium 3,4-(methylenedioxy)cinnamate	10000	9.23	34.21	39.87	41.61	45.29
4. sodium 3,4-(methylenedioxy)cinnamate	30000	14.64	47.96	57.23	58.43	58.61
5. sodium 3-nitrocinnamate	1000	1.43	4.83	4.41	2.62	4.82
6. sodium 3-nitrocinnamate	5000	14.09	14.74	15.59	15.24	14.31
7. sodium 3-nitrocinnamate	10000	15.59	22.65	27.92	27.96	28.02
8. sodium 3-nitrocinnamate	30000	16.21	45.94	60.54	61.02	60.99
9. round up	1000	81.92	100	100	100	100
10. round up	5000	84.84	100	100	100	100
11. round up	10000	100	100	100	100	100
12. round up	30000	100	100	100	100	100
13. Control	-	0	0	0	0	0

3.4.4 Effects of sodium 3,4-(methylenedioxy)cinnamate at 1000 ppm, 5000 ppm, 10000 ppm and 30000 ppm on *Chloris barbata* Sw.

For monocotyledon, *C. barbata* Sw. were selected as an indicator. This plant also grown ups rapidly and can reproduce so many seeds, too. After decided to choose this plant as indicator using the same methodology. Then, the results were show in the Table 3.8. Indicated that this chemical show moderate effect the percentage were around 30.6 to 44.31. The most suitable time that can show out about herbicidal effect was 6 days after application. The result was showed in Fig 3.11.

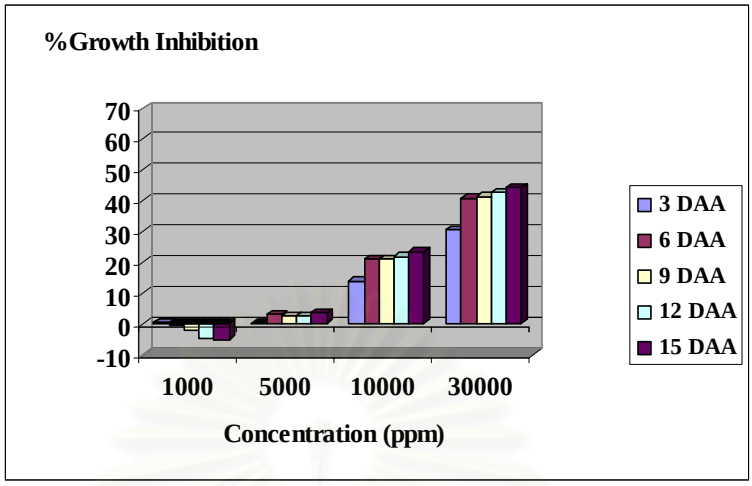


Fig 3.11 Effect of sodium 3,4-(methylenedioxy)cinnamate on *C. barbata* Sw.

3.4.5 Effects of sodium 3-nitrocinnamate at 1000 ppm, 5000 ppm, 10000 ppm and 30000 ppm on *C. barbata* Sw.

According to herbicidal activity of sodium 3-nitrocinnamate in laboratory scale, show highly inhibitory effect. This experiment was designed to find out about activity in larger scale like pot test or field, also. The herbicidal activity of this chemical on *Chloris barbata* Sw. was show in Table 3.8 and indicated that this chemical has moderate effect, too. The inhibition percentage was around 24.45 to 45.23 when applied at 30000 ppm. The most effective time that this chemical released its activity was 6 days after application. The result was showed in Fig 3.12.

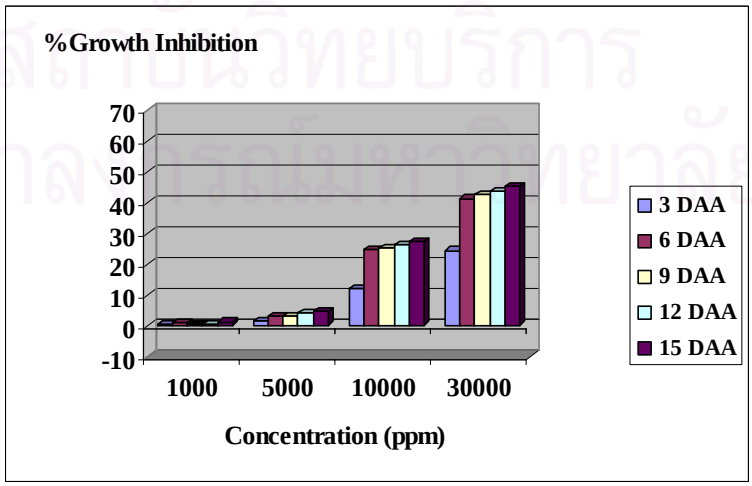


Fig 3.12 Effect of sodium 3-nitrocinnamate on *C. barbata* Sw.

3.4.6 Effects of commercial herbicide, round up at 1000 ppm, 5000 ppm, 10000 ppm and 30000 ppm on *C. barbata* Sw.

Apart from this chemical, still show highly inhibitory effect against this weed, *C. barbata* Sw. To indication for this result, this chemical shows highly inhibitory effect when used only 1000 ppm. At 3 days after application 60.68% of tested plants were died and 6 days after application show completely inhibitory effect (100%) on tested plant. These chemical shows completely affect that very well to excellent weed control. The weeds were completely destruction. To confirmation this result sees also Fig 3.13.

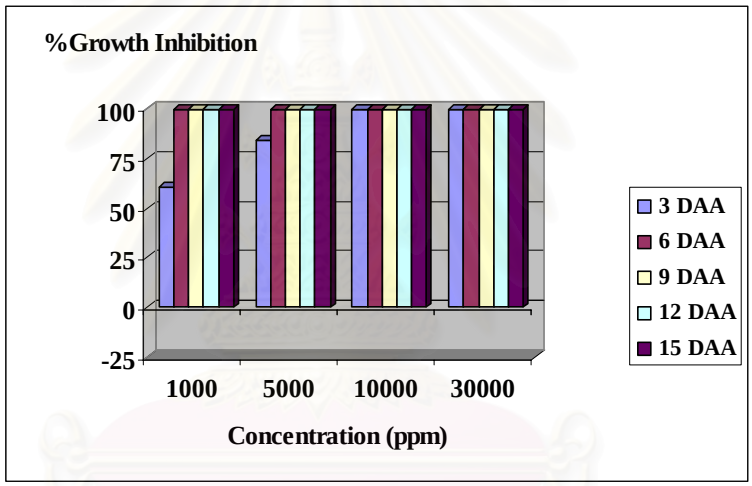


Fig 3.13 Effect of commercial herbicide, Round up on *C. barbata* Sw.

Referring to Fig. 3.11-3.12 contain herbicidal activity of tested chemicals on *C. barbata* Sw. The graphs indicated that tested chemicals had moderately effect on *C. barbata* Sw. when used at 10000 ppm, they were show slightly effect. The inhibition percentage was around 20. Considered at 30000 ppm, the growth inhibition percentage was moderate increased from 10000 ppm. They were showed moderately effect on *C. barbata* Sw. the inhibition percentage was around 40. The results was calculated and summarized in Table 3.8.

Table 3.8 Effects of tested chemical on the growth of *Chloris barbata* Sw.

Treatments	Conc. (ppm)	%Growth Inhibition (DAA)				
		3	6	9	12	15
1. sodium 3,4-(methylenedioxy)cinnamate	1000	0.20	-0.47	-2.25	-4.73	-5.26
2. sodium 3,4-(methylenedioxy)cinnamate	5000	-0.21	2.97	2.41	2.41	3.37
3. sodium 3,4-(methylenedioxy)cinnamate	10000	13.94	20.96	21.04	21.81	23.34
4. sodium 3,4-(methylenedioxy)cinnamate	30000	30.6	40.85	41.49	42.67	44.31
5. sodium 3-nitrocinnamate	1000	0.28	0.83	-0.02	0.21	1.12
6. sodium 3-nitrocinnamate	5000	1.54	2.89	2.98	4.21	4.76
7. sodium 3-nitrocinnamate	10000	11.87	24.55	25.30	26.26	27.50
8. sodium 3-nitrocinnamate	30000	24.45	41.41	42.64	43.89	45.23
9. round up	1000	60.68	100	100	100	100
10. round up	5000	84.31	100	100	100	100
11. round up	10000	100	100	100	100	100
12. round up	30000	100	100	100	100	100
13. Control	-	0	0	0	0	0

Apart from this section, the result could be concluded that sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate were show moderate effect. In the case of commercialized herbicide, glyphosate shows completely effect. The usage of sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate were impossible because of its lower effect than glyphosate. The development of these tested chemicals were necessary, especially to study about physical qualification as degradation, leaching, reaction in soil structure and co-related between soil microorganism and chemical, and the study about chemical structure was important, also.

3.5 Effects of sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy) cinnamate on plant growth at different age

Concerning about effectiveness of this chemical in laboratory scale, sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate were picked up by their highly herbicidal activity. Twenties plants were selected and transplanting into 5×7

inches pots. When the seeds were germinated and have 3 leaves, tried to eliminated them and kept it 5 seedlings per pot. All pots were put in the natural condition. After the first series were 7 days, transplanting the new series of experimental and took care of them. Following to the experiment after transplanting for the 4^{th} series tried to spray tested chemicals on tested plants. The results were collected 15 days after application.

To evaluation for chemical affection, the experimental was split for 4 series based on the age of plants. Preparing them for 3 groups, ones treated with sodium 3-nitrocinnamate, the next were treated with sodium 3,4-(methylenedioxy)cinnamate and the last were choose as control set. The results from this experimental would be vary by plants species and described below:

3.5.1 Effect of tested chemicals on *Z. may* L.

According to this experiment, *Z. may* L. was choose to test for toxicity effect of tested chemicals, sodium 3,4-(methyllenedioxy)cinnamate and sodium 3-nitrocinnamate. The results were exhibited that both of tested chemicals still have an inhibitory effect on crops, too. For determining the effectiveness of these chemicals, was necessary to compute the factors as type of chemical, concentration usage and age of plant before application. Considering about these factors to analyze the data and could be concluded;

Type of chemical, both sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate have an inhibitory effect on this crops but the effect of both chemicals are not different than the other but they are different from control set.

Concentration usage, in this topic can split in to 3 different groups as 0, 10000 and 50000 ppm which any groups are different from the others. The concentration level that can affect to this plant most was 50000 ppm.

Age of plant before application, it’s not clear to describe about this factor. Considering for taking 10000 ppm of tested chemicals, the most response age was 2 weeks before application. Exempt for 50000 ppm stand for 0 weeks before application has the most effectively.

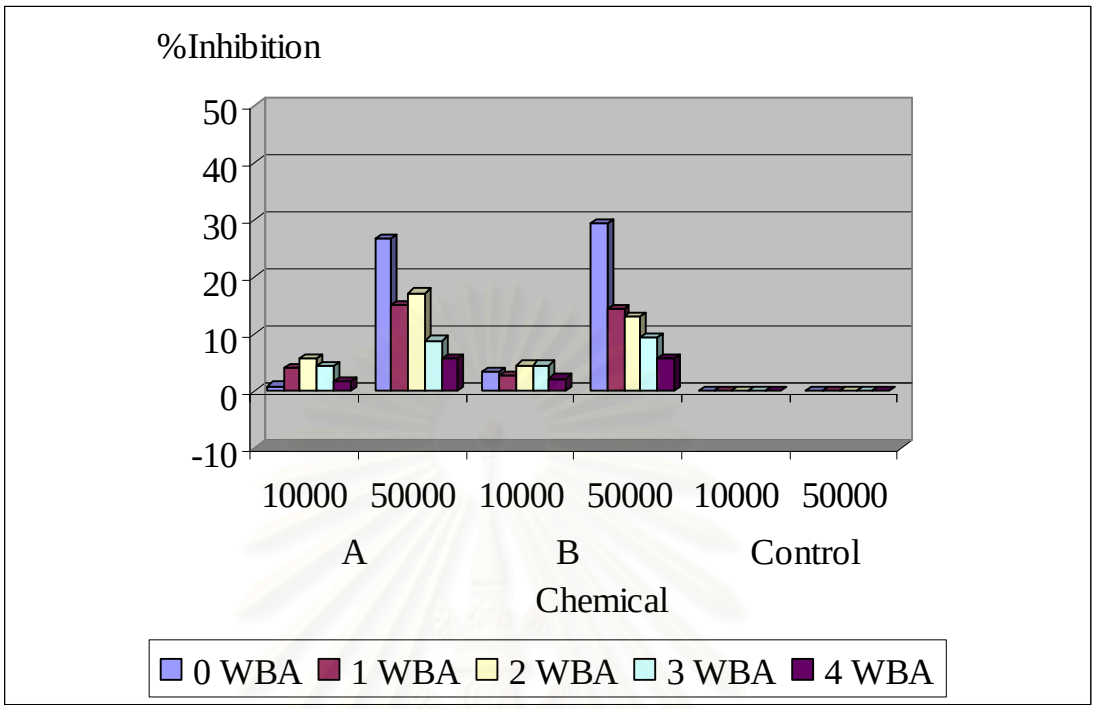


Fig 3.14 Inhibition Percentage of tested chemicals on *Z. may* L.

According to Fig 3.14, the concentration usage of tested chemicals was directly effect on the growth of *Z. may* L. The toxicity level of tested chemicals, sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate were 26.75 and 29.20 percent, respectively. Both sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate were slightly toxic.

3.5.2 Effect of tested chemicals on *M. lathyroides* (L.) Urb.

In case of *M. lathyroides* (L.) Urb., the inhibitory effect of tested chemicals was described by choosing percentage of inhibition as show in Fig 3.15. Focus on the factors that cause the inhibition effect on this plant. Considering with 3 factors; Type of chemical, Concentration usage and Age of plant before application were determined and summarized below;

Type of chemical, both sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate still show the inhibitory effect on this plants. Determining about effectiveness, the two chemicals were show the inhibition percentage that was different from control set but they are not different than the other.

Concentration usage, in this topic can split in to 3 different groups as 0, 10000 and 50000 ppm which any groups are differently from the others. The concentration level that can affect to this plant most was 50000 ppm.

Age of plant before application, it's not clear to describe about this factor. Considering for taking 10000 ppm of tested chemicals, the most response age was 1 weeks before application. Exempt for 50000 ppm stand for 0 weeks before application has the most effectively.

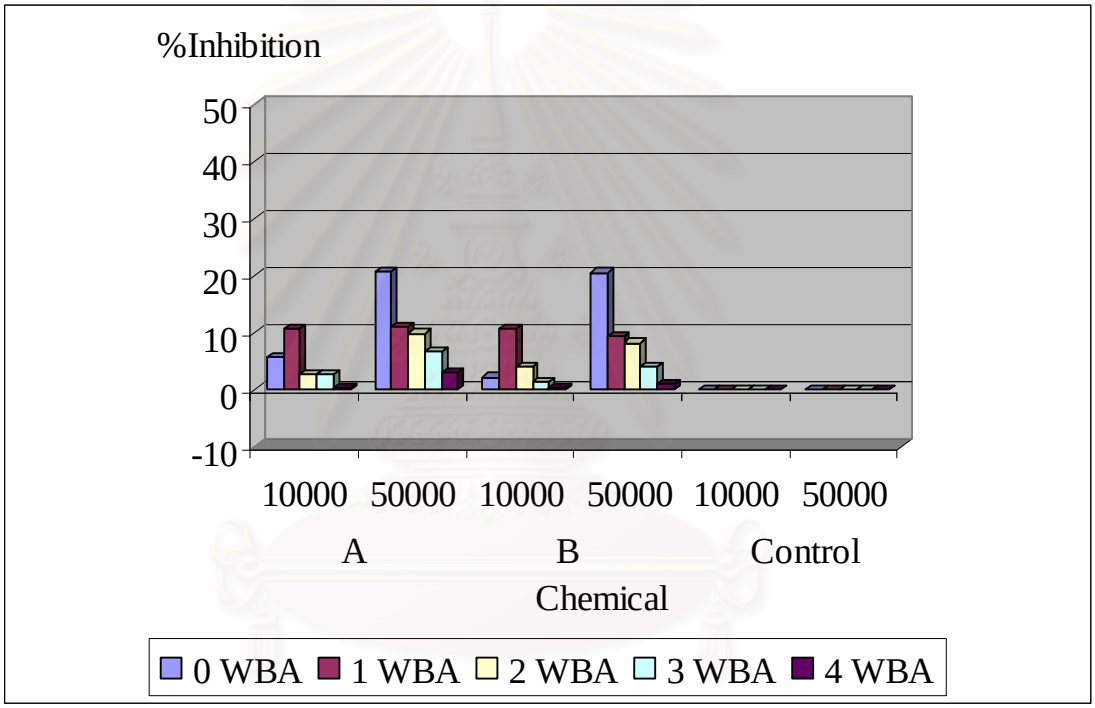


Fig 3.15 Inhibition Percentage of tested chemicals on *M. lathyroides* (L.) Urb.

Examining form Fig 3.15 the growth inhibitory effect on this plant was show, A is effect of sodium 3-nitrocinnamate, B is effect of 3,4-(methylenedioxy)cinnamate and C is Control set that no need to application any chemical.

Apart from A, the graph was split for 2 sets. The first one stand for the effect of sodium 3-nitrocinnamate when applied at 10000 ppm. and the next one stand for effect of the same chemical at 50000 ppm., indicated that this chemical can cause effectiveness when applied to tested plant at high concentration. According from the

graph, the most effective value of sodium 3-nitrocinnamate is 20.65 percent, applied at 50000 ppm.

Considering B section, the graph was split for 2 sets, too. Each set stand for the concentration, where first set was stand for 10000 ppm and second set was stand for 50000 ppm., the most effective value of sodium 3,4-(methylenedioxy)cinnamate is 20.47 percent, applied at 50000 ppm.

Both sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate have slightly toxic on this plant.

3.5.3 Effect of tested chemicals on *A. viridis* L.

Focus on *A. viridis* L., the plant growth inhibitory effect of tested chemicals were exhibited as Fig 3.16. Three factors were test for their effectiveness on the growth of *A. viridis* L., and described as below;

Type of chemical, both sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate still show the inhibitory effect on this plants. Determining about effectiveness, the two chemicals were show the inhibition percentage that was different from control set but not differently from the other., the most effective chemical was sodium 3,4-(methylenedioxy)cinnamate

Concentration usage, in this topic can split in to 2 different groups as 0-10000 and 50000 ppm which any groups are different from the others. The concentration level that can effect to this plant most was 50000 ppm. Considering to the case of 10000 ppm the inhibition percentage was not different from the control.

Age of plant before application, its not clear to describe about this factor. Considering for taking 10000 ppm of tested chemicals, the most response age was 0 weeks before application. Considering to the case of 50000 ppm stand for 0 weeks before application also has the most effectively.

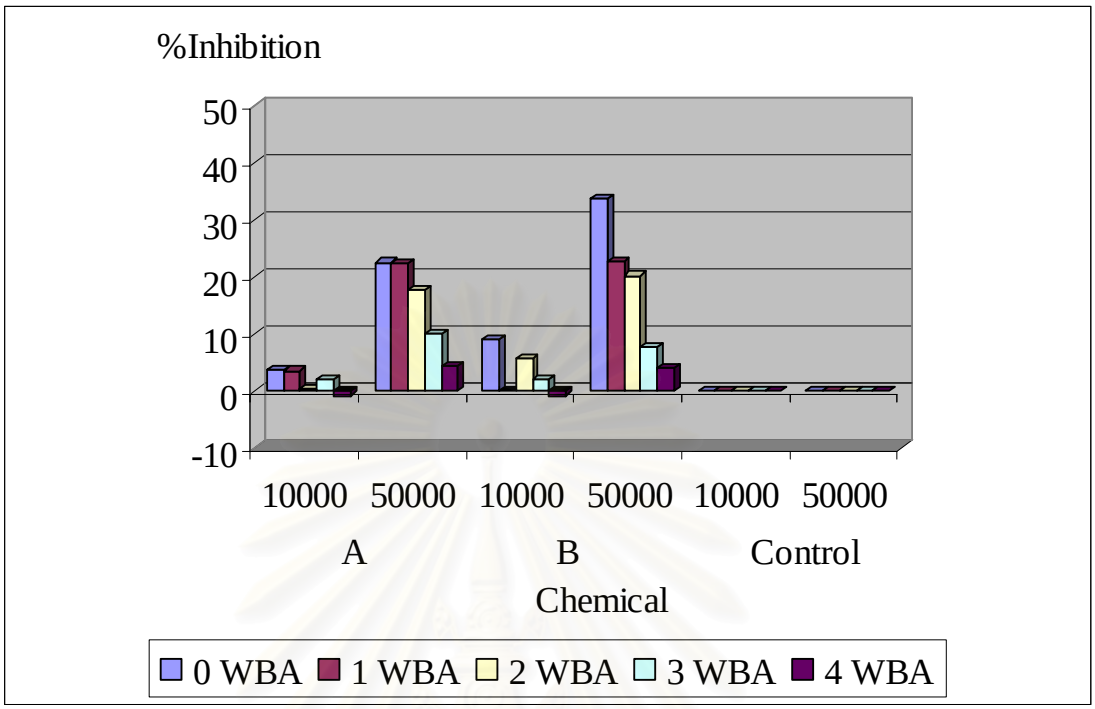


Fig 3.16 Inhibition Percentage of tested chemicals on *A. viridis* L.

Focusing on Fig 3.16, the most effective chemical that show a highest inhibitory effect on tested amaranth was sodium 3,4-(methylenedioxy)cinnamate. The percentage of this chemical was around 33.70 percent applied at 50000 ppm.

Referring to Fig 3.16, both of tested chemicals were set into slightly effect testing with 50000 ppm, considering about 10000 ppm these herbicides exhibited no effect where the inhibition percentage was less than 10 in any case.

3.5.4 Effect of tested chemicals on *M. pigra* L.

In case of *M. pigra* L., these chemicals also show the inhibitory effect where compute as inhibition percentage. Determining about 3 factors, those have done before with other plants. The results indicated as describe below,

Type of chemical, both sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate still show the inhibitory effect on this plants. Determining about effectiveness, the two chemicals were show the inhibition percentage that was different from control set but not different to each other. The most effective chemical was sodium 3-nitrocinnamate.

Concentration usage, in this topic can split in to 3 different groups as 0, 10000 and 50000 ppm, which any groups are different from the others. The concentration level that can effect to this plant most was 50000 ppm.

Age of plant before application, Considering for taking 10000 ppm of tested chemicals, the most response age was 1 weeks before application. Considering to the case of 50000 ppm stand for 0 weeks before application also has the most effectively.

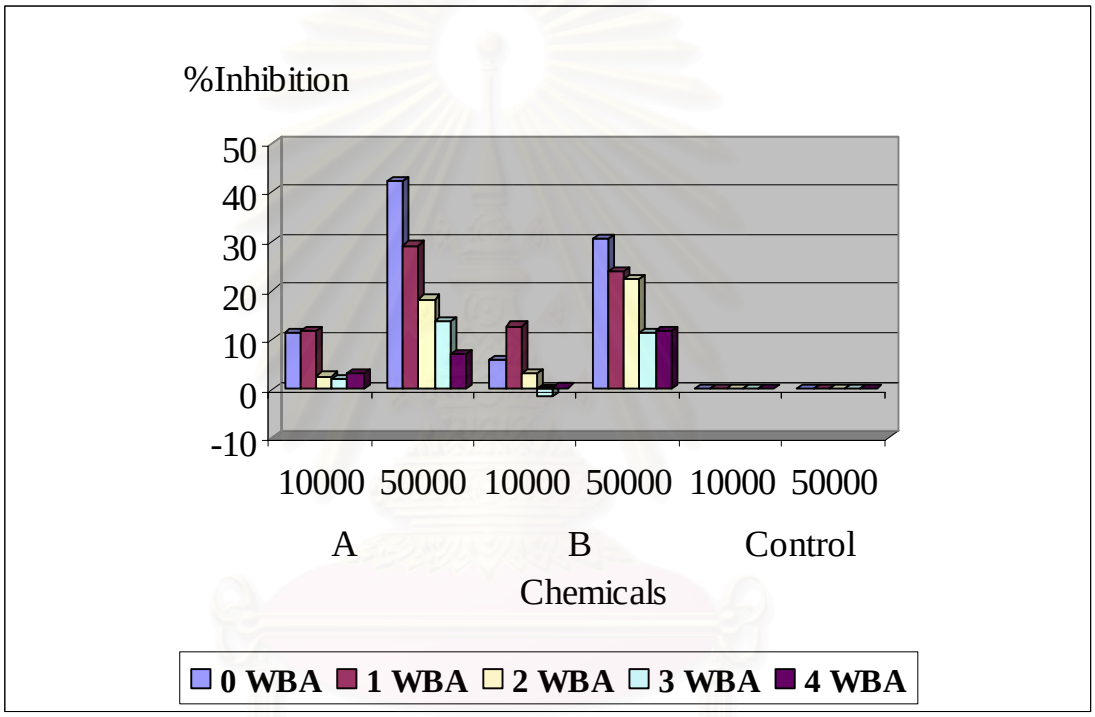


Fig 3.17 Inhibition Percentage of tested chemicals on *M. pigra* L.

Achieving the data from Fig 3.17, the inhibitory effect of tested chemicals was definitely depended on their concentration. Considering for other factor, it was also cause effectiveness, too.

Referring to Fig 3.17, sodium 3-nitrocinnamate was set as moderate effect, applied at 50000 ppm on 0 weeks after application. Exempt for sodium 3,4-(methylenedioxy)cinnamate, its still set as slightly effect.

3.5.5 Effect of tested chemicals on *R. tuberosa* L.

According to this experimental, *R. tuberosa* L. was transplanting for testing about inhibitory effect of tested chemicals. Focusing on type of chemical, effective concentration and suitable age to application. The results were displayed in Fig 3.18, and indicated as follow:

Type of chemical, both sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate still show the inhibitory effect on this plants. Determining about effectiveness, the two chemicals were showing the inhibition percentage that was different from control set but not different to each other.

Concentration usage, in this topic can split in to 3 different groups as 0, 10000 and 50000 ppm, which any groups are different from the other. The concentration level that can effect to this plant most was 50000 ppm.

Age of plant before application, Considering for taking 10000 ppm of tested chemicals, the most response age was 1 weeks before application. Considering to the case of 50000 ppm stands for 1 week before application too and also has the most effectively.

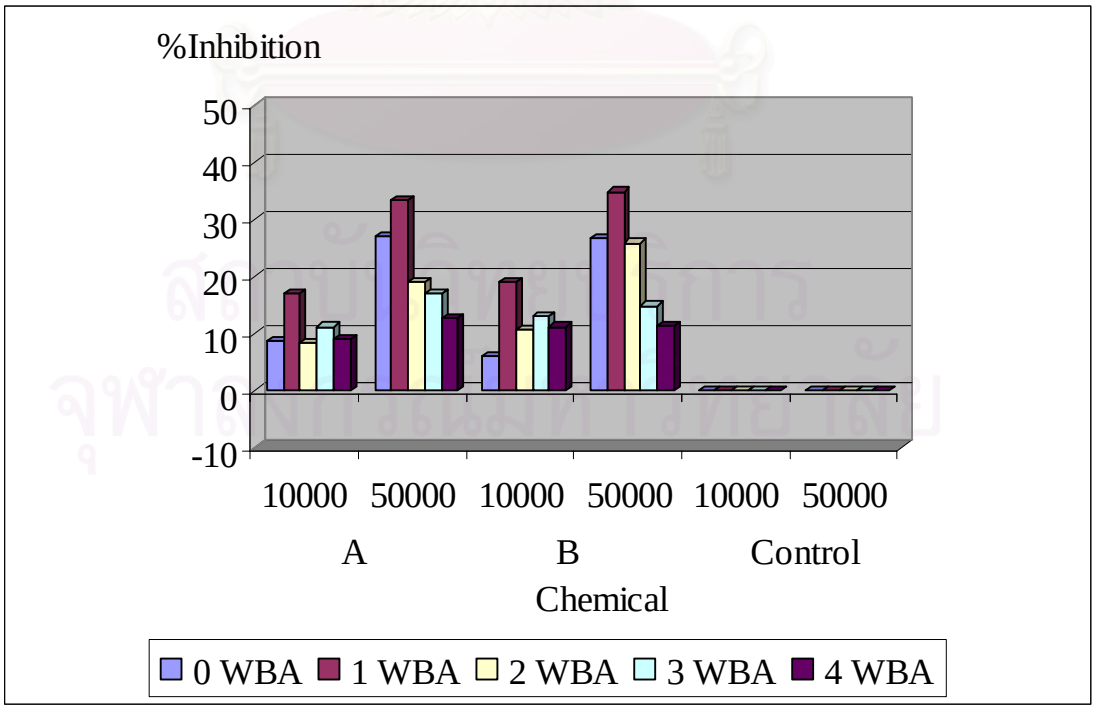


Fig 3.18 Inhibition Percentage of tested chemicals on *R. tuberosa* L.

Determining from Fig 3.18, the results could be conclude that both of tested chemicals have an inhibitory effect on popping pod (*R. tuberosa* L.). To comparing the results above indicated that both sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate has nearby each other.

Referring to Fig 3.18, both sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate was set as slightly effect, applied at 50000 ppm on 1 week after application.

3.5.6 Effect of tested chemicals on *C. viscosa* L.

Quoted on *C. viscosa* L., this plant also a weed that commonly found in any area and wide spread through out Thailand. This plant was transplanting to determined the inhibitory effect of tested chemicals. The result was show in Fig 3.19 and informed as follow:

Type of chemical, both sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate still show the inhibitory effect on this plants. Determining about effectiveness, the two chemicals were showing the inhibition percentage that was different from control set but not different to each other.

Concentration usage, in this topic can split in to 3 different groups as 0, 10000 and 50000 ppm, which any groups are different from the others. The concentration level that can effect to this plant most was 50000 ppm.

Age of plant before application, Considering for taking 10000 ppm of tested chemicals, the most response age was 1 weeks before application. Considering to the case of 50000 ppm stands for 0 weeks before application too and also has the most effectively.

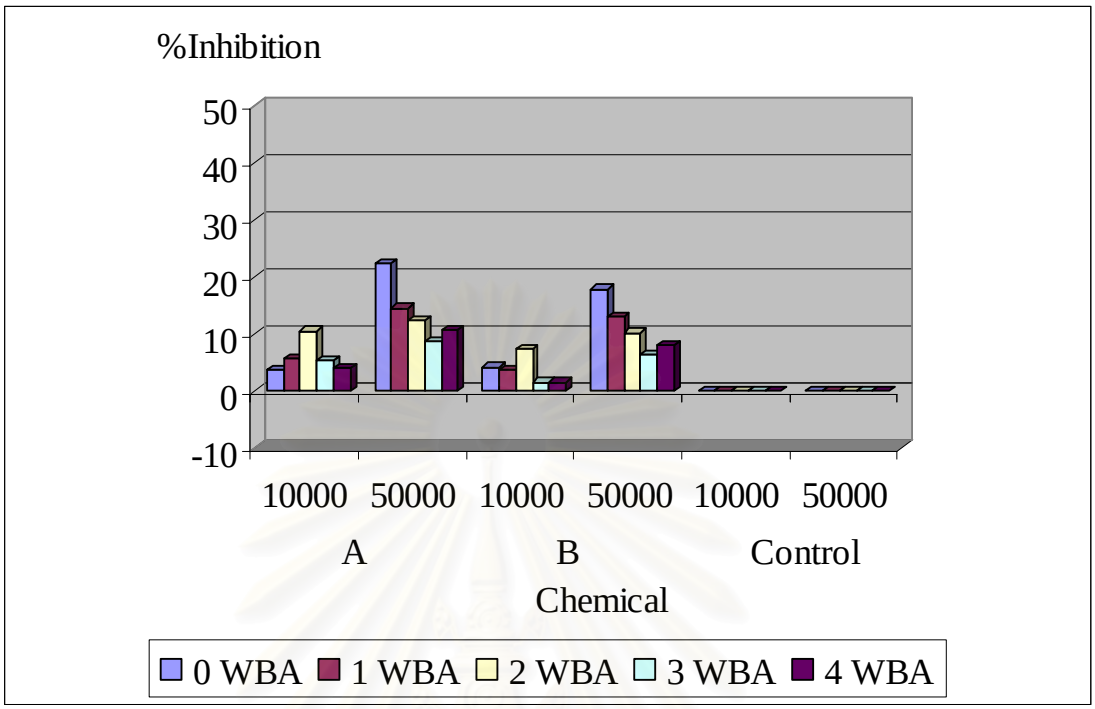


Fig 3.19 Inhibition Percentage of tested chemicals on *C. viscosa* L.

Referring to Fig 3.19, both sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate was set as slightly effect, applied at 50000 ppm on 0 weeks after application.

3.5.7 Effect of tested chemicals on *I. aquatica* Forsk.

Focus on *I. aquatica* Forsk., the plant growth inhibitory effect of tested chemicals were exhibited as Fig 3.20. Three factors were test for their effectiveness on the growth of *A. viridis* L., and described as below;

Type of chemical, both sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate still show the inhibitory effect on this plants. Determining about effectiveness, the two chemicals were show the inhibition percentage that was different from control set but not different from the other. The most effective chemical was sodium 3,4-(methylenedioxy)cinnamate.

Concentration usage, in this topic can split in to 3 different groups as 0, 10000 and 50000 ppm which any groups are different from the others. The concentration

level that can effect to this plant most was 50000 ppm. Considering to the case of 10000 ppm the inhibition percentage was not different from the control.

Age of plant before application, its not clear to describe about this factor. Considering for taking 10000 ppm of tested chemicals, the most response age was 2 weeks before application. Considering to the case of 50000 ppm stand for 0 weeks before application also has the most effectively.

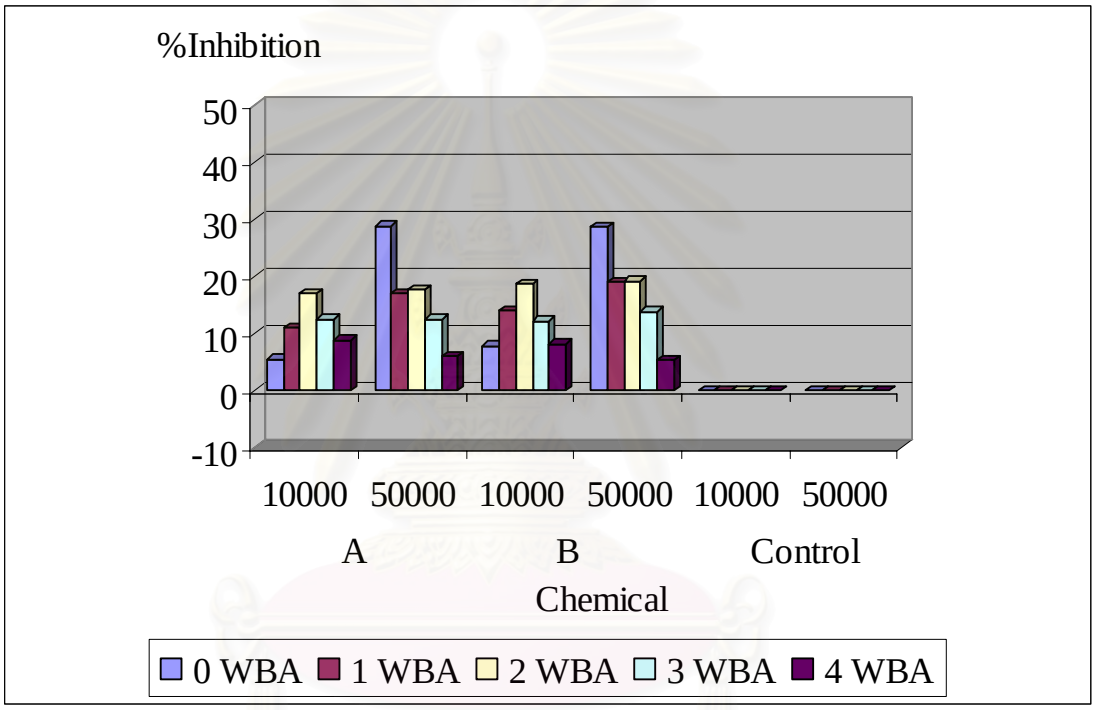


Fig 3.20 Inhibition Percentage of tested chemicals on *I. aquatica* Forsk.

Achieving the data from Fig 3.20, the inhibitory effect of tested chemicals was definitely depended on their concentration. Considering for other factor, it was also cause effectiveness, too.

Quoted on Fig 3.20, both sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate was set as slightly effect, applied at 50000 ppm on 0 weeks after application.

3.5.8 Effect of tested chemicals on *D. aegyptium* Willd.

In case of *D. aegyptium* Willd., these chemicals also show the inhibitory effect where compute as inhibition percentage. Determining about 3 factors, those have done before with other plants. The results indicated as describe below,

Type of chemical, both sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate still show the inhibitory effect on this plants. Determining about effectiveness, the two chemicals were showing the inhibition percentage that was different from control set but not different to each other. The most effective chemical was sodium 3-nitrocinnamate.

Concentration usage, in this topic can split in to 3 different groups as 0, 10000 and 50000 ppm, which any groups are different from the others. The concentration level that can effect to this plant most was 50000 ppm.

Age of plant before application, Considering for taking 10000 ppm of tested chemicals, the most response age was 0 weeks before application. Considering to the case of 50000 ppm stand for 0 weeks before application also has the most effectively.

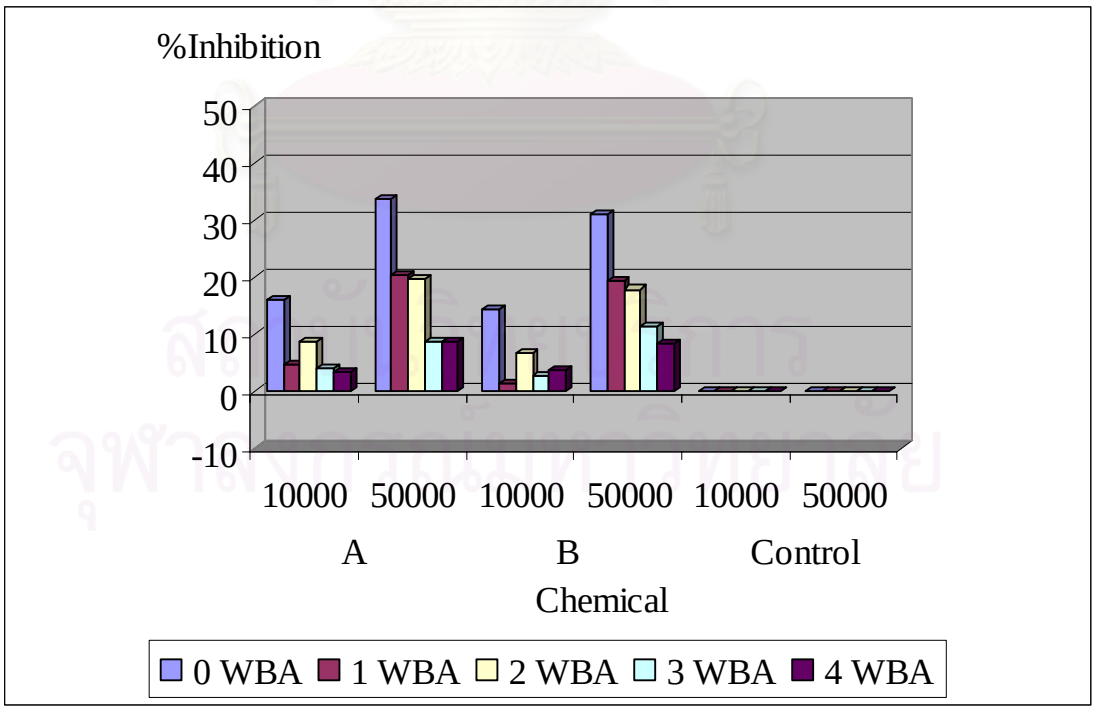


Fig 3.21 Inhibition Percentage of tested chemicals on *D. aegyptium* Willd.

Referring to Fig 3.21, both sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate was set as slightly effect, applied at 50000 ppm on 0 weeks after application.

3.5.9 Effect of tested chemicals on *V. radiata* L.

Focus on *V. radiata* L., the plant growth inhibitory effect of tested chemicals were exhibited as Fig 3.22. 3 factors were test for their effectiveness on the growth of *A. viridis* L., and described as below;

Type of chemical, both sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate still show the inhibitory effect on this plants. Determining about effectiveness, the two chemicals were show the inhibition percentage that was different from control set but not different from the other. The most effective chemical was sodium 3nitrocinnamate

Concentration usage, in this topic can split in to 2 different groups as 0-10000 and 50000 ppm which any groups are different from the others. The concentration level that can effect to this plant most was 50000 ppm. Considering to the case of 10000 ppm the inhibition percentage was not different from the control.

Age of plant before application, its not clear to describe about this factor. Considering for taking 10000 ppm of tested chemicals, the most response age was 0 weeks before application. Considering to the case of 50000 ppm stand for 0 weeks before application also has the most effectively.

According to Fig 3.22, these chemicals were very effective on the growth of this crop. The plant inhibition concentration when treat at 50000 ppm of sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate were around 5 to 42 percent. Age of plant that cans response to the chemical most is 0 weeks before application. The inhibition percentage was about 42% and 28%, respectively.

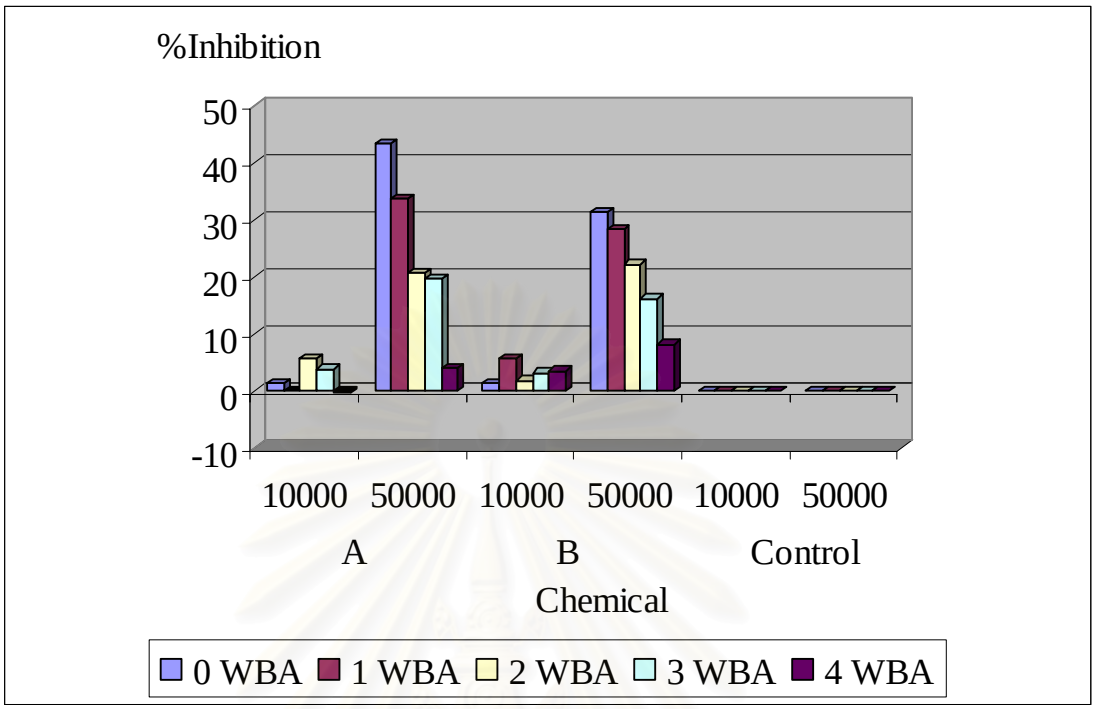


Fig 3.22 Inhibition Percentage of tested chemicals on *V. radiata* L.

3.5.10 Effect of tested chemicals on *O. sativa* L.

According to this experimental, *O. sativa* L. was transplanting for testing about inhibitory effect of tested chemicals. Focusing on type of chemical, effective concentration and suitable age to application. The results were displayed in Fig 3.23, and indicated as follow:

Type of chemical, both sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate still show the inhibitory effect on this plants. Determining about effectiveness, the two chemicals were showing the inhibition percentage that was different from control set but not different to each other.

Concentration usage, in this topic can split in to 3 different groups as 0, 10000 and 50000 ppm, which any groups are different from the other. The concentration level that can effect to this plant most was 50000 ppm.

Age of plant before application, Considering for taking 10000 ppm of tested chemicals, the most response age was 1 weeks before application. Considering to the case of 50000 ppm stands for 0 weeks before application too and also has the most effectively.

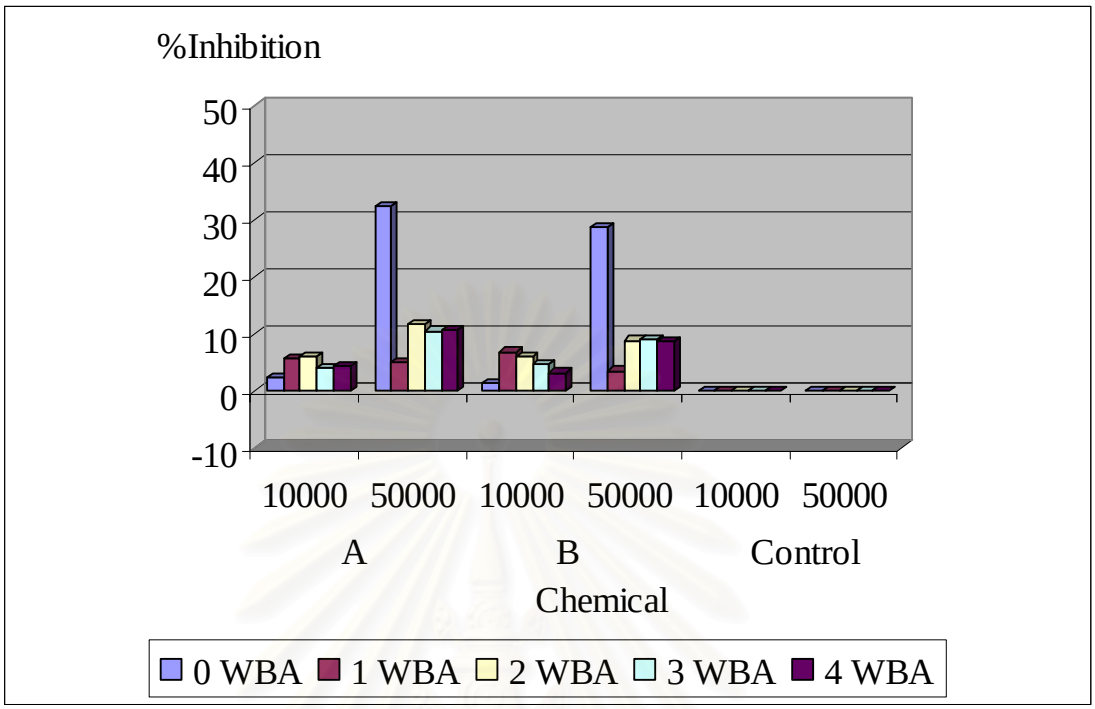


Fig 3.23 Inhibition Percentage of tested chemicals on *O. sativa* L.

Referring to Fig 3.23, both sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate was set as slightly effect, applied at 50000 ppm on 0 weeks after application.

3.5.11 Effect of tested chemicals on *E. crus-galli* (L.) P. Beauv.

According to the tested with *E. crus-galli* (L.) P. Beauv., was transplanting for testing about inhibitory effect of tested chemicals. Focusing on type of chemical, effective concentration and suitable age to application. The results were displayed in Fig 3.24, and indicated as follow:

Type of chemical, both sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate still show the inhibitory effect on this plants. Determining about effectiveness, the two chemicals were showing the inhibition percentage that was different from control set but not different to each other.

Concentration usage, in this topic can split in to 3 different groups as 0, 10000 and 50000 ppm, which any groups are different from the other. The concentration level that can effect to this plant most was 50000 ppm.

Age of plant before application, Considering for taking 10000 ppm of tested chemicals, the most response age was 1 weeks before application. Considering to the case of 50000 ppm stands for 0 weeks before application too and also has the most effectively.

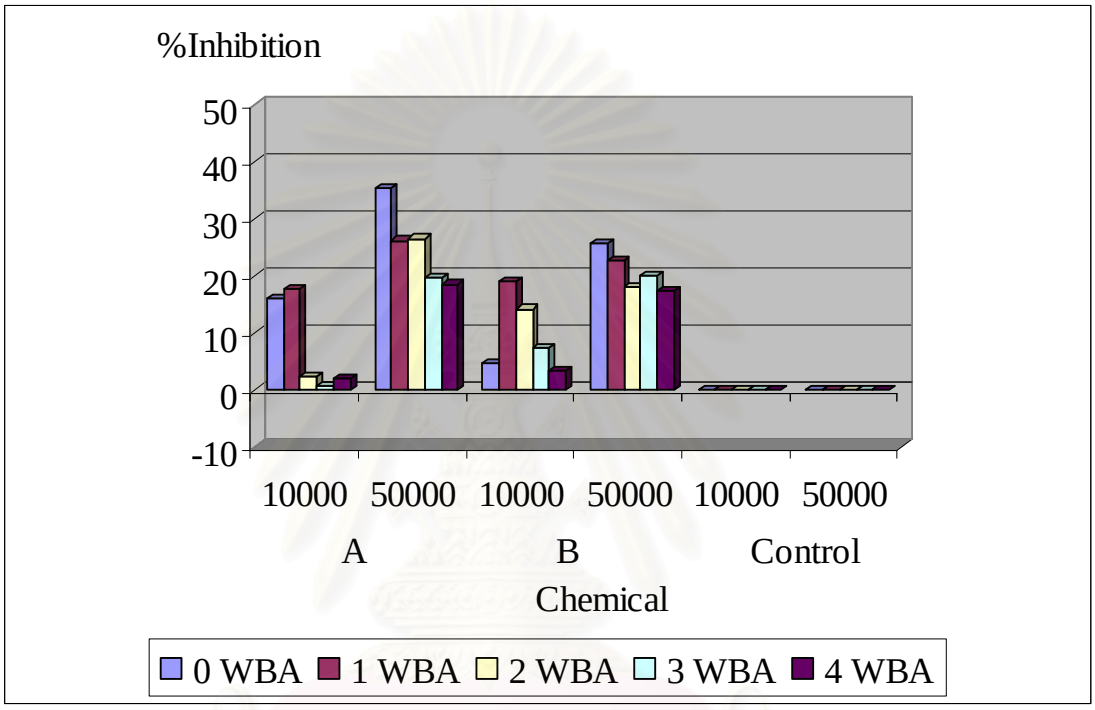


Fig 3.24 Inhibition Percentage of tested chemicals on *E. crus-galli* (L.) P. Beauv.

Referring to Fig 3.24, both sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate was set as slightly effect, applied at 50000 ppm on 0 weeks after application.

3.5.12 Effect of tested chemicals on *C. barbata* Sw.

According to tested plant, *C. barbata* Sw. was transplanting for testing about inhibitory effect of tested chemicals. Focusing on type of chemical, effective concentration and suitable age to application. The results were displayed in Fig 3.25, and indicated as follow:

Type of chemical, both sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate still show the inhibitory effect on this plants. Determining about

effectiveness, the two chemicals were showing the inhibition percentage that was different from control set but not different to each other.

Concentration usage, in this topic can split in to 3 different groups as 0, 10000 and 50000 ppm, which any groups are different from the others. The concentration level that can effect to this plant most was 50000 ppm.

Age of plant before application, Considering for taking 10000 ppm of tested chemicals, the most response age was 1 weeks before application. Considering to the case of 50000 ppm stands for 0 weeks before application too and also has the most effectively.

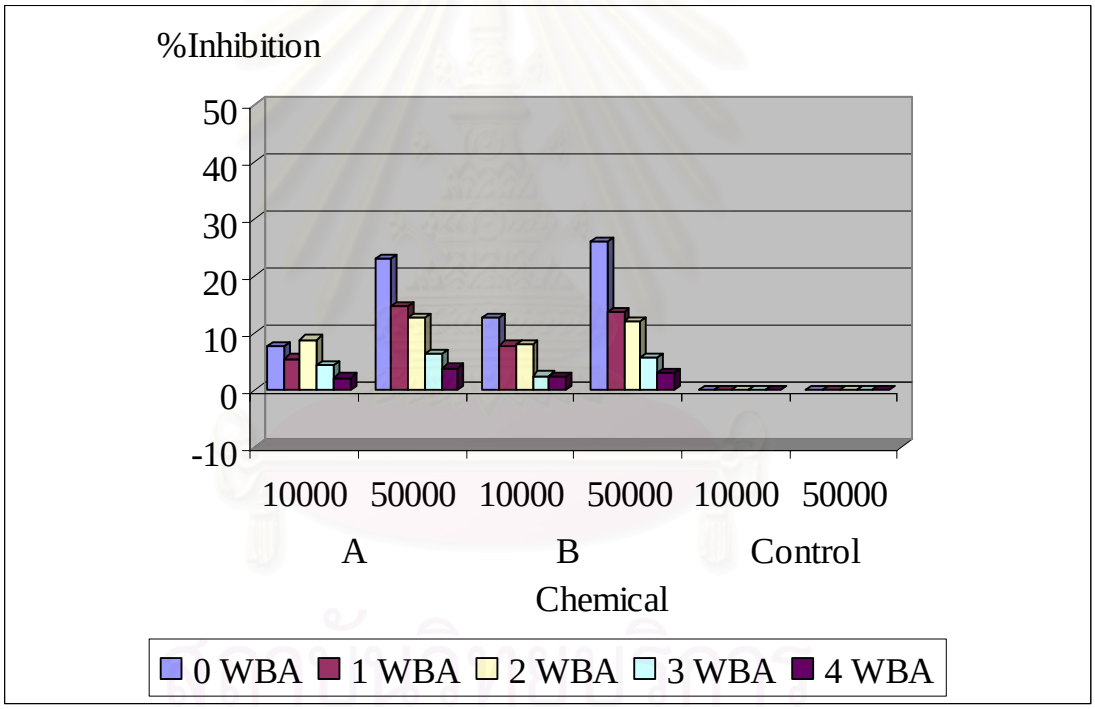


Fig 3.25 Inhibition Percentage of tested chemicals on *C. barbata* Sw.

Referring to Fig 3.25, both sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate was set as slightly effect, applied at 50000 ppm on 0 weeks after application.

According to this experiment, all of tested plant species were response to tested chemicals only a little although used in high concentration, 50000 ppm. The

abnormally symptom that commonly found on tested plant species were leaves burnt, curly leaves and a little dwarf.

To describe for the reason why tested chemicals has no effect on any plants may be below:

1. The concentration level may be less until it can cause no effect
2. All plants are resistant to this chemical
3. Because this experimental are done in natural condition
   3.1 The chemicals may be lost with pouring water
   3.2 The chemicals may be degrade by light intensity
   3.3 The chemicals may be degrade by soil microorganism
4. Some part of plant can be eliminate the chemical

3.6 Effect of tested chemicals on golden apple snail

To study for toxic level of tested chemicals, 3,4-(methylenedioxy)cinnamic acid, 3-nitrocinnamic acid, sodium 3,4-(methylenedioxy)cinnamate and sodium 3-nitrocinnamate. Golden apple snail was choosing as target. The results were exhibited in Table 3.9:

Table 3.9 Mortality of *P. canaliculata* at 72 and 96 hours

Substance	**% mortality of snail at (ppm)**							
	72 hours				**96 hours**			
	1000	**100**	**10**	**1**	**1000**	**100**	**10**	**1**
3-nittrocinnamic acid	6.67	0	0	0	13.33	6.67	0	0
3,4-(methylenedioxy)cinnamic acid	6.67	0	0	0	13.33	0	0	0
Sod. 3-nitrocinnamate	6.67	0	0	0	13.33	6.67	0	0
Sod. 3,4-(methylenedioxy)cinnamate	6.67	0	0	0	13.33	0	0	0
Control	0				0			

The toxicity of tested chemicals was evaluated against golden apple snail at 72 hours. The results of percent mortality of 3-nitrocinnamic acid, at concentration of 1000 ppm, 100 ppm, 10 ppm and 1 ppm were 6.67%, 0%, 0% and 0%, respectively. On the other hand, 3,4-(methylenedioxy)cinnamic acid displayed as the same results.

It expressed 6.67%, 0%, 0% and 0% mortality at concentration of 1000, 100 and 10 ppm and 1 ppm, respectively.

According to the results at 96 hours, the results of mortality percentage of 3-nitrocinnamic acid at concentration of 1000 ppm, 100 ppm, 10 ppm and 1 ppm were 13.33%, 6.67%, 0% and 0%, respectively. Focus on 3,4-(methylenedioxy)cinnamic acid, this chemical also show very low toxically level. It expressed 13.33% 0%, 0% and 0% mortality at concentration of 1000 ppm, 100 ppm, 10 ppm and 1 ppm, respectively.

Throughout these results, both 3-ntrocinnamic acid and 3,4-(mrthylenedioxy)cinnamic acid has a very low toxicity. It expressed with low percentage to control *P. canaliculata* Lamarck., indicated that it has low molluscicidal activity. So these chemicals cannot use for molluscicide.

CHAPTER IV
CONCLUSION

From this experiment indicated that tested chemicals, 3-nitrocnnamic acid, sodium 3-nitrocinnamate, 3,4-(methylenedioxy)cinnamic acid and sodium 3,4-(methtylenedioxy)cinnamate shown their highly inhibitory effect both, growth inhibition and germination inhibition. At higher concentration (100 ppm, 1000 ppm) most of plant die or could not germinate. To confirmation about these results pot test was set up. After prepared the materials all plants were transplanting and treated with tested chemicals at 1000, 5000, 10000 and 30000 ppm but the results were opposites when compared with laboratory scale.

Firstly, about laboratory scale, at low level concentration (1 ppm and 10 ppm) these chemicals still have some effect on tested plant. Most of plants were inhibit with herbicidal effect from the chemicals but some plants were grown rapidly that call promoter effect.

About 3-nitrocinnamic acid, the herbicidal activity shows highly effective at 100 ppm. The growth of many plants was inhibited. The results were also show in Table 3.3. The sensitive plants were *S. aculeatissimum* Jasq. > *M. pigra* L. > *V. radiata* L. > *M. lathyroides* (L.) Urb. > *C. melo* Linn., respectively. At 1000 ppm, the tested plants were inhibited most of plants die or could not germinated.

For 3,4-(methylenedioxy)cinnamic acid, the plant growth inhibitory effect was also highly, too. At 100 ppm show high effective on tested plants. The results were show in Table 3.4. The most sensitive plants were *S. aculeatissimum* Jasq. > *V. radiata* L. > *M. lathyroides* (L.) Urb. > *M. pigra* L. > *C. melo* Linn., respectively. At 1000 ppm, the tested plants were inhibited most of plants die or could not germinated.

In case of sodium 3-nitrocinnamate, this chemical still shows highly inhibitory effect on tested plant although some parts of this chemical were changes. The effective of this chemical was as same as 3-nitrocinnamic acid. At 100 ppm the growth rate of many plants were prohibited. The results were show in Table 3.5. The most sensitive plants

were *S. aculeatissimum* Jasq. > *O. americanum* Linn. ≅ *R. tuberosa* L. > *V. radiata* L. > *O. sativa* L. ≅ *B. chinensis* L. var. *chinensis*, respectively.

Referring to sodium 3,4-(methylenedioxy)cinnamate, This chemical also show highly effective to inhibited plant growth. In case of 100 ppm show that was highly effective against all tested plant. The results were show in Table 3.6. The most sensitive plant species were *V. radiata* L. > *S. aculeatissimum* Jasq. > *O. sativa* L. > *I. aquatica* Forsk. > *R. tuberosa* L., respectively.

In case of *C. frutescens* Linn., *C. sativum* Linn., *D. aegyptium* Willd., *C. viscosa* L. and *C. argentia* L., these plants also show highly growth inhibition percentage when treat with tested chemicals but these plant species also had very low germination percentage indicated that the results of these plants could not be trusted.

Second, the next step is to find out the effective of tested chemicals when applied in pot test. *C. barbata* Sw. and *M. lathyroides* (L.) Urb. were choose as indicator because of their highly germination percentage. Tested plants were transplanted in each pot. Then applied tested chemicals 3 weeks after transplanted at the different concentration, 1000, 5000, 10000 and 30000 ppm respectively. At low level concentration (1000 - 5000 ppm) the chemicals has no effect on any plants. In case of 10000 and 30000 ppm tested plants show a little abnormal status as leaves burn, curly leaves or plant leaves was smaller than normal and some of plants were died 15 days after application. The herbicidal effect started for 7 days after application and indicated that all of tested chemical has slightly effect when applied in the pot. To concluded the effect of each chemical and compared their effectiveness on tested plants. Sodium salt was the formulation that suitable to apply because this form can easily be dissolved in water and there is no different when compared the results with acid form.

Third, pot scale planting to gained the results of the effective of tested chemicals. Sodium salt, sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate were choose to tested for herbicidal activity. 20 plants were choosing as described in chapter I. The object of this experiment was to find out about the effective of tested chemicals on

difference age of plants. In this experiment after planting for 4 weeks (the ages of plants was 0, 1, 2, 3 and 4 weeks respectively). The results were collected 15 days after planting and show that these chemicals have a little bit slightly effect on plant growth. That was mean these chemical nearly has no effect, a little symptom, leaves burnt, curly leaves and little dwarf although in this experiment choose 50000 ppm tested chemicals. To describe about the reason why tested chemicals has no effect on any plants may be below:

1. The concentration level may be less until it can cause no effect
2. All plants are resistant to this chemical
3. Because this experimental are done in natural condition
   3.1 The chemicals may be lost with pouring water
   3.2 The chemicals may be degrade by light intensity
   3.3 The chemicals may be degrade by soil microorganism
4. Some part of plant can be eliminate the chemical

Forth, effect of tested chemicals on tested animal was determined by choosing golden apple snail. The results were indicated that all of tested chemicals were not harmful aspect or safety to use. When collect the results at 72 hours, all tested chemicals were very safety that has the same value of $LD_{50}(72)$ equal as 1354.43. Even test for 96 hours the results still in the same way, 3-nitrocinnamic acid and sodium 3-nitrocinnamate has the same value as 1648.49. For 3,4-(methylenedioxy)cinnamic acid and sodium 3,4-(methylenedioxy)cinnamate has the same value as 1194.82, respectively.

Proposal for the Future Work

From this study, the results of plant growth inhibition of four effective chemicals, 3-nitrocinnamic acid, 3,4-(methylenedioxy)cinnamic acid, sodium 3-nitrocinnamate and sodium 3,4-(methylenedioxy)cinnamate was evaluated that these chemicals has slightly effect when applied in large scale. To describe the reason, physical qualification of these chemicals could be study. For example, leaching, degradation includes light intensity, heat and microorganism. In addition, these chemicals can be show a highly effective in laboratory scale so it is possible to prepare in to other form effective than sodium salt form.

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APPENDIX A

Appendix A

Table A.1 Germination percentage of tested plant, treated with 3-nitrocinnamic acid

Plants	Concentration (ppm)				
	Control	**1**	**10**	**100**	**1000**
O. sativa L.	97.78	86.67	66.67	20.00	15.56
Z. mays L.	84.44	70.00	57.78	26.67	23.33
V. radiata L.	92.22	85.56	64.44	20.00	8.89
S. aculeatissimum Jasq.	64.44	52.22	25.56	10.00	5.56
B. chinensis L. var. *chinensis*	92.50	80.00	66.67	29.17	13.33
O. americanum Linn.	84.67	76.67	64.00	12.00	7.33
A. graveolens L.	79.33	73.33	60.00	10.67	8.67
C. melo Linn.	78.89	73.33	50.00	25.56	14.44
C. frutescens Linn. var. *frutescens*	27.78	17.78	17.78	15.56	10.00
C. sativum Linn.	27.78	23.33	16.67	13.33	8.89
D. aegyptium Willd.	8.00	5.33	6.67	6.00	2.67
M. lathyroides (L.) Urb.	50.67	47.33	34.67	19.33	12.67
A. viridis L.	72.00	42.67	36.00	28.00	22.00
M. pigra L.	96.67	78.89	62.22	24.44	20.00
R. tuberosa L.	90.00	85.83	70.83	14.17	10.00
C. viscosa L.	11.33	11.33	10.67	10.00	6.00
I. aquatica Forsk.	85.00	76.67	51.67	12.50	7.50
C. argentia L.	8.67	2.67	3.33	3.33	2.00

Table A.2 Germination percentage of tested plant, treated with 3,4-(methylenedioxy) cinnamic acid

Plants	Concentration (ppm)				
	Control	**1**	**10**	**100**	**1000**
O. sativa L.	97.78	87.78	66.67	23.33	14.44
Z. mays L.	84.44	74.44	62.22	28.89	27.78
V. radiata L.	92.22	90.00	70.00	23.33	16.67
S. aculeatissimum Jasq.	64.44	55.56	26.67	12.22	2.22
B. chinensis L. var. *chinensis*	92.50	88.33	70.83	37.50	18.33
O. americanum Linn.	84.67	76.67	69.33	15.33	7.33
A. graveolens L.	79.33	76.67	65.33	14.67	9.33
C. melo Linn.	78.89	72.22	52.22	31.11	14.44
C. frutescens Linn. var. *frutescens*	27.78	22.22	20.00	20.00	11.11
C. sativum Linn.	27.78	25.56	16.67	15.56	10.00
D. aegyptium Willd.	8.00	4.67	6.67	8.00	4.00
M. lathyroides (L.) Urb.	50.67	48.00	34.00	21.33	12.67
A. viridis L.	72.00	42.00	38.67	26.67	22.00
M. pigra L.	96.67	88.89	72.22	25.56	24.44
R. tuberosa L.	90.00	85.83	67.50	16.67	10.83
C. viscosa L.	11.33	8.00	13.33	7.33	4.67
I. aquatica Forsk.	85.00	78.33	59.17	14.17	10.00
C. argentia L.	8.67	10.00	6.00	5.33	4.67

Table A.3 Germination percentage of tested plant, treated with sodium 3-nitrocinnamate

Plants	Concentration (ppm)				
	Control	**1**	**10**	**100**	**1000**
O. sativa L.	97.78	91.11	67.78	22.22	15.56
Z. mays L.	84.44	75.56	58.89	36.67	22.22
V. radiata L.	92.22	84.44	65.56	25.56	14.44
S. aculeatissimum Jasq.	64.44	53.33	21.11	8.89	3.33
B. chinensis L. var. *chinensis*	92.50	84.17	66.67	30.00	15.00
O. americanum Linn.	84.67	76.00	67.33	15.33	8.00
A. graveolens L.	79.33	74.67	57.33	17.33	8.67
C. melo Linn.	78.89	76.67	54.44	34.44	13.33
C. frutescens Linn. var. *frutescens*	27.78	28.89	20.00	13.33	7.78
C. sativum Linn.	27.78	22.22	17.78	13.33	7.78
D. aegyptium Willd.	8.00	6.67	5.33	4.67	3.33
M. lathyroides (L.) Urb.	50.67	47.33	34.67	23.33	14.00
A. viridis L.	72.00	46.67	35.33	26.67	16.67
M. pigra L.	96.67	80.00	58.89	31.11	21.11
R. tuberosa L.	90.00	85.83	70.83	19.17	12.50
C. viscosa L.	11.33	8.67	7.33	8.00	6.67
I. aquatica Forsk.	85.00	75.83	46.67	18.33	12.50
C. argentia L.	8.67	5.33	4.67	2.67	1.33

Table A.4 Germination percentage of tested plant, treated with sodium 3,4-(methylenedioxy)cinnamate

Plants	Concentration (ppm)				
	Control	**1**	**10**	**100**	**1000**
O. sativa L.	97.78	92.22	71.11	26.67	12.22
Z. mays L.	84.44	81.11	70.00	38.89	23.33
V. radiata L.	92.22	87.78	55.56	26.67	12.22
S. aculeatissimum Jasq.	64.44	54.44	24.44	8.89	4.44
B. chinensis L. var. *chinensis*	92.50	88.33	63.33	30.83	15.00
O. americanum Linn.	84.67	78.67	68.00	16.67	8.67
A. graveolens L.	79.33	80.00	63.33	16.00	9.33
C. melo Linn.	78.89	70.00	51.11	37.78	15.56
C. frutescens Linn. var. *frutescens*	27.78	26.67	17.78	18.89	5.56
C. sativum Linn.	27.78	21.11	17.78	14.44	7.78
D. aegyptium Willd.	8.00	7.33	6.67	4.00	3.33
M. lathyroides (L.) Urb.	50.67	46.67	43.33	24.00	14.67
A. viridis L.	72.00	48.00	38.67	22.67	12.67
M. pigra L.	96.67	86.67	61.11	34.44	24.44
R. tuberosa L.	90.00	83.33	71.67	20.83	11.67
C. viscosa L.	11.33	13.33	12.00	6.67	2.67
I. aquatica Forsk.	85.00	80.83	60.83	27.50	12.50
C. argentia L.	8.67	7.33	4.67	2.67	0.67

Table A.5 Plant germination inhibition percentage of 3-nitrocinnamic acid

Plants	Concentration (ppm)				
	Control	**1**	**10**	**100**	**1000**
O. sativa L.	0.00	11.36	31.82	79.55	84.09
Z. mays L.	0.00	17.11	31.58	68.42	72.37
V. radiata L.	0.00	7.23	30.12	78.31	90.36
S. aculeatissimum Jasq.	0.00	18.97	60.34	84.48	91.38
B. chinensis L. var. *chinensis*	0.00	13.51	27.93	68.47	85.59
O. americanum Linn.	0.00	9.45	24.41	85.83	91.34
A. graveolens L.	0.00	7.56	24.37	86.55	89.08
C. melo Linn.	0.00	7.04	36.62	67.61	81.69
C. frutescens Linn. var. *frutescens*	0.00	36.00	36.00	44.00	64.00
C. sativum Linn.	0.00	16.00	40.00	52.00	68.00
D. aegyptium Willd.	0.00	33.33	16.67	25.00	66.67
M. lathyroides (L.) Urb.	0.00	6.58	31.58	61.84	75.00
A. viridis L.	0.00	40.74	50.00	61.11	69.44
M. pigra L.	0.00	18.39	35.63	74.71	79.31
R. tuberosa L.	0.00	4.63	21.30	84.26	88.89
C. viscosa L.	0.00	0.00	5.88	11.76	47.06
I. aquatica Forsk.	0.00	9.80	39.22	85.29	91.18
C. argentia L.	0.00	69.23	61.54	61.54	76.92

Table A.6 Plant germination inhibition percentage of 3,4-(methylenedioxy)cinnamic acid

Plants	Concentration (ppm)				
	Control	**1**	**10**	**100**	**1000**
O. sativa L.	0.00	10.23	31.82	76.14	85.23
Z. mays L.	0.00	11.84	26.32	65.79	67.11
V. radiata L.	0.00	2.41	24.10	74.70	81.93
S. aculeatissimum Jasq.	0.00	13.79	58.62	81.03	96.55
B. chinensis L. var. *chinensis*	0.00	4.50	23.42	59.46	80.18
O. americanum Linn.	0.00	9.45	18.11	81.89	91.34
A. graveolens L.	0.00	3.36	17.65	81.51	88.24
C. melo Linn.	0.00	8.45	33.80	60.56	81.69
C. frutescens Linn. var. *frutescens*	0.00	20.00	28.00	28.00	60.00
C. sativum Linn.	0.00	8.00	40.00	44.00	64.00
D. aegyptium Willd.	0.00	41.67	16.67	0.00	50.00
M. lathyroides (L.) Urb.	0.00	5.26	32.89	57.89	73.68
A. viridis L.	0.00	41.67	46.30	62.96	75.00
M. pigra L.	0.00	8.05	25.29	73.56	74.71
R. tuberosa L.	0.00	4.63	25.00	81.48	87.96
C. viscosa L.	0.00	29.41	-17.65	35.29	58.82
I. aquatica Forsk.	0.00	7.84	30.39	83.33	88.24
C. argentia L.	0.00	-15.38	30.77	38.46	46.15

Table A.7 Plant germination inhibition percentage of sodium 3-nitrocinnamate

Plants	Concentration (ppm)				
	Control	**1**	**10**	**100**	**1000**
O. sativa L.	0.00	6.82	30.68	77.27	84.09
Z. mays L.	0.00	10.53	30.26	56.58	73.68
V. radiata L.	0.00	8.43	28.92	72.29	84.34
S. aculeatissimum Jasq.	0.00	17.24	67.24	86.21	94.83
B. chinensis L. var. *chinensis*	0.00	9.01	27.93	67.57	83.78
O. americanum Linn.	0.00	10.24	20.47	81.89	90.55
A. graveolens L.	0.00	5.88	27.73	78.15	89.08
C. melo Linn.	0.00	2.82	30.99	56.34	83.10
C. frutescens Linn. var. *frutescens*	0.00	-4.00	28.00	52.00	72.00
C. sativum Linn.	0.00	20.00	36.00	52.00	72.00
D. aegyptium Willd.	0.00	16.67	33.33	41.67	58.33
M. lathyroides (L.) Urb.	0.00	6.58	31.58	53.95	72.37
A. viridis L.	0.00	35.19	50.93	62.96	76.85
M. pigra L.	0.00	17.24	39.08	67.82	78.16
R. tuberosa L.	0.00	4.63	21.30	78.70	86.11
C. viscosa L.	0.00	87.86	89.81	88.89	90.74
I. aquatica Forsk.	0.00	10.78	45.10	78.43	85.29
C. argentia L.	0.00	38.46	46.15	69.23	84.62

Table A.8 Plant germination inhibition percentage of sodium 3,4-(methylenedioxy) cinnamate

Plants	Concentration (ppm)				
	Control	**1**	**10**	**100**	**1000**
O. sativa L.	0.00	5.68	27.27	72.73	87.50
Z. mays L.	0.00	3.95	17.11	53.95	72.37
V. radiata L.	0.00	4.82	39.76	71.08	86.75
S. aculeatissimum Jasq.	0.00	15.52	62.07	86.21	93.10
B. chinensis L. var. *chinensis*	0.00	4.50	31.53	66.67	83.78
O. americanum Linn.	0.00	7.09	19.69	80.31	89.76
A. graveolens L.	0.00	-0.84	20.17	79.83	88.24
C. melo Linn.	0.00	11.27	35.21	52.11	80.28
C. frutescens Linn. var. *frutescens*	0.00	4.00	36.00	32.00	80.00
C. sativum Linn.	0.00	24.00	36.00	48.00	72.00
D. aegyptium Willd.	0.00	8.33	16.67	50.00	58.33
M. lathyroides (L.) Urb.	0.00	7.89	14.47	52.63	71.05
A. viridis L.	0.00	33.33	46.30	68.52	82.41
M. pigra L.	0.00	10.34	36.78	64.37	74.71
R. tuberosa L.	0.00	7.41	20.37	76.85	87.04
C. viscosa L.	0.00	81.48	83.33	90.74	96.30
I. aquatica Forsk.	0.00	4.90	28.43	67.65	85.29
C. argentia L.	0.00	15.38	46.15	69.23	92.31

VITA

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