

## INFLUENCE OF SELECTED ENVIRONMENTAL FACTORS ON GERMINATION AND EMERGENCE OF *Hyptis suaveolens* OF COCONUT PLANTATIONS IN SRI LANKA

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**Abstract:** *Hyptis suaveolens* is a prominent and dominant weed species in the coconut plantations of Sri Lanka. Hence, laboratory and greenhouse studies were conducted to determine the effects of pH, osmotic stress, planting depth and submerged time period on *H. suaveolens* seed germination and emergence. Seed germination was significantly reduced in solutions with osmotic potentials below -0.6MPa. The highest germination was at 0 Mpa, and seedling emergence was not observed at -1.3MPa. The optimum pH range for germination of *H. suaveolens* seed was between 5 and 8, although some seeds germinated at pH levels of 4 and 9. The maximum *H. suaveolens* emergence occurred when seeds were planted on the soil surface. Seedlings did not emerge when seeds were planted at a depth of 7 cm. No seedlings emerged when seed was exposed to flooding for 13 days or more. The highest percentage (95%) of seeds emerged from a depth of 1cm when the soil was flooded for one day. These results suggest that *H. suaveolens* seed is capable of germinating and surviving in a range of climatic and edaphic conditions, and that flooding is not a viable management option for controlling this weed after emergence.

**Key words:** Coconut, weed seed, *Hyptis suaveolens*, germination

### Introduction

The growth habit and canopy structure of the coconut palm requires a wide spacing between palms, which permits abundant sunlight to the ground vegetation. Thus, a wide range of perennial and annual weed species invade the unutilized space beneath the palms (Senarathne *et al.* 2003). Among these weed species (*Hyptis suaveolens*) is one of the most problematic dicotyledonous weed in coconut plantations in Sri Lanka. It is a major weed of the family *Lamiaceae* and is a perennial, broad leaved erect strongly aromatic herb (Stone, 1970). The weed grows on all types of well drained soils in areas that receive between 250 mm – 3000 mm of rainfall per annum (Stone, 1970). It resists drought very well and is tolerant to salt spray. Aerial portion of the plant are killed by temperature of -2°C, but quickly grows back (Wagner *et al.* 1999). Invasion of *H. suaveolens* has been a problem in areas such as distributed pastures, overgrazed areas, open forests, plantations and slash and burn agricultural fields. The shrub is reported to highly allelopathic to vegetation (Smith, 2002). It may grow as a single plant and it grows from near sea level up to 1300 m in elevation (Wanger *et al.* 1999). *Hyptis suaveolens* plant flowers and fruits throughout the year (Smith, 2002). Seeds are dispersed by animals, humans, field machinery and when attached to fur, clothing and mud (Smith, 2002).

Seed germination is the key event in determining the success of a weed in an agro ecosystem. Several environmental factors such as temperature, light, soil salinity, moisture and pH are known to affect weed seed germination (Chachalis and Reddy, 2000; Koger *et al.* 2004). Burial depth of seeds also affects germination and seedling emergence (Koger *et al.* 2004; Shaw *et al.* 1991) and the availability of moisture, diurnal temperature fluctuation, and light exposure varies with depth. All of these attributes of the microenvironment potentially influences the behavior of weed seeds. Therefore, it is critical to procure information on seed germination, persistence and seedling emergence to improve the management systems for specific weed species (Mennan and Ngouajio, 2006). There is little information on the seed

biology of *H. suaveolens* which affects the development of strategies for the management of this weed. Therefore, the objective of this study was to determine the effect of osmotic stress, pH, flooding and burial depth on germination of this specie using laboratory and green house experiments.

## Materials and Methods

Seeds of *Hyptis suaveolens* were collected from five different locations in the major coconut growing region of Sri Lanka between February to March 2005 and were stored at 5°C under dark conditions. The selected treatments of the experiments were arranged in a Complete Randomized Design (CRD) with ten replicates (each Petri dish and pot representing one replication in each trial) in the respective studies.

### *Effect of moisture stress*

Aqueous solutions of polyethylene glycol (PEG) (average molecular weight of 6000) were prepared to obtain osmotic potentials of 0, -0.3, -0.4, -0.6, -0.9 and -1.3 MPa by dissolving 0, 154, 191, 230, 297 or 350 g of PEG in 1 liter of deionized water (Michel and Kaufmann, 1973). Thereafter, 50 seeds of *H. suaveolens* were placed in individual 9 cm diameter Petri dishes containing two filter papers. The filter papers were moistened with 5 ml deionized water or the test solutions and the Petri dishes were placed in a green house. Seed germination was counted once in two days for a period of 30 days.

### *Effect of pH*

*Hyptis suaveolens* seeds were placed in Buffer solutions having pH values of 4, 5, 6, 7, 8 and 9 with distilled water as a control. The buffer solutions were prepared as described by Reddy and Singh (1992), using Potassium hydrogen phthalate, and were adjusted to pH 4 with HCl. The 2(N-morpholino)ethanesulfonic acid solutions were adjusted to pH 5 and 6, N-(2-Hydroxymethyl) piperazine-N-(2-ethanesulfonic acid) solution was adjusted to pH 7 and 8 and N-Tris(hydroxymethyl)methylglycine (Tricine) solution was adjusted to pH 9 with NaOH. Fifty seeds were placed on two sheets of filter paper placed in 9 cm diameter Petri dishes and moistened with 5 ml of the respective pH solutions. Seed germination was counted once in two days for 30 days.

### *Effect of planting depth*

Fifty *Hyptis suaveolens* seeds were planted in a sandy clay loam soil in polythene pots (15 cm diameter) at depths of 0, 1, 3, 5, 7, 9 and 11 cm, and placed in a green house, where the temperatures were 30°C ± 4°C during the day and 26°C ± 4°C during the night. Pots were watered as needed to maintain between available moisture 70% - 80% soil moisture. Germinated seedlings were counted once in 7 days for 30 days. Seedlings were considered emerged when the cotyledons could be visually discerned and were removed after counting at 7 day intervals.

### *Effect of submerged time period (flooding)*

Fifty *Hyptis suaveolens* seeds were planted 1 cm deep in a sandy clay loam soil in plastic pots (9 cm diameter). Flooding was imposed by maintaining water at a height of 1.5 cm above the soil surface. The water level was maintained for 1, 3, 5, 7, 9, 11, 13 and 15 days after planting. Flooding was discontinued after the indicated period and seeds were watered as needed to maintain adequate moisture. Emergence was recorded weekly for a period of 28 days after planting.

### Statistical analysis

In all experiments except the pH test, percentage of germination data were transformed using the  $\log(X + 1)$  transformation, where  $X$  is the percentage of germination, to improve homogeneity. The ANOVA and regression analysis were performed on both transformed and non transformed percentages of germination. Means from experiments were separated using the Fishers protected LSD test at  $p=0.05$ .

## Results and Discussion

### Effect of moisture stress

The impact of osmotic potential on the germination of *H. suaveolens* seeds presented as a quadratic equation (Figure 1).

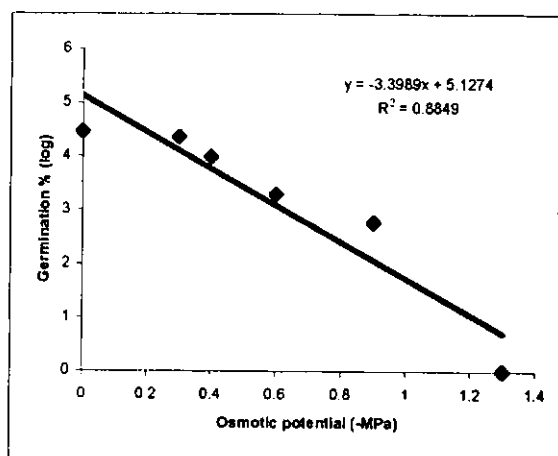


Figure 1. Effect of moisture stress (osmotic potential – Mpa) on germination of *Hyptis suaveolens* seeds.

Germination of *H. suaveolens* seeds decreased when the osmotic potential increased from 0 MPa to -1.3 MPa indicating that these seeds can germinate under high water stress conditions. Seed germination was highest at osmotic potential of 0 and -0.3 MPa. Seeds (16%) germinated at an osmotic potential of -0.9 MPa. No germination occurred at an osmotic potential of -1.3 MPa. Germination over a broad range of osmotic potential indicates that *H. suaveolens* could pose a weed threat under both low and high moisture conditions and could grow in wet, intermediate and dry zone coconut lands of Sri Lanka. In general, germination of *H. suaveolens* seed is inhibited under high water stress conditions. Such conditions can occur temporarily between periods of rainfall at the start of the growing seasons in Sri Lanka. However, weed species such as Red Vine (*Brunnichia ovata* (Walt) Shinnery) are highly sensitive to low water potential (Shaw *et al.* 1991). The rate of decline in *H. suaveolens* seed germination due to the different moisture stress conditions was 3.3989. The results of the study suggest that *H. suaveolens* is highly tolerant to conditions of water stress, and germination is likely to be favored by a moderately moist environment.

### Effect of planting depth

Seedling emergence decreased with increased planting depth. No seedlings emerged from seeds placed at a depth of 7cm. The highest seed germination (85%) was at the soil surface (Figure 2). However, reduced seedling emergence of seeds placed on the soil surface has been reported previously for many weeds (Singh and Achhireddy, 1984; Balyan and Bhan, 1986; Shaw *et al.* 1991; Horak and Sweat, 1994).

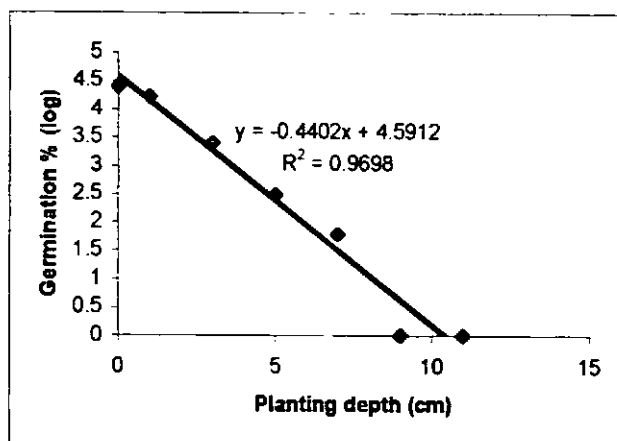


Figure 2. Effect of planting depth on germination of *Hyptis suaveolens* seeds

In many weed species, seedling emergence decreased with increased depth of seed burial (Cussans *et al.* 1996; Qi and Upadhyaya, 1993; Shaw *et al.* 1997). Emergence after burial in soil depends on seed size and light conditions. Large seeds with sufficient reserves can emerge from greater depths (Baskin and Baskin, 1998). *Hyptis suaveolens* seed is a relatively large seed and does not require light for germination and seedlings emerge well from moderate depths up to 4cm.

Depth mediated *H. suaveolens* emergence (expressed as a percentage of maximum emergences) is well described by a logistic model, with the greatest emergence occurring from the soil surface. This trend has been observed in other weed species, where greater emergence is often from the soil surface when conditions are favorable for germination (Benvenuti *et al.* 2001). The decreasing rate of seed germination due to the different planting depths was 0.4402.

#### *Effect of pH*

*Hyptis suaveolens* seeds germinated over a wide pH range, indicating that pH is not likely to be a limiting factor for germination in most soil types. Seed germination of *H. suaveolens* seeds followed a quadratic response to increasing pH with enhanced germination between pH 4 and pH 7 and decreasing germination at pH levels of 7 to 9 (Figure 3). The maximum germination in *H. suaveolens* was at pH 6, although seeds of *H. suaveolens* germinated at pH 4 and pH 9 which were acid and alkaline conditions.

The percentage of seeds of *H. suaveolens* that germinated at pH 4 and pH 9 were 5% and 34%, respectively. Therefore, the ability to germinate over a wide pH range supports the view that *H. suaveolens* weed is adapted to a wide range of soil conditions. This characteristic is common in many weed species such as *Asclepias syriaca* L. and *Scoparia dulcis* (Evetts and Burnside, 1972; Jain and Singh, 1989). Other weed species such as *Avena fatua* L may require a specific pH to break dormancy (Adkins *et al.* 1985). Germination under a variety of soil conditions aids the ability of a plant to invade diverse habitats.

#### *Effect of submerged time period (flooding)*

Emergence of seedlings of *Hyptis suaveolens* decreased with increasing duration of submergence. The highest percentage of seedlings (95%) emerged from a depth of 1 cm when not exposed to the flood conditions or duration of flooding was one day. Seedling emergence decreased gradually when duration of flooding was three days or longer (Figure 4).

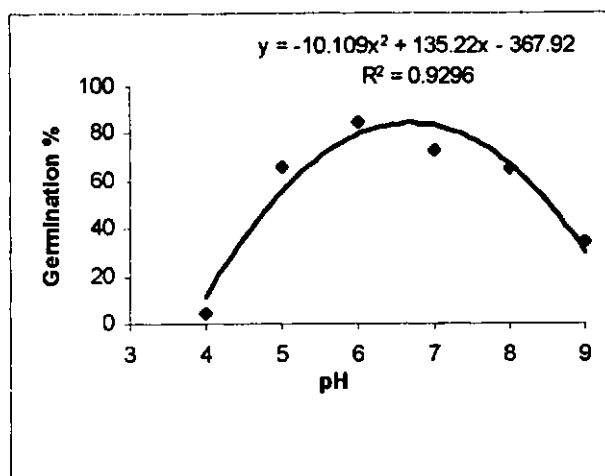


Figure 3. Effect of pH on germination of *Hyptis suaveolens* seed

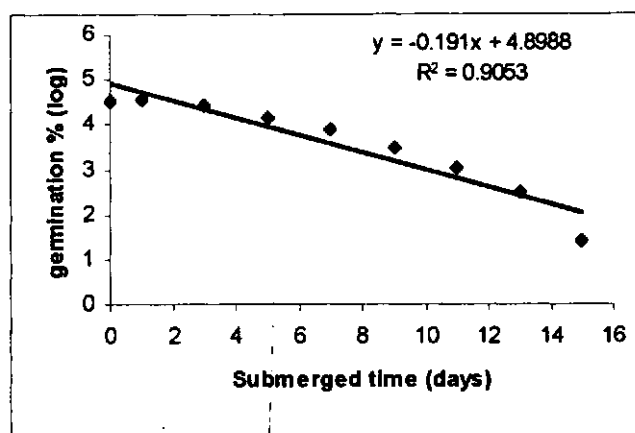


Figure 4. Germination of *Hyptis suaveolens* seeds as affected by submerged times

The rate of decline in *H. suaveolens* seed germination due to the different submergence time periods was 0.1910. However, seedling emergence (81%) was observed when flooding was maintained 15 days. Hence, germination may be favored in areas prone to even short period of flooding. Activation of the physiologically process necessary for seed germination requires an O<sub>2</sub> supply, however, soil inundation restricts O<sub>2</sub> availability to the embryo and thereby prevents or delays seed germination in many species (Kozłowski and Pallardy, 1997). In general, soaking seeds of upland species is recommended for several hours to few days to accelerate germination, whereas soaking for long periods inhibits this process (Kozłowski and Pallardy, 1997).

### Conclusions

*Hyptis suaveolens* seed germination was observed over wide range of soil pH values. This suggests that soil acidity or alkalinity is not likely to be a limiting factor for seeds of this species to germinate in most coconut growing soil types in Sri Lanka. Seedling emergence was optimal at shallow burial depths, which indicate that agricultural practices such as no till and minimum tillage that promotes shallow burial of weed seeds may stimulate greater seedling emergence of *Hyptis suaveolens*. When seeds were buried in deep layers of the soil, seed germination percentage was reduced, suggesting that ploughing and harrowing can be used to suppress this species. Generally seed germination is severely restricted under both osmotic stress and flooded conditions. However, *Hyptis suaveolens* seeds could germinate at

over a broad range of osmotic potentials indicating that this weed could pose a weed threat under both low and high moisture stress conditions. The overall results suggest that *Hyptis suaveolens* has the ability to germinate under a broad range of environmental conditions. Prevailing ecological conditions could determine the extent of germination, subsequent emergence, and severity of *H. suaveolens* infestations in coconut plantations. The warm climate and well and moderately drained soil in coconut lands coupled with abundant moisture (rainfall) and frequent fertilization are ideal for *Hyptis suaveolens* seed germination and establishment. Therefore, it is fast becoming a prominent weed species in wet, intermediate and dry zone coconut plantations in Sri Lanka, and results from this study could become useful in developing possible control measures.

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