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HERBICIDAL EFFICACY OF EUCALYPTUS OIL ON PARTHENIUM(*PARTHENIUM HYSTEROPHORUS*L.) CONTROL

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ABSTRACT:

Parthenium hysterophorus L., being a declared invasive weed is threatening the biodiversity and human health in many parts of the world especially in India, Australia, Taiwan, Ethiopia and parts of the U.S. Several researchers have documented the herbicidal efficacy of eucalyptus oil on *Parthenium* at laboratory level. However, pot culture and field studies needed before it can be widely adapted as a commercial practice. Therefore, we carried out a set of experiments at Annamalai University, India to study the herbicidal efficacy of eucalyptus oil with six levels of 0, 0.5,1,2,4 and 8 ppm to control *Parthenium* at laboratory. Eucalyptus oil at lower concentrations up to 8 ppm did not damage the *Parthenium* seedlings. Hence, we tried at higher levels of 0, 10, 20, 30, 40 and 50 ppm in pot culture and main field. Laboratory based experiment shows that increasing concentration of eucalyptus oil severely damaged the *Parthenium* shoots and death noticed at 4 and 8 ppm at 72 hours. In pot culture experiment, complete death of seedlings were observed under 40 and 50 ppm at 24 hours onwards and the lowest fresh biomass of 0.70 g pot^{-1} was recorded at 50 ppm. Field experiment indicates that eucalyptus oil at higher concentrations significantly reduced the relative plant density and the minimum was registered under 50 ppm, which was 75.90 % decreased from 0 ppm. This might be due to presence of allelochemicals in eucalyptus oil. Here we show that eucalyptus oil used as a bio herbicide against *Parthenium* plant and that these results provide encouragement for the future commercial application of this oil as eco-friendly method of weed control.

KEY WORD: *Eucalyptus Oil, Herbicidal Efficacy, Parthenium Control, Shoot Cut Bioassay, Seedling Bioassay, Relative Plant Density.*

INTRODUCTION:

Parthenium hysterophorus L. (Asteraceae), an annual asteraceous herb, is native to Central and South America and considered to have originated from the Gulf of Mexico (Rollins, 1950). It considered very invasive and is a major weed pest in India, Australia, Taiwan, Ethiopia, and parts of the U.S. (Oudhia, 2001). *Parthenium* probably entered India before 1910 (through the contaminated cereal grain), but went unrecorded until 1956. Since 1956, the weed has spread like wildfire throughout India. Most of the Indian states are currently under threat by *Parthenium* and occupied over 5 million hectares of land in the country (Anonymous, 2007).Infestation by *Parthenium* degrades natural ecosystems and this weed is an aggressive colonizer of fallows, wastelands, pastures and roadsides in India. *P. hysterophorus* competes strongly with crops such as sunflowers and in infested sorghum, suppresses yield, as well as contaminating the grain samples. It reported to cause yield loss up to 40 per cent in several crops (Khosla and Sobti, 1979) and reduction in forage production up to 90 per cent (Nath, 1988). The germination and growth of indigenous plants inhibited by its allelopathic effect (Deshpande *et al.* 2005).

Regular contact with the pollen grains, air borne pieces of dried plant materials and roots of parthenium can cause allergy-type responses to human beings. In animals, the plant can cause anorexia, pruritus, alopecia, dermatitis, and diarrhea and even can cause death within 30 days if consumed in significant amount (10-50%) of the weed in the diet (Narasimhan *et al.* 1977).

Manual uprooting of *Parthenium* before flowering and seed setting is the most effective method. This is possible when the soil is as wet. Uprooting the weed after seed setting will increase the area of infestation. Parthenium is reported to be controlled by foliar spray of some chemical herbicides such as bromocil, diuron, terbacil, diquat, chlorimuron ethyl, metasulfuron methyl and buctril super (Javaid *et al.* 2006).Although herbicides are the most effective immediate solution to most weed problems but increased and indiscriminate use of these resulted in resistance and resurgence in pests. Moreover, persistent residues of DDT and HCH highly poisonous to human beings have been found in vegetables, milk, butter, meat as well as in mothers' milk (Schoreder and Muller-Scharer, 1995). Furthermore, increasing public concern on environmental issues requires alternative weed management systems, which are less pesticide dependant or based on naturally occurring compounds (Singh *et al.* 2003).

Allelopathy, understood as the effect of chemical interactions between plants (Muller, 1969). Rice (1984) defined allelopathy is the effect(s) of one plant on other plants through the release of chemical compounds in the environment .These bioactive compounds are also known as allelochemicals (Whittaker and Feeney, 1971). Under appropriate conditions, allelochemicals may release in quantity, which suppress germination, the developing weed seedlings and often exhibit selectivity similar to synthetic herbicides (Weston, 1996). Allelopathy is associated with *Eucalyptus spp*. due to the presence of allelochemicals; several studies have demonstrated the release of phenol and volatile compounds in its foliage (Al-Naib and Al-Mousawi, 1976). Essential oils of aromatic plants being explored to find out possible herbicides since they do not persist in soil or contaminate ground water and causes little or no mammalian toxicity

(Isman, 2000). Eucalyptus is the one of the aromatic plants and releases the volatile oils from its foliage, which appear to have an inhibitory effect on the growth of under-storey vegetation, and this could lead to the development of natural herbicides (Peter Golob *et al.* 2007). Therefore, this study aimed to evaluate the herbicidal efficacy of eucalyptus oil on *Parthenium* control.

MATERIALS AND METHOD:

Collection of *Parthenium hysterophorus* L.seeds

Seeds of *Parthenium hysterophorus* L. collected near Annamalai University Experimental Farm during January 2012 and dried in shade for about a week. Air dried seeds with moisture content below 12% managed through repeated weighing and drying, was used for this experiments.

Eucalyptus oil

The sample investigated in this study purchased from the company Perfume Paradise, Yercaud, and Tamilnadu - 636601 (India).

Preparation of spray solution

Eucalyptus oil dissolved in ethanol at 1: 5 ratios as suggested by Reynolds (1982) and different concentrations (v/v) were prepared 30 minutes prior to application.

Treatments and design

Laboratory experiment

The experiments consisted of six levels of eucalyptus oil of 0, 0.5,1,2,4 and 8 ppm and lay out by adopting randomized block design (RBD) with three replications.

Pot culture and field experiment

Eucalyptus oil at lower concentrations did not damage the parthenium seedling, hence we tried at increased levels of 0, 10, 20, 30, 40 and 50 ppm and the experiments laid out in RBD and replicated thrice.

Laboratory experiment

Shoot cut bioassay

To test the effects on shoot growth, 10-cm shoots of *Parthenium* with one or two inflorescences taken, washed in tap water, dipped in 1% NaOCl solution for 3 min and the tips immediately washed in sterilized distilled water to remove any residual trace of the chemical. An inclined cut made at the tip, and the shoots placed in conical flask containing 100 ml of solution, with cotton buds and aluminum foil to make airtight. The effect of the Eucalyptus oil observed after 24, 48 and 72 hours (hrs) at room temperature. Phytotoxic damage was recorded on a scale (0-5, where 0 = no effect; 1 = slight chlorosis/lower leaf drops; 2= marked chlorosis and slight necrosis; 3 = acute chlorosis and marked necrosis/drooping of entire twig; 4 = falling of flowers and leaves/high necrosis and chlorosis; 5 = acute chlorosis and very high necrosis leading to death of the whole shoot.

Pot culture and field experiment

Pot culture experiments

Seedling bioassay

Parthenium seedlings were raised in mud pots of 15 cm diameter and 30 cm deep containing sterilized soil, sand and peat (1: 1: 1) under partial shade. These seedlings were sprayed with different concentrations eucalyptus oil and the effect was assessed after 24, 48 and 72 h. Phytotoxic damage was recorded on a scale (0 – 4, where 0 = no effect ; 1 = slight chlorosis ; 2 = marked chlorosis ; 3 = drooping of seedling ; 4 = death of seedlings).

Fresh biomass

At the end of seedling bioassay, randomly five seedlings from each pot harvested and data regarding fresh biomass was determined and expressed in gram (g).

Field experiment

Relative plant density

An area of 0.25 m^2 was marked in the parthenium weeds infested area by using 1 x 1 m quadrate. The plant density was determined by counting the number of living parthenium plants prior to the treatment application. Treatment plots sprayed with different concentrations of eucalyptus oil and distilled water spray as control. The plant with drooping of entire leaves, falling of flowers and very high necrosis considered as dead plant. The number of live *Parthenium* plants counted again in the same manner at 10 days after spraying. The relative plant density calculated using the following formula,

$$\text{Relative plant density (\%)} = \frac{\text{Number of live plants after treatment}}{\text{Number of live plants before treatment}} \times 100$$

Statistical analysis

The experimental data analyzed as per the procedure outlined by Gomez and Gomez (1984).The critical difference worked out as five percent probability level for significant results.

RESULTS AND DISCUSSIONS:

Laboratory experiment

Shoot cut bioassay

The phytotoxic damage inflicted on shoot of *Parthenium* by eucalyptus oil given in *figure* 1. Eucalyptus oil up to 1 ppm did not show any phytotoxic effect on *Parthenium* shoot at 24, 48 and 72 hours (hrs). Lower leaf drops recorded in 2 ppm at 24 hrs and dropping of entire twigs noticed under the same treatment at 48 and 72 hrs. Eucalyptus oil at 4 ppm recorded slight chlorosis and lower leaf drops for the first 24 hrs. Acute chlorosis and marked chlorosis observed at 48 hrs. The *Parthenium* shoots exhibited blackening of stem, drooping and curling of leaves, severe chlorosis and necrosis, finally leading to death of treated shoots noticed at 72 hrs. Visual observations have also shown a great effect of the eucalyptus oil on *Parthenium* shoots (*figure* 2). The same trend of result observed under 8 ppm. The maximum damage and death of *Parthenium* shoots might be due to the presence of allelochemicals in eucalyptus oil, which limits the biological activities of *Parthenium* (Singh *et al.* 2005). Further, the continuous contact of shoots with this oil causes cell damage, which affects the transport of water. These results lined with the findings of Kohli *et al.* (1998) who reported that eucalyptus oil reduces cellular respiration, chlorophyll content and increases water loss resulting in complete wilting of the plants.

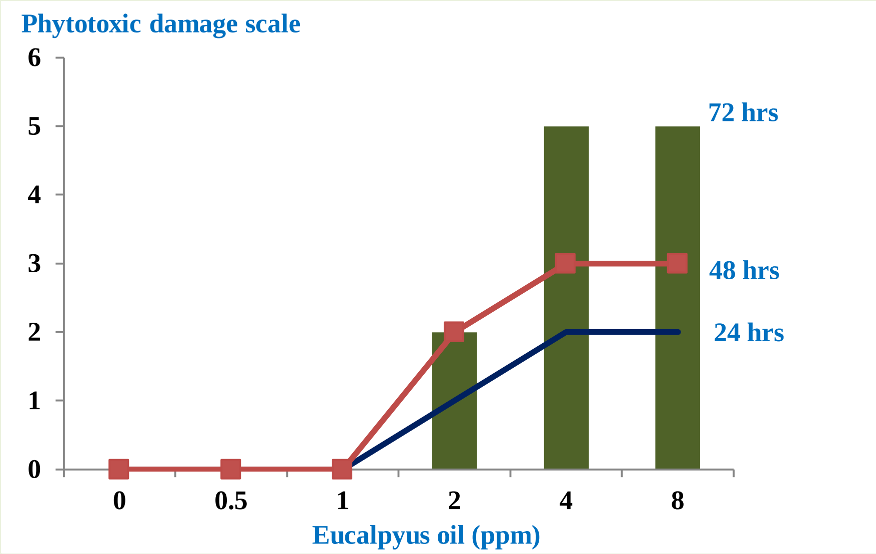

Figure 1 . Herbicidal efficacy of eucalyptus oil on parthenium shoots

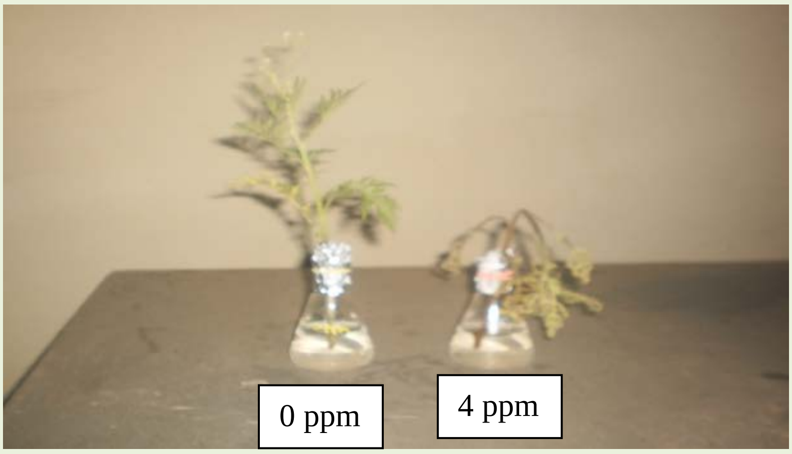

Figure 2 . Phytotoxic damage caused by eucalyptus oil on parthenium shoots at 72 hrs

Pot culture experiments

Seedling bioassay

Phytotoxic damage rating was determined by spraying eucalyptus oil on 45 days old *Parthenium* seedlings. As the concentration of the oil, increase the damage of the seedlings also higher (*figure* 3). The complete death of *Parthenium* seedlings observed under 40 and 50 ppm at 24, 48 and 72 hrs. Visual observations have also shown the phytotoxic damage by eucalyptus oil on *Parthenium* seedlings (*figure* 4). It is clear from data that eucalyptus oil affected the aerial parts of the seedlings by disturbing the basic plant processes such as hormonal balance, protein synthesis, respiration, photosynthesis, chlorophyll formation, permeability and plant water relations due to presence of allelochemicals (Yamane *et al*. 1992). Herbicidal activities of volatile oils of *Eucalyptus citriodora* against *Parthenium* has earlier reported by Singh *et al.* (2005). Similarly Zhao-Hui Li *et al.* (2010) reported that eucalyptus oil contain indeed growth inhibitors such as *p*-coumaric,gallic, gentisic, *p*-hydroxybenzoic, syringic and vanillic acids and catechol that are capable of reducing the growth and survival of *Parthenium* plant. Distilled water caused no damage at all.

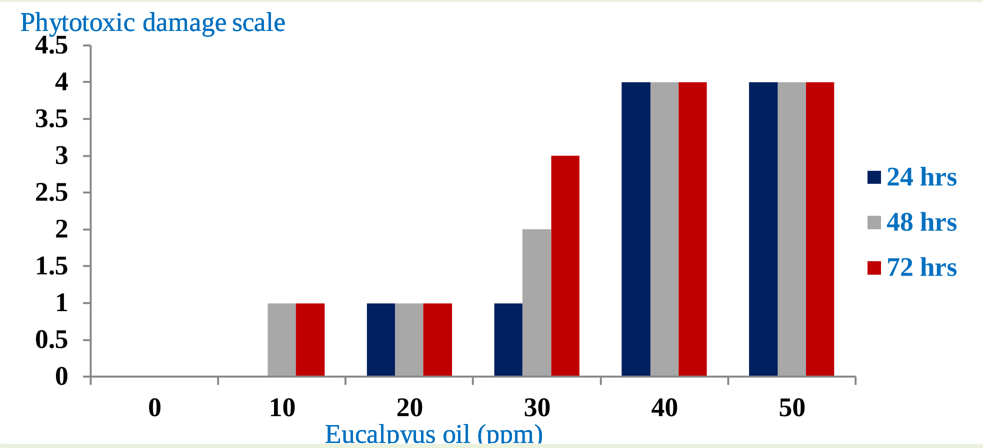

Figure 3 . Herbicidal efficacy of eucalyptus oil on parthenium seedlings

Figure 4 . Phytotoxic damage caused by eucalyptus oil on parthenium seedlings at 72 hrs

Fresh biomass

As evident from *figure* 5, decreased in fresh biomass of parthenium seedlings recorded with increased concentration of eucalyptus oil. Eucalyptus oil at 50 ppm registered its superiority over lower levels and recorded the lowest fresh biomass of 0.70 g pot^{-1}. This was on par with 40 ppm. Decreased in fresh biomass of parthenium seedlings is due to eucalyptus oil attributed to presence of allelochemicals. Plant growth and productivity usually correlated to both the total leaf area and the photosynthetic rate per unit of leaf. It has documented that allelochemical treatment significantly decreased plant biomass together with reduced leaf area and stunt plant growth. Zhou and Yu (2006) have reported the factors associated with the decreases in the photosynthetic capacity per unit leaf area induced by allelochemicals. Moreover, allelochemicals also have detrimental effects on cell division and enlargement; eventually induce a reduction in leaf area and growth of seedlings (Buckolova, 1971).The maximum fresh biomass noticed under control.

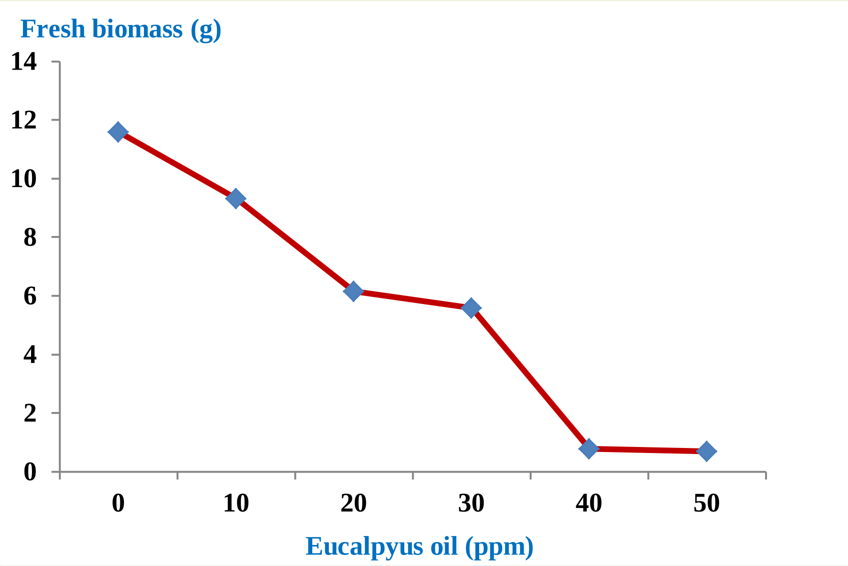

Figure 5 . Herbicidal efficacy of eucalyptus oil on fresh biomass of parthenium seedlings

Field experiment

Relative plant density

Parthenium plant density adversely affected with eucalyptus oil. Increase in concentration of the eucalyptus oil significantly reduced the plant density under field condition (*figure* 6). The lowest density registered at 50 ppm and this treatment caused the maximum death of plants within 24 hrs. It could be due to decreases in the capacity to capture photo synthetically active radiation are also a main factor in determining the reduction in the photosynthetic productivity of the oil exposed plants. The mode of action might be by inhibiting respiration (Rice, 1984) and energy transfer, responsible for ATP synthesis, or perhaps inhibiting gibberellin and IAA-induced growth. Polyphenolic compounds and other allelochemicals are changing the permeability of plasma membrane and leading to cell leakage (Abbas *et al.*1992). Inhibition of photosynthetic process depletes food reserves, and then proteins and other compounds can serve as respiratory substrates, further decrease in carbohydrate and protein contents, which might cause the death of plant (Taiz and Zeiger, 1998). This follows by Eucalyptus oil at 40 ppm and the effect decreased thereafter. Distilled water caused no effect on *Parthenium* plant.

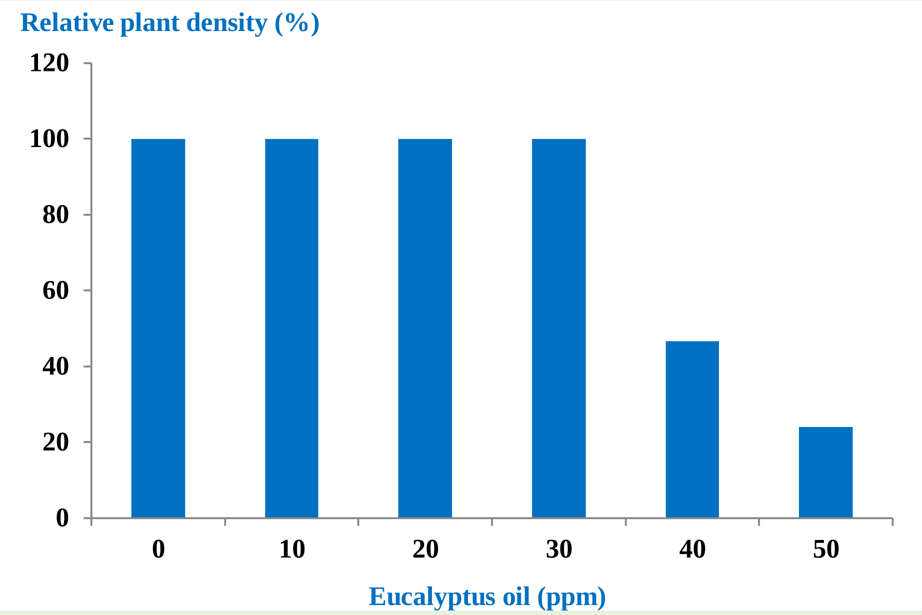

Figure 6 . Herbicidal efficacy of eucalyptus oil on relative plant density of *Parthenium* in the main field.

CONCLUSION:

The present study shows that eucalyptus oil contain inhibitors probably allelochemicals, for growth and survival of *Parthenium*. Further research is underway to identify bioactive compounds derived from eucalyptus oil and it can be utilize for future weed management programmes against different weeds in crop and aquatic ecosystem.

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