TREE–CROP INTERACTIONS IN THE AGROFORESTRY SYSTEM OF MIZORAM

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Received April 2007

KUMAR, M., LAKIANG, J. J. & SINGSHI, S. 2008. Tree–crop interactions in the agroforestry system of Mizoram. The study explored the economic cultivation of tree species having least allelopathic effects and are useful for agricultural combination in agroforestry. In both studies the tree species were, in general, toxic to the growth of agricultural crops. It was found that trees in order of suitability to crops were *Anthocephallus chinensis* > *Albizzia procera* > *Aporosa octandra* and in order of crop resistance to trees were *Oryza sativa* > *Glycine max* and *Brassica campestris*. However, another study concluded that the most suitable tree for crops was *Artocarpus heterophyllus* followed by *Alnus nepalensis* and *Emblica officinalis* and the most toxic crop for trees was *Phaseolus vulgaris* followed by *O. sativa* and *Pisum sativum*.

Keywords: Toxic, allelochemical, leachate, inhibition, stimulation

KUMAR, M., LAKIANG, J. J. & SINGSHI, S. 2008. Interaksi pokok–tanaman dalam sistem hutan tani di Mizoram. Kajian ini memeriksa kesesuaian penanaman spesies pokok yang mempunyai kesan alelopatik yang paling sedikit dan penggunaannya dalam hutan tani. Kedua-dua kajian menunjukkan bahawa spesies pokok secara umumnya toksik kepada tanaman pertanian. Susunan kesesuaian pokok terhadap tanaman ialah *Anthocephalluus chinensis* > *Albizzia procera* > *Aporosa octandra* manakala susunan ketahanan tanaman kepada pokok ialah *Oryza sativa* > *Glycine max* dan *Brassica campestris.* Kajian lain mendapati *Artocarpus heterophyllus* paling sesuai ditanam diikuti oleh *Alnus nepalensis* dan *Emblica officinalis.* Tanaman yang paling toksik kepada pokok ialah *Phaseolus vulgaris* diikuti oleh *O. sativa* dan *Pisum sativum.*

INTRODUCTION

Pressure on agriculture lands has increased manifolds due to increasing population, erosion, flood damage, salinization, alkalinization, advance desert, industrialization and urbanization. These then necessitated acquisition of more and more land under cultivation to meet the increasing demand for food, fodder, vegetable, fuelwood, timber and medicines. To meet the demand for food production, a management system needs to be devised that is capable of producing food from marginal agricultural land and also capable of maintaining and improving the quality of the producing environment. Under these circumstances, agroforestry is the best means for sustainable agriculture, which not only feeds our basic needs but also helps in the promotion of a better environment. Agroforestry practices are the intentional combination of trees with crops, which involve intensive management of the interaction between the components as an integrated agroecosystem. The main aim of agroforestry system is to optimize positive interactions between various biological components such as trees/shrubs/crops/animals and the physical environment to obtain more diversified and sustainable production from all available land resources under the prevailing ecological and socio-economic conditions (Lundgren & Raintree 1983).

The success of any agroforestry system relies heavily on exploitation of the component interactions due to difference in growth pattern and resource requirement of the components, although crop inhibition in association with trees are not uncommon. Such inhibitions are primarily caused by shade effect as well as below root zone ground competition for nutrients and water. In same cases inhibitory effects may also result from allelochemicals secreted by some tree species (allelopath). There is a great deal of evidence that plant–plant interactions can go well beyond direct competition for shared resources such as light, water, nutrients and space (Schenk *et al.* 1999, Callaway 2002).

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In the agroforestry system of Mizoram, a number of principal trees and crops are grown. In Mizoram production of agricultural crops is the main source of subsistence because more than 80% of the population depends on agriculture. Combining trees, crops and livestock is a long standing practice and the benefits are on a sustainable basis. It has been observed that members of the farming community are starting to neglect tree species within the farming system. The basic cause of neglecting trees are reducing the production of agricultural crops. The agricultural crops in this region are basically grown on terraces and steep slope under tree species. Washing or leaches of tree chemicals may have some allelopathic effects on understorey crops. Therefore, this project was conducted to study the allelopathic effects of trees on crops.

MATERIALS AND METHODS

The experiment was carried out at the Department of Forestry, Mizoram University campus (92° 38' to 92° 42' E and 23° 42' to 23° 46' N, 900 m asl). Mizoram is hilly in its topography, consisting of steep hills and precipitous gorges. Summer temperature ranges from 21 to 33 °C and winter, 11 to 23 °C. Premonsoon rains occur in March and April and actual monsoons commence from June and continue until October. The annual rainfall ranges from 2000 to 2500 mm, mainly due to the south-western monsoon during summer and north-eastern monsoon during late autumn. According to the survey of Agricultural Department Aizawl, the soil has three orders, namely Utisol, Inceptisol and Entisol. The soil is acidic in nature, having low base saturation with low productivity potential and varies from sandy loam, clayey loam to clay.

Keeping in view the problems of farmers neglecting trees from agricultural fields and their adverse effects on crops for suitable tree crop combinations, two separate combinations of trees and crops were studied.

Experiment I. Effects of *Aporosa octandra, Anthocephallus chinensis* and *Albizzia procera* on *Oryza sativa, Brassica campestris* and *Glycine max*

(a) In bioassay culture, mature leaf and dry natural flaked off bark of middle-aged trees were collected. The leaf and bark were sun dried and ground separately in a mechanical grinder. A powder sample of 2 g of each component (leaf and bark) was weighed, added to 100 ml of double distilled water and kept for 24 hours at room temperature (25–30 °C). The resulting brownish and dark solutions were filtered through three layers of Whatman No. 1 filter paper and stored in a dark place in conical flasks until required. The effects of aqueous extracts on germination and radicle length were tested by placing 25 seeds of each test crop in Petri dishes (four replicates) containing three layers of filter paper saturated with the aqueous extracts. A separate control series was set up using distilled water. Moisture in the Petri dishes was maintained by adding aqueous extracts or distilled water as required. The number of seeds germinated was counted everyday for seven days.

(b) In pot culture, there were three factors, *viz.* three tree crops, three test crops and four growing media were sown in shallow pots (size 9 × 9 cm) using the following germination medium having 1 kg soil and five plants of test crops in each poly pot as:
   (1) Top soil (collected from 0 to 5 cm deep and 50 cm radius of tree bole).
   (2) Garden soil (from experimental garden) + sun-dried leaf powdered (2 g/pot).
   (3) Garden soil (from experimental garden) + sun-dried bark powdered (2 g/pot).
   (4) Garden soil alone served as control.

In pots, leaf and bark powder (leachates) of trees were mixed in the upper layer of the soil. Each crop was planted in soil under four treatments of each tree and replicated four times, and each pot contained five plants. The pots were watered regularly and seed germination was recorded after seven days of sowing. The growth attributes such as root and shoot lengths of test crops were recorded 90 days after sowing.

Experiment II. Effects of *Alnus nepalensis, Artocarpus heterophyllus* and *Emblica officinalis* on *Oryza sativa, Phaseolus vulgaris* and *Pisum sativum*

(a) In bioassay culture, the experiment methodology was followed as in experiment

Ia, except for per cent concentration, number of seeds and replication. In this experiment powdered sample of leaf were used of 1 and 2 g for 1 and 2% concentration. Germination and radicle length were taken by placing 10 seeds uniformly in Petri dishes. This was replicated five times.

(b) In pot culture, there were three factors, *viz.* three tree crops and three test crops and three growing media were sown in pots (size 9 × 9 cm) using the following germination medium having 1 kg soil and five plants of test crops in each poly pot as:
   (1) Garden soil (from experimental garden) + sun dried leaves powdered (1 g/pot).
   (2) Garden soil (from experimental garden) + sun dried leaves powdered (2 g/pot).
   (3) Garden soil alone served as control.

The experiment for pot culture was also conducted similarly to experiment Ib. The growth attributes such as shoot length and root length of test crops were recorded 60 days after sowing.

RESULTS

Effects of *Aporosa octandra, Anthocephallus chinensis* and *Albizzia procera* on *Oryza sativa, Brassica campestris* and *Glycine max*

In bioassay culture, leaf and bark extracts of *A. octandra* inhibited germination of all food crops compared with the control (Figure 1). Among the crops, *O. sativa* was the most resistant to leaf and bark extracts and the average (bark and leaf) germination was 87% followed by *G. max* (82.5%) and *B. campestris* (10%). *Anthocephallus chinensis* was toxic to all food crops. However, the germination of *O. sativa* was most susceptible to *A. procera* (Figure 1). The radicle length of all test crops decreased in all tree types compared with the control except for *G. max* which was stimulated 30.03% over the control in bark aqueous extract of *A. chinensis* (Figure 2).

In pot culture, the germination of crops decreased under all growth media of *A. octandra* compared with the control. The germination of *O. sativa* was maximum in top soil followed by soil mulched with bark and soil mulched with leaf (Figure 3). Similar decreasing order of germination of *G. max* was in topsoil > soil mulched with bark > soil mulched with leaf and for *B. campestris* soil mulched with bark > top soil > soil mulched with leaf.

The germination of crops also reduced in *A. chinensis* (Figure 3). The maximum (72.5%) germination of *O. sativa* was in soil mulched with leaf and minimum (62.5%) in soil mulched with bark. However, the germination of *B. campestris* was most restrained (43.3%) in soil mulched with leaf. *Glycine max* attained maximum germination in topsoil followed by soil mulched with bark and soil mulched with leaf.

Albizzia procera also depressed the germination of all crops (Figure 3). In *O. sativa,* the highest reduction (22.9%) of germination was in soil mulched with leaf. The per cent germination of *B. campestris* was recorded (62.2%) same as soil mulched with leaf and top soil, whereas, in bark was 65%. *Glycine max* showed maximum germination in soil mulched with leaf compared with soil mulched with bark and topsoil (Figure 3).

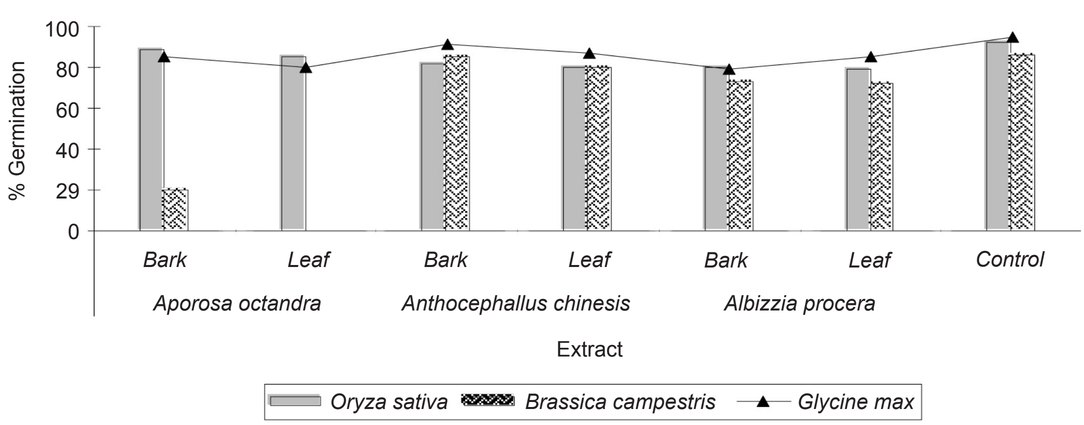

Figure 1 Germination of *Oryza sativa, Brassica campestris* and *Glycine max* in bioassay culture

Root and shoot lengths of *O. sativa*, *B. campestris* and *G. max* were depressed significantly ($p < 0.05$) under all growth media of *A. octandra* when compared with the control. Similarly, in *A. chinensis* and *A. procera*, root and shoot lengths of *O. sativa* were stimulated significantly ($p < 0.05$) under all growth media, and *B. campestris* and *G. max* depressed ($p < 0.05$) compared with the control (Figure 4).

Effects of *Alnus nepalensis*, *Artocarpus heterophyllus* and *Emblica officinalis* on *Oryza sativa*, *Phaseolus vulgaris* and *Pisum sativum*

In bioassay culture (Figure 5), the germination of *O. sativa* was stimulated in both 1 and 2% aqueous extracts of *A. nepalensis*, depressed in 2% aqueous extract of *A. heterophyllus* and *E. officinalis* but was not toxic to 1% aqueous extract of *E. officinalis*. Similarly, *P. vulgaris* grown under the same tree species showed no toxic effects in 1% aqueous extract of *A. nepalensis* and, 1 and 2% aqueous extracts of *A. heterophyllus,* while germination was reduced under *E. officinalis* compared with the control. All trees had adverse impact on germination of *P. sativum*, which was severely depressed.

The radicle length of *O. sativa* was restrained significantly in all aqueous extracts of trees compared with the control (Figure 6). The maximum radicle length of *Oryza sativa* was 4.17 cm in 1% of *A. nepalensis* and minimum (1.29 cm) in 2% of *E. officinalis*. Similarly, *P. vulgaris* and *P. sativum* had significantly reduced radicle length in 1 and 2% aqueous extracts of all tree species. The radicle length of all crops decreased with increased aqueous concentration.

In pot culture, the germination of *O. sativa*, *P. vulgaris* and *P. sativum* was depressed compared with the control (Figure 7). Among the crops (irrespective of trees and per cent concentration), *P. vulgaris* was the least toxic followed by *O. sativa* and *P. sativum.* Similarly, per cent germination under tree species (irrespective of crops) was highest in 1% aqueous extract of *A. nepalensis* and lowest in 2% extract of *A. heterophyllus.*

All crops had decreased shoot length in higher concentration of leaf leachates (Figure 8). Among the tree species, the maximum shoot and root lengths of *O. sativa* were in 1% leaf leachates of *A. nepalensis*. However, minimum length of short was in 2% *A. nepalensis* and root in 2% *E. officinalis*. *Phaseolus vulgaris* attained highest shoot length in 1% leaf leachates of *A. nepalensis* followed by *E. officinalis* and *A. heterophyllus.* The lowest shoot and root lengths were evident in *P. sativum.*

DISCUSSION

Effects of *Aporosa octandra*, *Anthocephallus chinensis and Albizzia procera* on *Oryza sativa*, *Brassica campestris* and *Glycine max*

In the bioassay culture, the leaf and bark aqueous extracts of trees were toxic to the food crops. Based on the average per cent germination of food crops (irrespective of trees and source of extract), *G. max* (84.5%) was the most resistant crop followed by *O. sativa* (82.5%) and *B. campestris* (55%). However, irrespective food crops, *A. chinensis* (84.27%) was the most favourable tree followed by *A. procera* (78%) and *A. octandra* (59.8%). Based on radicle length (irrespective of trees and source of extract), *G. max* attained greatest radicle length (8.42 cm) followed by *O. sativa* (4.72 cm) and *B. campestris* (2.95 cm). Among the trees (irrespective of crops), the highest radicle length of crops was in *A. chinensis* (6.44 cm) followed by *A. procera* (6.25 cm) and *A. octandra* (3.39 cm).

In pot culture, the germination of *B. campestris* was severely depressed under *A. octandra* and *A. chinensis*, whereas *A. procera* had the least toxic effect. On the other hand, the germination of *O. sativa* and *G. max* was restrained under all tree species. The average root and shoot lengths of *O. sativa* were depressed highly under *A. octandra* but *A. procera* and *A. chinensis* stimulated it. The shoot and root lengths of *G. max* and *Brassica campestris* were depressed significantly under growth media of all trees.

Effects of *Alnus nepalensis*, *Artocarpus heterophyllus* and *Emblica officinalis* on *Oryza sativa*, *Phaseolus vulgaris* and *Pisum sativum*

Among the crops in the bioassay culture, the highest germination was in *P. vulgaris*. Similarly, radicle growth was also highest for *P. vulgaris*. Between the crops, in order of toxicity, the most resistant was *P. vulgaris,* followed by *O. sativa* and *P. sativum.*

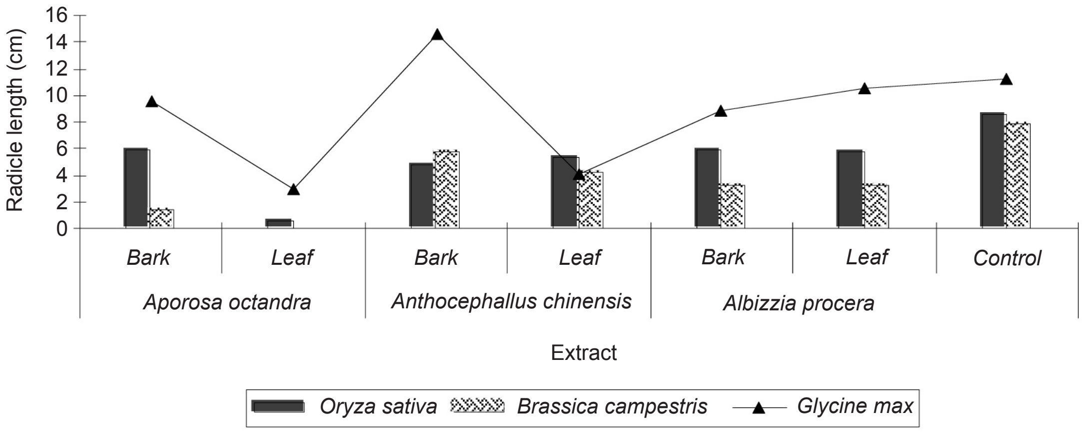

Figure 2 Radicle length of *Oryza sativa, Brassica campestris* and *Glycine max* in bioassay culture

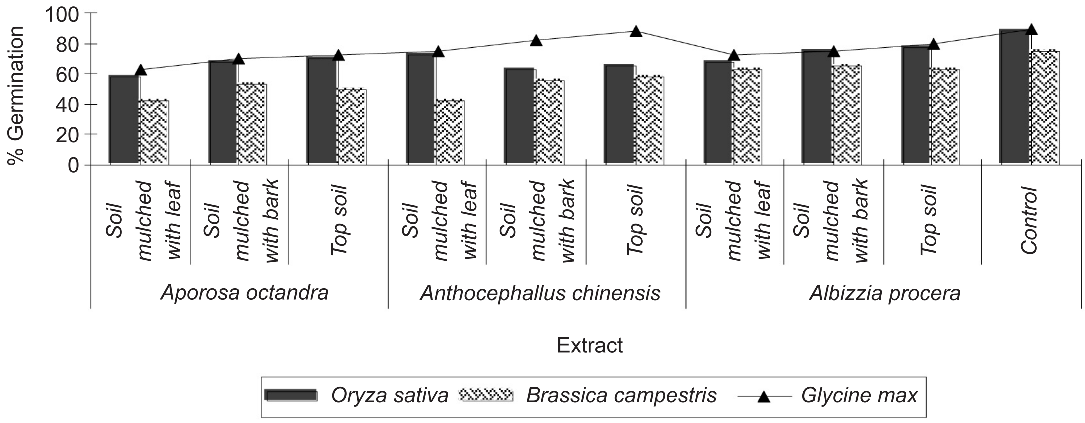

Figure 3 Germination of *Oryza sativa, Brassica campestris* and *Glycine max* under different growth media of trees in pot culture

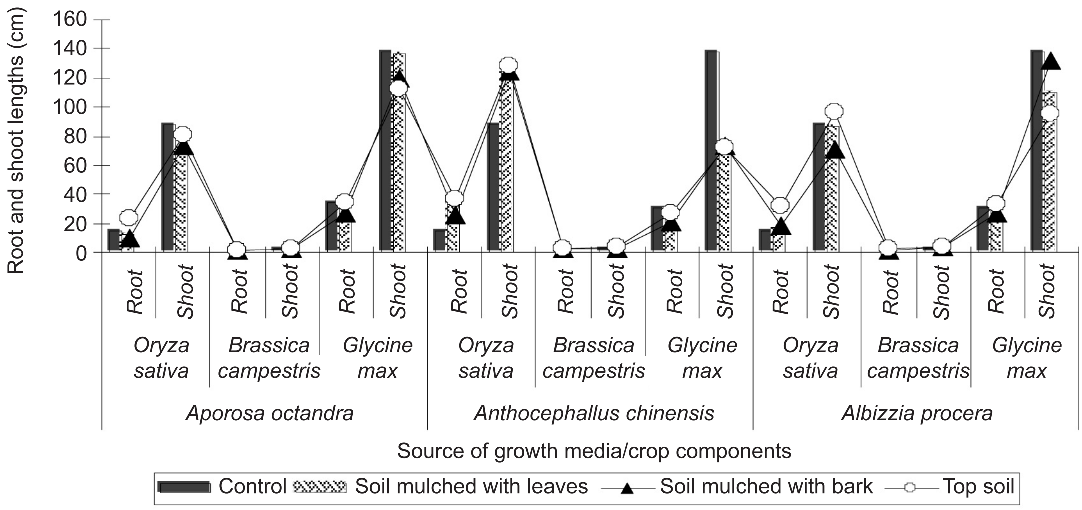

Figure 4 Root and shoot length of *Oryza sativa, Brassica campestris* and *Glycine max* under different growth media of trees in pot culture

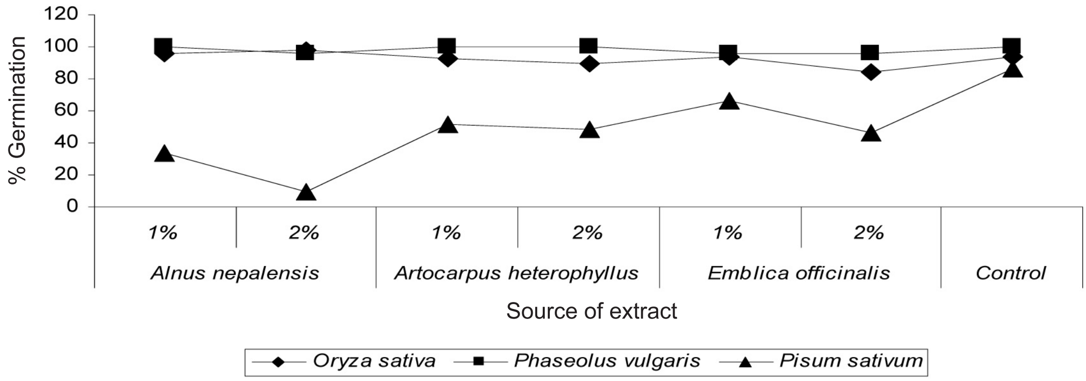

Figure 5 Germination of *Oryza sativa, Phaseolus vulgaris* and *Pisum sativum* in bioassay culture

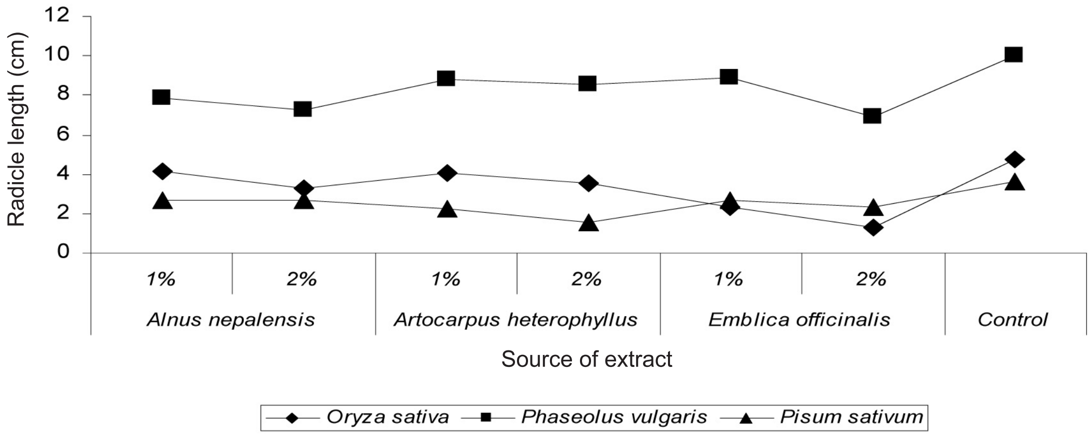

Figure 6 Radicle length of *Oryza sativa, Phaseolus vulgaris* and *Pisum sativaum* in bioassay culture

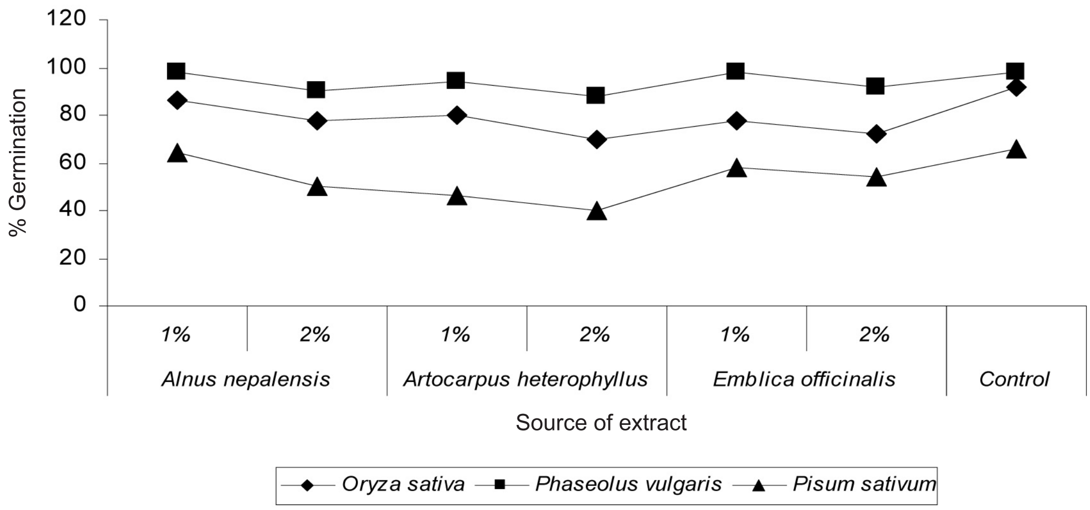

Figure 7 Germination of *Oryza sativa, Brassica campestris* and *Glycine max* under different concentrations of extracts in pot culture

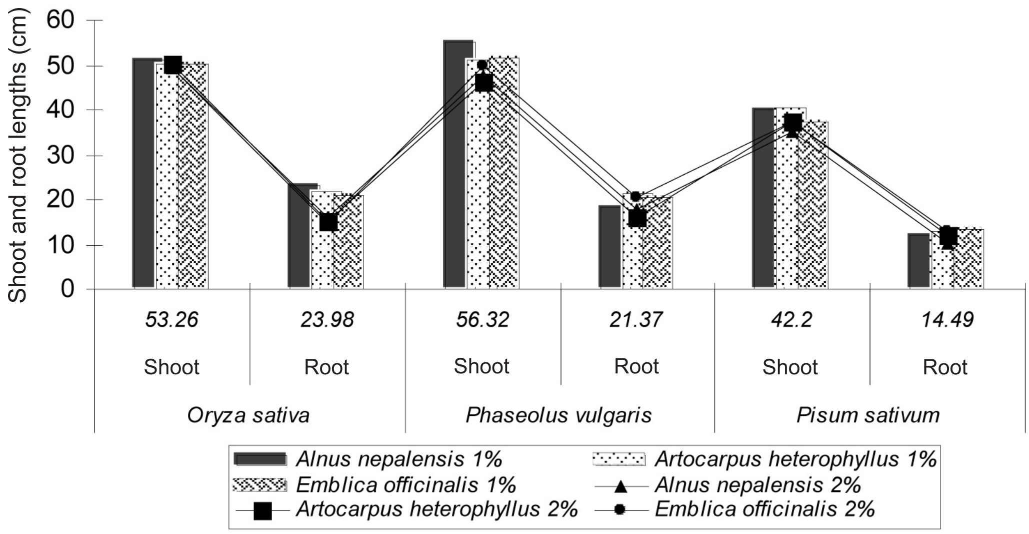

Figure 8 Shoot and root lengths of *Oryza sativa, Brassica campestris* and *Glycine max* under different concentrations of trees in pot culture at 60 days after sowing. Values below the bars indicated control values.

In pot culture the highest per cent germination was in *P. vulgaris, O. sativa* and *P. sativum.* Based on the average shoot and root lengths of crops (irrespective of per cent concentration and trees), the order was *P. vulgaris* > *O. sativa* > *P. sativum.* In terms of tree suitability for crops, the order was *A. heterophyllus* > *A. nepalensis* > *E. officinalis.*

Singh and Bawa (1982) found that leaf leachates of *Eucalyptus globulus* had inhibitory effect on seed germination of *Glaucium flavus.* A number of other species have also been reported with allelopathic effects on plant growth. They are *Celtis laevigata, Rhododendron albiflorum, Grevillea robusta, Quercus falcata, Quercus alba* (Rice 1974, 1979), *Pinus roxburghii, Cedrus deodara, Quercus leucotrichophora, Myrica esculenta* (Melkania 1983). Kaletha *et al.* (1996) also reported similar observation for aqueous extract of leaves and bark of *Grewia oppositifolia, Ficus roxburghii, Bauhinia variegata* and *Kydia calycina* on test crops *Echinochloa frumentacea, Eleusine coracana, Zea mays, Vigna unguiculata* and *Glycine max.* They found that the bark and leaf aqueous extracts of tree species were most toxic to food crops. Similarly, Bhatt and Chauhan (2000) found allelopathic effects of *Quercus* species on *Triticum aestivum, Brassica campestris* and *Lens culinaria.* It suppresses the germination, plumule and radicle lengths of all crops under leaf and bark extracts.

CONCLUSIONS

In experiment I, in terms of suitability of trees for food crops, the order was A. *chinensis* > *A. procera* > *A. octandra*, while that of crops to trees was *O. sativa* > *G. max* and *B. campestris.* For experiment II, the order of suitability of trees for crops was *A. heterophyllus* > *A. nepalensis* > *E. officinalis.* For toxicity, irrespective of tree and per cent concentration, *P. vulgaris* attained maximum average shoot and root lengths followed by *O. sativa* and *P. sativum.* Therefore, the toxicity of crops to trees was *P. vulgaris* > *O. sativa* > *P. sativum.*

ACKNOWLEDGEMENTS

The authors are thankful to the Mizoram University, Aizawl, for providing minor financial assistance and to B. Gopichand, Head of Forestry, for providing the necessary facilities in the laboratory.

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