Introduction

In natural plant communities, the negative effects of a plant on its neighbors are frequently observed. The plant may compete for light, water and nutrients in order to survive or dominate for succession. The most common interference among plants is found in agricultural ecosystems, especially the competition between weeds and crops. In some monoculture crops and a variety of forage crops, although the optimum essential resources are available or properly supplied, the reduction of harvestable yields also occur often. The difficulty of replanting fruit crops and the failure of reforestation have long been well-known to farmers, foresters and scientists. These phenomena are considered not solely due to the effects of resource competition. There are numerous evidences which indicate that plants release chemical compounds into its surrounding environment and interfere with the growth and development of other organisms (Rice, 1984). Chemical interference is different from competitive interference in that competition is due mainly to the removal of essential resources by neighboring plants and creates only adverse effects, while chemical interference or allelopathy is induced when plants release some chemicals into the environment and may provide either stimulatory or inhibitory effects (Inderjit and Moral,1997). Allelopathy has been suggested as an important factor in regulating the structure of plant communities in both natural and manipulated ecosystems (Weidenhamer, 1996).

The term "allelopathy" is derived from the Greek words, "allelon" (mutual) + "pathos" (harm) (Willis, 1994). Molisch (1937) coined this term to refer to the biochemical interactions both inhibitory and stimulatory between all types of plants including microorganisms. Rice (1984) deviated the term and defined it as any direct or indirect harmful effect by one plant, including microorganisms, on another plant through the production of chemical compounds that escape into the environment. Now most researchers have followed Molisch's original definition and used the term allelopathy in literature as any direct or indirect, harmful or beneficial effect of a plant, including microbes, on another plant through the release of chemicals that escape into the environment. (Inderjit, 1996b; Willis, 1994). Chemicals that impose allelopathic influences are called allelochemicals (Rice, 1987). The term "allelochemicals" derives from "allelochemics", coined by Whittaker and Feeny (1971) and has been used in literature dealing with interspecific chemical interactions between organisms.

Chemicals with allelopathic potential might be present in all plant tissue, including leaves, stems, roots, rhizomes, flowers, fruits and seeds (Putnam, 1985). Allelochemicals reported from higher plants are mostly secondary metabolites that arise from either the acetate or shikimate pathways, or their chemical skeletons come from a combination of the two origins (Einhellig, 1995b; Kim, 1995). There are a large number of known secondary metabolites which are produced in the metabolic pathways from some biogenic precursors; about 7,000 alkaloids from amino acids, 5,000 terpenoids from mevalonate, 1,000 flavonoids and 500 simple phenylpropanes from cinamic acid and more than 1,350 polyketides and polyacethylenes from acetyl CoA. Several hundred of these compounds are known to be allelochemicals (Einhellig, 1995a; Kim, 1995).

A key concept in allelopathy is that chemicals transfer through the environment from one organism to another (Einhellig, 1995a). Allelochemicals may be released from plant tissue in a variety of ways; including exudation of volatile chemicals from living plant parts, exudation of water-soluble chemicals from below ground parts, leaching of water-soluble substances from above ground parts in response to the action of rain, fog or dew, and the release of phytotoxic chemicals from nonliving plant parts through leaching of chemicals from litter, sloughed root cell or tissue decomposed by microorganisms (Alsaadawi *et al.*, 1990; An *et al.*, 1997; Heisey, 1990; Ismail and Mar, 1993; Kil and Yun, 1992; Li *et al.*, 1992a, 1992b; Lydon *et al.*, 1997; Macias *et al.*, 1993; Martin and Smith, 1994; Sahid and Sugau,1993; Shilling *et al.*, 1992; Vaughn and Boyston, 1997; Yun and Kil, 1992).

There are many factors affecting the production, release and biological activity of plant allelochemicals. Numerous documents have reported that biotic factors such as plant density, growth or age of plant, genetics of donor plant, soil microbial population, pathogen and predators, as well as abiotic factors such as light quality, light intensity, day length, chemicals, mineral deficiency, water stress, temperature stress, pH, soil texture, organic matter and clay content have direct or indirect, positive or negative effects on the productivity, viability and activity of allelochemicals (Alsaadawi *et al*, 1985; Blum, 1998; Chaves *et al.*, 1997; Dalton *et al.*, 1983; Dolling *et al.*, 1994; Einhellig, 1995a; Inderjit, 1996a, 1996b; Inderjit and Dakshini, 1994a, 1994b, 1995a, 1995b, 1996; Jaderund *et al.*, 1996; Kiemnec and Larson, 1991; Kitou and Yoshida, 1993; Mason-Sedun and Jessop, 1988; Penuelas and Llusia, 1997; Rice, 1984; Schmidt, 1988; Tang *et al.*, 1995; Teasdale, 1993; Zhang, 1993).

Allelopathy is a widespread phenomenon. It has been documented in agriculture, grass lands , forestry and fresh water and marine ecosystems (Anaya *et al.*, 1995; Anderson and Cruse, 1995; Bewick *et al.*, 1994; Cheam *et al.*, 1995; Choesin and Boerner, 1991; Chou, 1987, 1995a; Chung and Miller, 1995c; Dietz *et al.*, 1996; Duke and Abbas, 1995; Einhellig, 1996; Eskelsen and Crabtree, 1995; Inderjit and Mallik 1996; Iron and Brunside, 1982: Lisanework and Michelsen, 1993; Mersei and Singh, 1987; Miller, 1996; Nakamura and Nemoto, 1993; Nelson, 1996; Olofsdotter and Navarez, 1995; Przepiorkowski and Gorski, 1994; Rizvi and Rizvi, 1987; Waller *et al.*, 1995; Weston, 1996). Allelopathy plays an important role not only in agriculture and forestry but also on plant succession in natural ecosystems (Menelaou *et al.*, 1993; Putnam, 1985; Putnam and Tang, 1986; Weidenhamer, 1996). Some plants which have allelopathic potential grow in a step of succession but they release allelochemicals which inhibit germination and growth of some other species (Rice, 1984, 1987). Approximately 300 plant species in 164 genera of 64 families, mostly the plants in the family Pinaceae, Ericaceae, and Asteraceae, have been reported to have allelopathic potential (Elakovich and Wooten, 1995, 1996).

Tithonia diversifolia (Hemsl.) A. Gray (Mexican sunflower) is a member of the family Asteraceae. It is a shallow-rooted, broad-leafed perennial plant that grows to a height of 5 m or more and varies from branched at populations lower than 5 plants/m^2 to practically unbranched at populations higher than 30 plants/m^2 in tropical areas (Ayeni *et al.*, 1997a). Leaves are simple, alternate, ovate or ovate oblong with lobes, 10-20 cm wide,15-25 cm long. The flowers are heads, 6-14 cm in diameter; ray flowers sterile, ligules bright-yellow, 3-5 cm long; disc flowers fertile, yellow tubular shape, 0.7-1.0 cm long. Fruits are achenes, flat, black or brown color, 0.5-0.8 cm long (Nanakorn, 1995). The plant propagates primarily by seed and occasionally by branching off the old stem. The native origin of this plant is Mexico and Central America (Schuster *et al.*, 1992; Nanakorn, 1995). It was introduced to many countries in Africa, Asia, North America and Australia for particular purposes (Ayeni *et al.*,1997b; Pereira *et al.*, 1997). Farmers in Sri Lanka and Nigeria grow Mexican sunflower at the beginning of the rainy season and incorporate the plant into soil before planting the crop to serve as green manure (Ayeni *et al.*, 1997a; Harada, 1994). In Thailand, this plant has been grown in the mountains to prevent soil erosion and for its aesthetic value during the blooming season (Fig. 0.1). Because of the beauty of its yellow flowers which bloom around November to December, the area infested by this plant is often recommended as a sightseeing place (Zungsontiporn, 1995). Mexican sunflower accumulates as much as 5 kg of dry matter per plant within a 9 month growing season, which indicates that the plant uses substantial amounts of environmental resources such as light, nutrients and water to support normal growth and development within a short time (Ayeni *et al.*, 1997a). Mexican sunflower usually forms an almost pure stand with few other plant species (Fig. 0.2) (Zungsontiporn and Harada, 1995). This suggests its competitive ability and possible allelopathic activity on the growth of other plants. It has been reported that Mexican sunflower is a dominant weed in arable areas in many countries, including Thailand (Ayeni *et al.*, 1997a; Pereira *et al.*, 1997; Radanachales and Maxwell, 1992).

Mexican sunflower has been reported to contain several compounds of secondary metabolites such as sesquiterpene lactones, tagitinin A, tagitinin B, tagitinin C, tagitinin D, tagitinin E and tagitinin F; flavonoids, hispidulin and artemisinic acid analogue compounds (Baruah *et al.*, 1979; Bordoloi *et al.*, 1996; La Duke. 1982; Chowdhury *et al.*, 1980, 1983; Kuo and Chen, 1998; Pereira *et al.*, 1997). It has been reported that tagitinin A, tagitinin C and hispidulin isolated from this plant by organic solvent extraction exhibited feeding deterrency when evaluated against caterpillars of *Diacrisia obligua*, *Phissama transiens*, *Trabala vishnu* and *Epilachna vigintioctopunctata* (Dutta *et al.*, 1993). The inhibitory activity of Mexican sunflower on plant growth was first reported by Baruah *et al.* (1994) who found that tagitinin A, tagitinin C and hispidulin isolated from Mexican sunflower leaves at the concentration of 250-1,000 μ M reduced seed germination and seedling growth of radish, cucumber and onion in petri dish bioassays. However, the phytotoxic activity of these compounds in natural soil conditions or of other water extractable substance(s) contained in this plant, and especially its allelopathic potential, have not been examined yet.

Heisey (1990) revealed that although the chemicals are present in various plant parts or their extracts, their presence may not establish allelopathy. To clarify their involvement in allelopathy, it is important to find 1) their direct release from the plant into the environment and 2) that the chemicals are present in sufficient quantities and persist for a sufficient time in soil to affect the growth of plant species or microbes (Putnam and Tang, 1986).

Since Mexican sunflower has been introduced to grow in several tropical countries for some purposes, it becomes a dominant plant in its growing area (Ayeni *et al.*, 1997a, 1997b; Radanachales and Maxwell, 1992). Zungsontiporn and Harada (1995) reported that Mexican sunflower is widespread in the mountainous areas of Mae Hong Son province, in the northern part of Thailand. It was able to adapt and succeeded to become a dominant plant in that area. The succession of Mexican sunflower is hypothesized to be related to the allelopathic interaction. It is, thus, needed to investigate the interaction of this plant with other plants as the first step. Better understanding of the allelopathic potential of the plant will provide a basis for improving proper weed management in agriculture in the future.

The overall objectives of this research are

1. to find evidences of the allelopathic potential of Mexican sunflower.

2. to determine the factors affecting the production, release and phytotoxic activity of phytotoxic substances from Mexican sunflower in soil.

3. to evaluate the role of the allelopathic potential of Mexican sunflower under natural conditions.

This study aimed mainly to obtain basic information on the allelopathic potential of Mexican sunflower under natural conditions in mountainous areas in Thailand, for crop production and better weed management in sustainable agriculture in these areas.

Fig.0.1 Overview of Mexican sunflower in the mountain areas of northern Thailand.

Fig.0.2 Plant species growing under a Mexican sunflower canopy.