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# Allelopathic potential of native plants against water hyacinth

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**Abstract**

Classical biocontrol of water hyacinth using insects in India is constrained by seasonal occurrence of water flow and interrupted host range. Use of fungal pathogens is also difficult due to lack of shelf-life and virulence under severe climatic fluctuations and a lack of knowledge of spray techniques. Hence, the allelopathic potential of native plants is reviewed for use as an alternative bio-control tactic. Dried powder of the leaves of Omavalli *Coleus amboinicus* L. at 40 g $l^{-1}$ as a water suspension killed water hyacinth within 24 h reducing the fresh weight by 80.72% and the dry weight by 75.63% within one week. The lowest dose required to kill the whole plant was 10 g $l^{-1}$. Coleus powder was injurious to cut leaves of water hyacinth even at 0.1 g $l^{-1}$ dose as it was absorbed directly by the cut leaf, indicating that the dose required to kill the whole plant could still be reduced, if either the natural product or the active principle is formulated for absorption through foliage. 

*Keywords:* Allelopathy; Water hyacinth; Bio-control; *Coleus amboinicus*; Natural product

## 1. Introduction

The aquatic weed, water hyacinth *Eichhornia crassipes* (Mart.) Solms., is one of the most successful colonisers that interferes with agricultural, urban and recreational use of water. In addition to suppressing the diversity of biota in the ecosystem, it results in human health hazards. It is now widespread and recognised as one of the top ten weeds (Holms et al., 1977). Veeranum Lake in the Tamil Nadu state of South India, with its tributaries, forms the major irrigation source of the state, over an area of 18,000 ha, that has been severely infested with water hyacinth. Considering the various uses of the water, biological control has been suggested to control introduced and aggressive weeds dominating large areas (Andres, 1977). Use of insects and fungal pathogens as bio-herbicides is one tactic, but under tropical conditions, use of insects is constrained as the host range is interrupted by complete drying of water in the hot summer. In the monsoon seasons heavy rain-fall can wash away the insects. Fungal pathogens often suffer due to lack of virulence under severe climatic fluctuations, lack of shelf-life and a lack of knowledge of spray techniques. In India, the possibilities of using the allelopathic potential of native herbs as a biocontrol tactic for the control of water hyacinth have been gaining significance.

## 2. Allelopathy on water hyacinth

Chlorotic damage was observed in 12 species of aquatic plants due to treatment with 12 out of 30 isolates of *Penicillium, Aspergillus and Trichoderma*, the degree of damage varying with the type of plant (Charudattan and Lin, 1974). In four of the 12 isolates, oxalic acid was identified as the toxin. These culture solutions, fungal oxalate and pure oxalic acid caused slight chlorosis and root damage in water hyacinth.

Inoculation of five plants of an aquatic herb *Ottelia alismoides* (Linn.) Pers. in large artificial tanks, caused drastic morphological and anatomical changes and resulted in ultimate death in the weed community, within three weeks (Indra and Krishnamurthy, 1984). *Hydrilla verticillata* Royle. was also reported to inhibit the growth of water hyacinth growing along with it (Santiago, 1990).

Dry leaf powder and dry flower powder of *Parthenium hysterophorus* L. at 0.5% (w/v) killed water hyacinth within one month. The inhibitory effects of residues of different parts of *P. hysterophorus* on water hyacinth were shown to be in the order of leaves and flowers > stems > roots. The flowers and leaves of *P. hysterophorus* also had higher total phenolic acid levels in the medium which was responsible for the inhibition (Pandey et al., 1993). Dry powder of an epiphytic plant *Cassytha* sp. at

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1–2% w/v completely killed the leaves and drastically reduced the biomass of *Eichhornia crassipes* within 15 days (Kauraw and Bhan, 1994).

The sesquiterpene lactone Parthenin, one of the major toxins in the obnoxious weed *P. hysterophorus*, was toxic at 50 ppm to the floating water lettuce *Pistia stratiotes* Linn. and lemna *Lemna perpusilla* Torr. and at 100 ppm to water hyacinth. Inhibition of water hyacinth by Parthenin was reported to be associated with decline in water use, root dysfunction, excessive leakage of solutes from roots indicative of massive damage to cellular membranes, loss of dehydrogenase activity in the roots and loss of chlorophyll in leaves (Pandey, 1996a).

Among the 12 allelochemicals, viz., p-hydroxybenzoic acid, anisic acid, salicylic acid, coumaric acid, fumaric acid, tannic acid, gallic acid, chlorogenic acid, vanillic acid, caffeic acid and ferulic acid compared for their relative phytotoxicity on aquatic weeds, p-hydroxy benzoic acid showed the highest activity and was lethal at 50 ppm to all weeds tested, including floating aquatic weeds like salvinia (*Salvinia molesta*), azolla (*Azolla nilotica*), spirodella (*Spirodella polyrhiza*) and lemna (*Lemna paucicostaha*), and submerged weeds like hydrilla (*H. verticillata*), ceratophyllum (*Ceratophyllum demersum*) and najas (*Najas graminea*). However, p-hydroxybenzoic acid was lethal for water hyacinth and water lettuce only at 100 ppm. Water hyacinth (*E. crassipes*) water lettuce (*P. stratiotes*) and water fern (*S. molesta* Baker.) were relatively more tolerant to allelochemicals except for p-hydroxybenzoic acid compared to other floating or submerged weeds (Pandey, 1996b).

## 3. Allelopathy of *Coleus amboinicus* L. on water hyacinth

An Indian medicinal herb *Coleus amboinicus* L. commonly used for curing cold, flu and other such ailments upon raw consumption, showed remarkable activity on water hyacinth among different weeds and herbs tried for their allelopathy on water hyacinth. Dried leaves of this medicinal herb *C. amboinicus* were ground to powder and applied to the water system as a suspension ($30\ g\ l^{-1}$). Death of water hyacinth occurred within 24 h and nearly 100% reduction in biomass was achieved within 9 days (Table 1). However, spraying the natural product over the foliage of water hyacinth at $100\ g\ l^{-1}$ proved ineffective which was attributed to the lack of penetration and absorption of the natural product into the plant system. When applied as a suspension in water the natural product was active, killing the weed even at lower dosages of $12.5\ g\ l^{-1}$, over a fortnight (Kathiresan and Kannan, 1998; Kathiresan, 1999a). In the Philippines, 57

Table 1
Allelopathic inhibition of water hyacinth by different plant species

| Treatments | Fresh weight of water hyacinth (g) | | | | |
|---|---|---|---|---|---|
| | 3 DAT | 6 DAT | 9 DAT | 12 DAT | 15 DAT |
| *Coleus amboinicus* ($30\ g\ l^{-1}$) | 60.00 | 26.00 | 0.00 | 0.00 | 0.00 |
| | *7.77* | *5.14* | *0.70* | *0.70* | *0.70* |
| *Parthenium hysterophorus* ($30\ g\ l^{-1}$) | 61.00 | 27.00 | 0.00 | 0.00 | 0.00 |
| | *7.83* | *5.23* | *0.70* | *0.70* | *0.70* |
| *Cuscuta reflexa* ($30\ g\ l^{-1}$) | 90.00 | 62.00 | 48.00 | 20.00 | 0.00 |
| | *9.50* | *7.89* | *6.95* | *4.52* | *0.70* |
| *Tragia biflora* ($30\ g\ l^{-1}$) | 123.00 | 126.20 | 136.00 | 139.50 | 145.50 |
| | *11.10* | *11.24* | *11.67* | *11.82* | *12.05* |
| *Sodium chloride* ($30\ g\ l^{-1}$) | 100.00 | 85.00 | 69.33 | 60.00 | 50.00 |
| | *10.01* | *9.23* | *8.35* | *7.77* | *7.10* |
| Control | 126.00 | 129.00 | 140.00 | 143.00 | 149.00 |
| | *11.23* | *11.37* | *11.84* | *11.96* | *12.21* |
| SED | *0.43* | *0.38* | *0.35* | *0.34* | *0.33* |
| CD ($p = 0.05$) | *0.96* | *0.86* | *0.79* | *0.77* | *0.77* |
| *C. amboinicus* ($12.5\ g\ l^{-1}$) | 95.40 | 57.40 | 22.90 | 0.00 | |
| | *9.78* | *7.60* | *5.03* | *0.70* | |
| *P. hysterophorus* ($12.5\ g\ l^{-1}$) | 103.20 | 61.90 | 24.80 | 0.00 | |
| | *10.17* | *7.89* | *5.03* | *0.70* | |
| *C. reflexa* ($12.5\ g\ l^{-1}$) | 125.50 | 101.20 | 86.01 | 73.10 | |
| | *10.62* | *10.07* | *9.29* | *8.57* | |
| *T. biflora* ($12.5\ g\ l^{-1}$) | 141.44 | 176.86 | 212.23 | 275.90 | |
| | *11.90* | *13.30* | *14.57* | *16.61* | |
| Control | 141.61 | 176.10 | 210.90 | 279.05 | |
| | *11.92* | *13.28* | *14.53* | *16.71* | |
| SED | *0.50* | *0.46* | *0.43* | *0.42* | |
| CD ($p = 0.05$) | *1.22* | *1.14* | *1.05* | *1.05* | |

Table 2
Percentage reduction in the biomass of water hyacinth due to *C. amboinicus*

| Treatments | Fresh weight | | |
|---|---|---|---|
| | Shoot | Root | Total fresh weight |
| *Coleus amboinicus* (40 g $l^{-1}$) | 76.49 | 89.48 | 80.72 |
| *Coleus amboinicus* (20 g $l^{-1}$) | 68.50 | 76.74 | 71.18 |
| *Coleus amboinicus* (10 g $l^{-1}$) | 66.31 | 74.96 | 69.13 |
| Sodium chloride (40 g $l^{-1}$) | 36.25 | 3.28 | 2.51 |
| | Dry weight | | |
| | Shoot | Root | Total dry weight |
| *Coleus amboinicus* (40 g $l^{-1}$) | 70.79 | 88.79 | 75.63 |
| *Coleus amboinicus* (20 g $l^{-1}$) | 57.46 | 75.00 | 62.18 |
| *Coleus amboinicus* (10 g $l^{-1}$) | 53.96 | 48.27 | 52.43 |
| Sodium chloride (40 g $l^{-1}$) | 14.28 | 1.72 | 10.90 |

different compounds, including α humulene, carvacrol, thymol, α-pinene and α-terpine were identified from *C. amboinicus*. Some of these compounds showed a high degree of biological activity, proving lethal to several microorganisms, insects and snails (Vasquez et al., 1999).

Coleus powder was shown to inhibit algal growth in static-water systems (Kathiresan, 1998). Various dosages of the natural products of coleus were evaluated for their inhibitory effect on water hyacinth (Kathiresan, 1999b) through specific bio-assay methods, involving whole plants and cut leaves, separately (Table 2 and Fig. 1).

## 4. Magnitude of inhibition by *C. amboinicus*

All three dosages of the natural product of *C. amboinicus*, killed whole water hyacinth plants (Kathiresan, 1999a, b). The highest dosage of 40 g $l^{-1}$ and medium dosage of 20 g $l^{-1}$ caused death within 24 h whereas 10 g $l^{-1}$ took 9 days to impart a complete kill (Table 2). This result indicates that the allelopathic potential of *C. amboinicus* is greater than that with *P. hysterophorus* reported by Pandey et al. (1993) as the latter took one month to kill the weed. A drastic reduction of 80% in fresh weight of the whole plant was observed within one week after treatment with 40 g $l^{-1}$ of *C. amboinicus*. Sodium chloride at 40 g $l^{-1}$, the standard desiccant, caused a reduction of only 25% one week after treatment. These observations indicate that the inhibitory action is due not only to water loss but also physiological effects. The 75.63%, reduction in dry weight indicates allelopathic injury caused. Data for reduction in fresh and dry weight of roots (Table 2) suggest a higher magnitude of inhibition on the root system. This is in agreement with the earlier report on the allelopathic potential of *P. hysterophorus* on water hyacinth (Pandey, 1996a). Severe reduction in the biomass of water hyacinth consequent to treatment makes *C. amboinicus* a candid bio-control agent for managing water hyacinth. The risk or hazard of decomposing plant tissue in the water body and subsequent deoxygenation that occurs in herbicidal control of water hyacinth might not occur with the use of *C. amboinicus*.

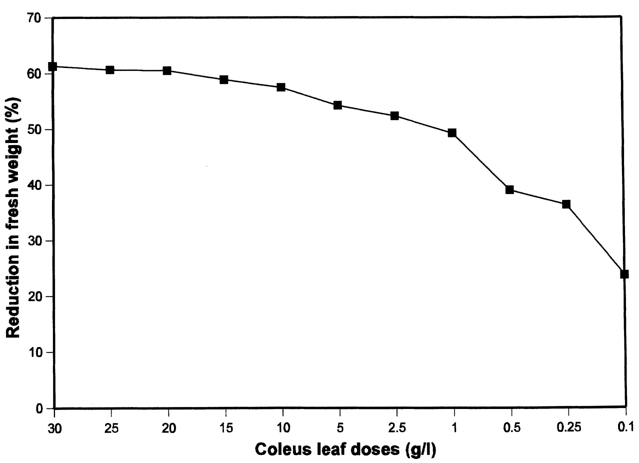


Fig. 1. Percentage reduction in fresh weight of water hyacinth leaves after 72 h of treatment with graded dosages of *C. amboinicus*.

## 5. Feasibility for use as a bio-control tool

The lowest dosage used (10 g $l^{-1}$) equivalent to 1% concentration may seem high but is similar to that widely used for therapeutic purposes. Earlier findings had shown that water hyacinth is comparatively tolerant to allelochemicals as 100 ppm of p-hydroxybenzoic acid was required to cause death whereas 50 ppm concentration was sufficient for other weeds (Pandey, 1996b). Similarly, fungal oxalates and pure oxalic acid that caused considerable and severe chlorosis in other aquatic weeds, induced only slight chlorosis in water hyacinth (Charudattan and Lin, 1974). Under these circumstances, a crude extract of a safe medicinal herb *C. amboinicus* causing death of water hyacinth within 9 days and 52.43% reduction in biomass within one week under natural conditions, may prove to offer a good lead for an efficient bio-control option. Furthermore, a stable inhibitory response caused by coleus powder applied to cut leaves of water hyacinth under controlled conditions in static water at dosages ranging from 30 g $l^{-1}$ down to 1.0 g $l^{-1}$ (Fig. 1) reduced fresh weight from 61 to 49%, respectively, and showed that coleus dry powder could exhibit adequate allelopathy at low dosages. The lowest dosage compared, 0.1 g $l^{-1}$ (equivalent to 100 ppm concentration) also inhibited the weed leaf, inflicting a fresh weight reduction of 24%. This observation reveals that the dosage of coleus powder to kill water hyacinth could still be reduced drastically, if either the natural product or the active principle is formulated to enhance absorption through foliage. When sources of irrigation water in India recede during the summer, the smaller quantity of water is more accessible for treating with coleus at $10\,g\,l^{-1}$ or 1% w/v. Coleus may also hold promise for bio-control of water hyacinth on small farms.

The coleus powder has also proved safe for other crops such as rice and cucumber with no significant inhibition on either the seed germination or biomass of the crops (Kathiresan, 1999b). This could be due to lack of seed germination inhibitors in the coleus powder and degradation of the allelopathic compounds by the soil.

## 6. Conclusion

Using allelopathic plants and their products, offers promising scope for the biological control of water hyacinth, the biomass of which is drastically reduced by treatment with dry powder of *Coleus amboinicus*. The quick action reduces the risk of decomposition of plants within the water system and subsequent deoxygenation is also reduced. The technique is likely to be more suitable on small areas of water during summer when the water level has receded.

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