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# Allelopathic Potential of *Tecomella undulata* (Roxb.) Seem

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## ABSTRACT

The aquatic extracts obtained from the dried roots and stem inner bark, leaves and flowers of *Tecomella undulata* (*Bignoniaceae*) were evaluated *in vitro* to examine their potential allelopathic effects. The inhibitory effects of the extracts at 0, 2.5, 5 and 10% (v/v) on germination and seedling growth of bread wheat (*Triticum aestivum* cv. 'Byate') and common or cranberry bean (*Phaseolus vulgaris* cv. 'Chiti') were tested. The extract at all concentrations completely suppressed the germination of wheat. Root and stem inner bark and flower extracts reduced significantly ($P \leq 0.05$) the length of wheat shoots and roots. The seed germination of common bean was affected only by root and stem inner bark. Root and stem inner bark, leaf and flower extracts at 2.5% reduced the length of common bean shoots and roots. The effect of root and stem inner bark extracts on seed germination and the length of shoots and roots were higher than by leaf and flower extracts, especially in wheat. Root and stem inner bark extracts could be used in herbicides against Gramineae weeds.

**Keywords:** allelopathy, bioherbicide, inhibitory effect
**Abbreviations: PEG**, polyethylene glycol

## INTRODUCTION

The *Bignoniaceae* is a taxon of flowering plants comprised mainly of trees, shrubs, lianas, and a few herbs. Family members are distributed mostly in the tropics and subtropics, but with a number of temperate species as well. The family includes about 650 species in 110 genera. Many of the timbers derived from members of this family contain the dermatitic compound lapachol (formerly known as tecomin). *Tecoma*, *Tabebuia* and *Tecomella* are some examples of such genera. Some species of *Tecoma* and *Tabebuia* have been reported to contain lapachol and are used in Brazil for traditional medicine (Gómez Castellanos *et al*. 2009; Pinto and de Castro 2009).

*Tecomella undulata* (Roxb.) Seem. (*Bignoniaceae*) is a deciduous or nearly evergreen large ornamental tree of arid and semi-arid regions. It occurs on flat and undulating areas, including gentle hill slopes, and sometimes in ravines. It is well adapted to well-drained loamy to sandy loam soil having a pH of 6.5-8.0. The species thrives very well on stabilized sand dunes, which experience extremely low and high temperatures. It grows in areas of scanty rainfall (annually 150-500 mm) and high temperature (35-48°C). It can withstand extremely low temperatures (0 to -2°C) during winter and high temperatures (48-50°C) in summer. It is drought, frost, fire and wind hardy. At the time of flowering (April-June), it produces beautiful showy yellow, orange and red flowers. Three types of flower-bearing trees can be observed close to each other in the same vicinity. Distribution of *T. undulata* is restricted to the drier parts of Arabia, Pakistan, Afghanistan, northwest India and the south of Iran up to an elevation of 1200 m. *T. undulata* is mainly used as a source of timber. Its wood is strong, tough and durable. *T. undulata* plays an important role in environmental conservation, for example protection of soil from flood water and enhances the productivity of associated plants by improving soil water in the upper soil layer, soil organic matter and N availability (Singh 2009; Mohsenzadeh *et al.* 2010; Tayyebi 2010).

Allelopathy is a biological phenomenon by which an organism produces one or more biochemicals that influence the growth, survival, and reproduction of other organisms. These biochemicals are known as allelochemicals and can have beneficial (positive allelopathy) or detrimental (negative allelopathy) effects on the target organisms (Reigosa *et al*. 2006). Allelopathy is an important mechanism of plant interference mediated by the addition of plant-produced phytotoxins to the plant environment and is a competitive strategy of plants (Oussama 2003). Allelochemicals are produced by plants as end products, by-products and metabolites and exist in the stems, leaves, roots, flowers, inflorescences, fruits and seeds of plants (Sisodia and Siddiqui 2010). The release of these chemical compounds into the environment acts on other organisms such as plants, including weeds, animals and microorganisms to either inhibit or stimulate activity (Fujii *et al*. 2003). There is increasing evidence that these plant chemicals can suppress germination and growth of different weed species (Singh *et al*. 2003; Turk and Tawaha 2003; Sampietro and Vattuone 2006; Mohsenzadeh *et al*. 2011). Worldwide, enormous amounts of chemical herbicides are used to manage these weeds. However, synthetic herbicides are often toxic and cause environmental problems (Khanh *et al*. 2004; Sodaeizadeh *et al*. 2009). Moreover, overuse of artificial herbicides has led to the development of weed biotypes with herbicide resistance (Sodaeizadeh *et al*. 2009). In agriculture, there is a worldwide effort to reduce the amount of chemicals used in crop production through modern biological and ecological methods. One of the possible solutions is the use of allelopathy to explore the negative chemical interaction between plants (Azizi and Fujii 2006). The importance of allelopathy in the natural control of weeds and crop productivity is now highly recognized (Khan *et al*. 2009). In recent years, medicinal plants have been increasingly explored for their allelopathic potential (Anjum *et al*. 2010). Medicinal plants may contain bioactive compounds such as ferulic, coumaric, vanillic, caffeic and chlorogenic acid that possess inhibitory activity (Modallal and Al-Charchafchi 2006). Naziret *al*. (2006) evaluated the allelopathic effects of the aqueous extracts of *Rheum emodi*, *Saussaurea lappa* and *Potentilla ful-*

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*gens* on some traditional food crops; germination of all crops was significantly reduced by *S. lappa* and *P. fulgens* extracts. Fujii *et al*. (2003) used 239 medicinal plants to evaluate the allelopathic activity on lettuce. They concluded that 223 species were inhibitory.

In this study, the allelopathic potential of the root and stem inner bark, leaves and flowers of *T. undulata* aqueous extract on germination and seedling growth of one monocotyledonous plant belonging to the *Poaceae* family and one dicotyledonous plants belonging to the *Fabaceae* family has been considered.

## MATERIALS AND METHODS

### Plant material

The root and stem inner barks, leaf and flower of *T. undulata* was harvested from five trees approximately 20 years old distributed around Firoozabad city in the Fars province of Iran. A voucher specimen (Mohsenzadeh 1002) was deposited in the herbarium of Shiraz University. The seeds of bread wheat (*Triticum aestivum* cv. 'Byate') as the representative monocotyledonous plant and common bean (*Phaseolus vulgaris* cv. 'Chiti') as the representative dicotyledonous plant were prepared by the College of Agriculture, Shiraz University.

### Extraction from *T. undulata*

The root and stem inner bark, leaves and flowers were dried at 40°C for 48 h using an oven and then were ground separately to a fine powder before extraction. Ground sample (20 g) was mixed with 200 ml of distilled water in a shaking water bath for 24 h at 50°C. The aquatic extracts were separated from solid by filtering them through Whatman No. 1 filter paper. The remaining residues were re-extracted twice and the extracts were pooled.

### Bioassay

In order to detect the allelopathic effect of the aquatic extract of *T. undulate*, dilutions were made of the original extract to 2.5, 5 and 10% (v/v, i.e., g amounts of original extract in 100 ml of distilled water) of the stock extract. In addition, a mixture of root and stem inner bark, leaves and flowers as a treatment and polyethylene glycol (PEG) 6000 as a positive standard at 2.5, 5 and 10% (v/v) were used. 20 seeds each of wheat and common bean were surface sterilized with a water-bleach solution (95: 5) and were placed on sterilized filter paper in 6-cm diameter Petri dishes. Each solution (4 ml) was added to each Petri dish; distilled water served as the control. Petri dishes were placed in a growth chamber with 16 h light at 25°C and 8 h dark at 15°C for 14 days and at a light intensity of 300 μmol/m$^2$/s. Relative humidity was 50%. Petri dishes were monitored daily and the evaporated contents were compensated with distilled water. The number of germinated and non-germinated seeds was counted and final radicle and epicotyl length were measured at the end of the 14$^{th}$ day. The seeds showing radical emergence were considered to be germinated.

### Statistical analysis

The experimental design was a complete randomized design with four replications for each treatment. Data were analyzed using SPSS v. 17.0 and mean comparisons were made following the LSD test at $P \leq 0.05$.

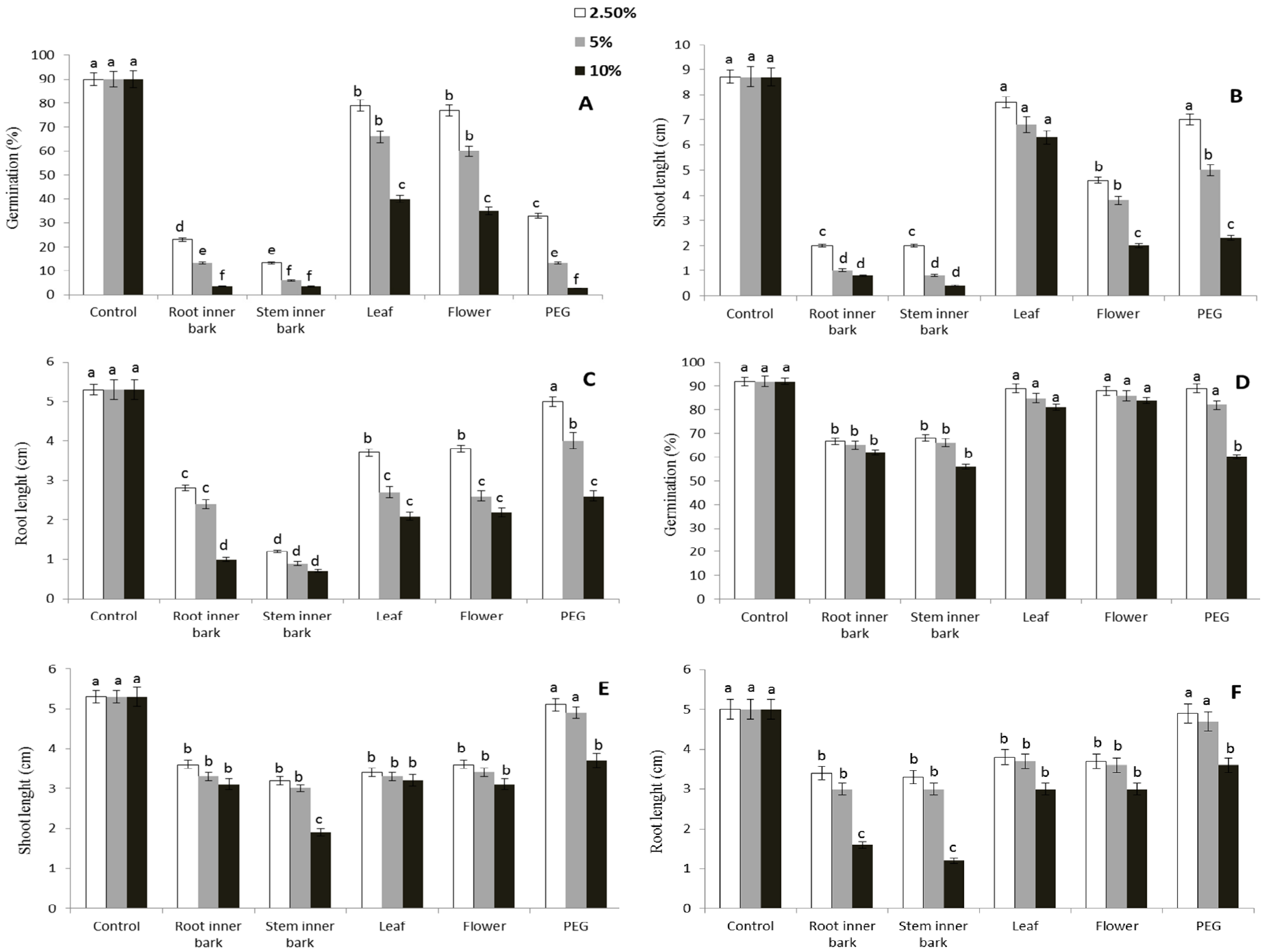


**Fig. 1** Effect of different organs extract of *T. undulata* at three concentrations and PEG on bread wheat seed germination (**A**), shoot length (**B**) and root length (**C**) and on common bean seed germination (**D**), shoot length (**E**) and root length (**F**). Different small letters show significant differences between means at $P \leq 0.05$.

## RESULTS AND DISCUSSION

Lapachol is a naphthoquinone (Pinto and de Castro 2009) isolated from *Tabebuia avellanedae* (Bignoniaceae) tree, which grows in South America. Lapachol has also been extracted from other species of the *Bignoniaceae* family (Gómez Castellanos *et al*. 2009). A wide spectrum of therapeutic activities has been attributed to lapachol or its derivatives (Awang *et al*. 1995; Babula *et al*. 2009). These include anti-abscess, anti-ulcer, antileishmanial, anticarcinomic, antiedemic, anti-inflammatory, antimalarial, antiseptic, antitumor, antiviral, bactericidal, fungicidal, insectifugal, pesticidal, protisticidal, respiradepressant, schistosomicidal, termiticidal, and viricidal (Guiraud 1994; Park *et al*. 2006; Esteves-Souza *et al*. 2007; Hussain *et al*. 2007; Lira *et al*. 2008; Salustiano*et al*. 2010). Apart from the *Bignoniaceae* family, lapachol can also be found in other families such as the *Verbenaceae*, *Proteaceae*, *Leguminosae*, *Sapotaceae*, *Scrophulariaceae* and *Malvaceae* (Joshi and Singh 1977).

All concentrations of all stock extracts completely suppressed germination of wheat (**Fig. 1A**). Root and stem inner bark and flower extracts at all three concentrations significantly ($P \leq 0.05$) reduced the length of wheat shoots and roots (**Figs. 1B, 1C**). In addition, the leaf extract significantly inhibited the length of wheat roots. The seed germination of common bean was affected only by root and stem inner bark extracts (**Fig. 1D**) although the root and stem inner bark, leaf and flower extracts of *T. undulata* at 2.5% reduced significantly ($P \leq 0.05$) the length of common bean shoots and roots (**Figs. 1E, 1F**).

PEG 6000 was used as the positive standard for the osmotic study. **Fig. 1A-1C** shows that seed germination and the length of wheat shoots and roots were affected by osmotic stress induces by PEG more than or similar to the effects caused by the leaf and flower extracts. This confirms that the leaf and flower extracts have an osmotic effect and not an not allelopathic property on wheat germination and seedling growth. However, the effects of root and stem inner bark extracts on seed germination and on the length of shoots and roots were higher than those caused by leaf and flower extracts, especially in wheat. It is possible that the optimum concentrations of root and stem inner bark extracts could be used as bioherbicides against Graminaceous weeds.

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