SUMMARY
Allelopathy generally refers to the detrimental effects of higher plants of one species (the donor) on the germination, growth and development of another species (the recipient). It can be separated from other mechanisms of interference because the detrimental effect is exerted through release of chemical inhibitors known as allelochemicals by the donor species to the plant environment. It is therefore different from competition which involves the removal or reduction of some growth factors from the environment that are required by some other plant, sharing the same habitat. Confusion has arisen in the literature because some biologists consider allelopathy to be a part of competition. This confusion can be lessened by using the term interference to refer to the overall influence of one plant on another (Muller 1969).

In many plant ecosystems, plants tend to pattern themselves as pure stands or as individuals spaced in rather specific densities or configurations. These patterns often can not be adequately explained by competition alone and are probably caused by a combination of factors including allelopathy. With regard to agroecosystems, weeds always interact with crop plants primarily by competing for light, water and nutrients and there may be chemical interactions between weeds and crops which influence the agricultural production. The potential allelopathic effects depend on the relative rates of addition of the allelochemicals to the environment and decomposition or inactivation (Burgos-Leon, 1976; Burgos-Leon et al., 1980; Lydon and Duke, 1989; Duke, 1990, 1991). It is in this context, the present investigation has been aimed to study the three possible interactions viz., weed on weed, weed on crop and autotoxicity. The possible allelopathic interactions were recorded as per the following schedule:

<table>
<thead>
<tr>
<th>Name of the association</th>
<th>Plant species selected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Weed on weed</td>
<td>P. zeylanica - A. tricolor</td>
</tr>
<tr>
<td>2. Weed on crop</td>
<td>P. zeylanica - horsegram</td>
</tr>
<tr>
<td>3. Autotoxicity</td>
<td>P. zeylanica - P. zeylanica</td>
</tr>
</tbody>
</table>

The sources of phytotoxicity employed in the experiments are root, shoot and seed extracts, root exudates, root and shoot residues of P. zeylanica.

Aqueous root, shoot and seed extracts were prepared from P. zeylanica and tested on A. tricolor and horsegram. Higher concentrations of all extracts significantly inhibited the germination and growth of test plants while the lower concentrations, however, stimulated. Among the three developmental stages, the extracts prepared from the mature stage of donor plant significantly inhibited the germination and growth followed by flowering and vegetative stages. The root exudates
collected from 20 day-old *P. zeylanica* seedlings significantly inhibited the germination and growth of test plants which was alleviated by decreasing the days. Studies on intraspecific effect also indicated that aqueous extracts (root, shoot and seed) significantly inhibited the germination and seedling growth of the same plant. Root and shoot residues of *P. zeylanica* also exhibited the same effect. In all the cases the inhibition on root length was more pronounced than shoot. The higher concentrations of root and shoot residues of *P. zeylanica* significantly reduced the leaf area, while it was enhanced at lower concentrations. The reduction in leaf area was maximum in 15 day-old plants followed by 30 and 45 day-old plants.

The aqueous extracts, exudates and residues of *P. zeylanica* adversely affected the dry mass production of root and shoot of test plants and their seedlings resulting in decreased mobilization of reserved food material from the cotyledons is concomitant with increase in cotyledonary dry mass.

The protein content also increased in cotyledons, while it decreased in root and shoots of horsegram seedlings treated with higher concentrations of extracts. The lower concentrations, however, decreased the cotyledonary protein content whereas, it increased in root and shoot of test plants. The residues of *P. zeylanica* also exhibited the same effect. The effect of aqueous extracts and residues of *P. zeylanica* on total free amino acids content in *A. tricolor* and horsegram was evaluated. The higher concentrations of extracts decreased the amino acid levels in cotyledons of horsegram seedlings. However, the lower concentrations increased the amino acid levels in root and shoots. The increase in amino acid levels was maximum in 15 day-old plants followed by 30 and 45 day-old plants treated with higher concentrations of *P. zeylanica* residues, while decreased at lower concentrations.

The studies on the photosynthetic pigments revealed that the total chlorophylls, chlorophyll a and chlorophyll b levels were markedly reduced in test plants treated with higher concentrations of extracts / residues of *P. zeylanica*. The lower concentrations, on the contrary, elevated the photosynthetic pigment levels. A positive correlation existed between the chlorophyll content and shoot growth of test plants.

The levels of carbohydrate fraction was estimated in *A. tricolor* and horsegram treated with *P. zeylanica* extracts / residues. Significant increase in reducing sugars, decrease in non-reducing sugars and starch was observed in roots and shoots of test plants / seedlings, treated with higher concentrations. At lower concentrations, decrease in reducing sugars and increase in non-reducing sugars and starch were observed and vice versa effect in cotyledons.
Germination of seed depends on enzymatic hydrolysis of stored products like proteins and starch in cotyledons. The decrease in sugars and increase in starch in cotyledons of treated seedlings may directly correlate with the germination and amylase activity. Germination might partly be inhibited through the inhibition of amylase activity. Inhibition in the activity of amylase might have resulted in increased levels of starch of test plants leading to the non-degradation of reserve material especially starch in the cotyledons. There is a correlation between decreased levels of starch and decrease in dry weight. The decrease in chlorophyll content in turn might have resulted in loss in net photosynthetic efficiency resulting in decreased starch levels that ultimately led to the reduction in drymass.

The levels of plant nutrients like magnesium, calcium and potassium were altered when compared to the control in test plants treated with residues of *P. zeylanica*. The levels of magnesium and potassium content significantly decreased whereas the calcium levels increased when treated with higher concentrations and vice versa at lower concentrations. The alterations in the nutrient levels may be due to physiological disturbances caused by the allelochemicals. The nutrient imbalance may affect the growth and can be implicated as a causal factor in growth inhibition. There is a positive correlation between leaf area, dry weight and nutrient imbalance in treated plants and it is one of the important factors in growth regulation.

The present investigation reveals that the extracts, exudates and residues of *P. zeylanica* have strong inhibitory on the test plants. The root extracts / residues exhibited more pronounced effect than shoot which prompted us to undertake the study of fractionation and characterization of allelochemicals present in the aqueous extract according to Weston et al (1987). The aqueous root extract was fractionated with five solvents based on polarity. The inhibitory activity of these fraction (1.0 mg/ml) towards the germination and radicle length of both test plants followed the order: hexane > diethyl ether > n-butanol > dichloromethane > ethylacetate. Since the hexane fraction was more inhibitory to the test plants, it was further purified and characterized for the allelochemicals. A single compound was isolated from the hexane fraction and characterized as **Plumbagin** by spectral analysis viz., C.H.N. analysis, mass spectra, $^1$H-NMR and $^{13}$C-NMR spectras. Further, different concentrations (0.5 - 1.0 mg/ml) of plumbagin was also bioassayed using the test plants.
Summary

From the results of the present investigation it is quite evident that *P. zeylanica* population offers stiff competition with regard to nutrients and moisture in crop fields. Besides, they exhibit allelopathic influence and inhibit the germination and protrusion of seedling establishment. The effect on germination may be the easiest to identify but effects on growth may be the most common under field conditions. Hence, there is a need to avoid the weed (*P. zeylanica*) which interferes with horsegram crop plants. Besides, it was also strongly inhibitory to *A. tricolor* weed population. Further, the allelochemical compound, plumbagin is recommended for evaluation studies to understand the natural herbicidal properties.
1 & 2: Effect of root (PR) and shoot (PS) extracts of Plumbago zeylanica on seedling growth of Amaranthus tricolor on 5th day.
3 & 4: Effect of root (PR) and shoot (PS) extracts of P. zeylanica on seedling growth of horsegram on 5th day.
5 & 6: Effect of root (PR) and shoot (PS) extracts of *P. zeylanica* on seedling growth of *Amaranthus tricolor* on 7th day.
7 & 8: Effect of root (PR) and shoot (PS) residues of *P. zeylanica* on plant growth of *Amaranthus tricolor* (15 day-old).
9 & 10: Effect of root (PR) and shoot (PS) residues of *P. zeylanica* on plant growth of *Amaranthus tricolor* (30 day-old).
11 & 12: Effect of root (PR) and shoot (PS) residues of *P. zeylanica* on plant growth of *Amaranthus tricolor* (45 day-old).
13 & 14: Effect of root (PR) and shoot (PS) residues of *P. zeylanica* on plant growth of horsegram (15 day-old).
15 & 16: Effect of root (PR) and shoot (PS) residues of *P. zeylanica* on plant growth of horsegram (30 day-old).
17 & 18 : Effect of root (PR) and shoot (PS) residues of *P. zeylanica* on plant growth of horsegram (45 day-old).
19 : Effect of Hexane fraction of *P. zeylanica* root on germination of *Amaranthus tricolor* at 1 mg/ml concentration. (C = Control; PRF-H = *P. zeylanica*, Hexane Root Fraction).

20 : Effect of Hexane fraction of *P. zeylanica* root on germination of horsegram at 1 mg/ml concentration. (C = Control; PRF-H = *P. zeylanica*, Hexane Root Fraction).