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Studies on herbicidal activity of parthenin, a constituent of *Parthenium hysterophorus*, towards billgoat weed (*Ageratum conyzoides*)

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Parthenin, a constituent of *Parthenium hysterophorus*, was evaluated for herbicidal activity against *Ageratum conyzoides* (billgoat weed) under *in vitro* conditions. It inhibited/retarded germination of *A. conyzoides* at concentrations ranging from 0.02 to 0.1 mg/ml. Radicle elongation and seedling length were severely reduced. The germination of wheat, however, remained unaffected at similar concentrations. The study, therefore, paves a way for possible exploitation of parthenin as a selective herbicide.

NATURAL plant products are fast catching attention of scientists for their use as herbicides to control weeds[1]. Unlike synthetic herbicides, they do not cause pollution and undesired side effects on environment. Sesquiterpene lactone parthenin – a constituent of the noxious weed *Parthenium hysterophorus*[2,3], has been shown to be phytotoxic against some aquatic weeds[4]. A work was, therefore, initiated to explore its herbicidal activity against a terrestrial weed *Ageratum conyzoides* (billgoat weed) commonly found in agricultural fields in northwestern India.

Parthenin was extracted from healthy, shade-dried leaves of *Parthenium hysterophorus* (collected locally from wildly growing stands as per the method of Saxena *et al.*[5]). The parthenin, so obtained, was dissolved in a few drops of ethanol and the final volume was made with distilled water to get solution ranging from concentrations 0.02 to 0.1 mg/ml (in increments of 0.02 mg/ml). To test the herbicidal property of parthenin, seeds of *A. conyzoides* (collected locally from wild stands) and wheat *Triticum aestivum* var. HD-2329 (procured from Punjab Agricultural University, Ludhiana, India) were subjected to germination in solutions of parthenin. Fifty seeds each of *A. conyzoides* and wheat were dipped in treatment solutions for 16 h. Treatment with distilled water served as control. The dipped seeds were then placed on the upper surface of Whatman filter paper no. 1 in a 12-cm petri plate. Below the filter paper a thin cotton pad soaked in the treatment solution was placed. The petri plates were incubated at 27°C, 16 h photoperiod and 75% relative humidity in a germination chamber. The entire experiment was arranged in a randomized block with four replications. The number of seeds germinated were counted and radicle length was measured after 72 h. After 10 days of treatment, the seedling length was measured. Mean values and the standard errors of the data were calculated and presented with respect to control. Besides, values of correlation coefficient between different concentrations and parameters were also calculated using polynomial regression analysis.

The results show that in response to different concentrations of parthenin, all the seeds of wheat germinated like that of water-treated control, whereas, seeds of *A. conyzoides* responded differently (Table 1). At the concentration of 0.02 mg/ml parthenin, the germination of *A. conyzoides* was nearly 50% whereas it was reduced to less than 20% at the concentrations ranging from 0.04 to 0.08 mg/ml. None of the seeds, however, could germinate at 0.1 mg/ml parthenin (Table 1).

Radicle length of *A. conyzoides* after 72 h was drastically reduced at all the concentrations of parthenin used and was nearly 50% of the control at the lowest concentration, i.e. 0.02 mg/ml. In contrast, a slight stimulation in radicle elongation of wheat was observed at this concentration (Figure 1). Almost similar trends were observed in case of seedling length (Figure 2).

Based on these results, a concentration of 0.04 mg/ml parthenin is recommended for further studies since at this concentration, germination of *A. conyzoides* was reduced by 90% whereas that of wheat remained unaffected.

From the present study it is clear that sesquiterpene lactone parthenin exhibits selective phytotoxicity and may, thus, find a potential use in the field of agriculture. In fact, a number of natural products such as cineole[1], 1,3,7-trimethylxanthine[6], ailanthone[7], including the sesquiterpene lactones such as artemisinin[8,9] are fast emerging as selective phytotoxins/herbicides. The greater biological activity profiles of sesquiterpene

Table 1. Germination of *A. conyzoides* and wheat in response to different concentrations of parthenin ($n = 4$)

Concentration (mg/ml)	Germination *A. conyzoides*	Germination Wheat	% change from control *A. conyzoides*	% change from control Wheat
0 (control)	43.75a	50a	–	–
0.02	22.50b	50a	48.57	–
0.04	11.25c	50a	74.86	–
0.06	5.00d	50a	88.57	–
0.08	4.50d	50a	89.94	–
0.1	0	50a	100	–

Similar alphabets along a column represent insignificant difference at $p = 0.05$.

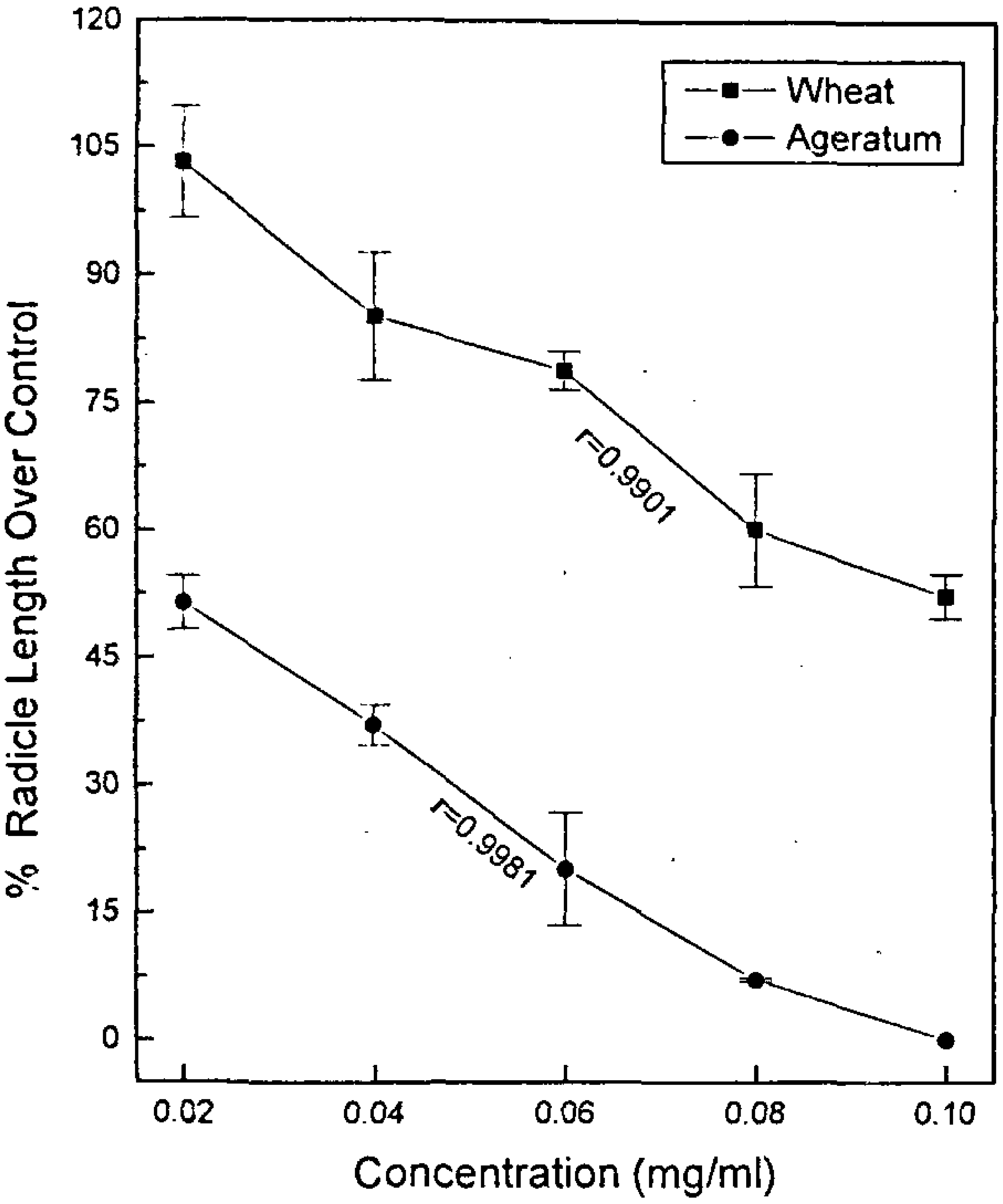

Figure 1. Effect of different concentrations of parthenin on % radicle elongation. *r* value along each line represents correlation coefficient between concentration and radicle length.

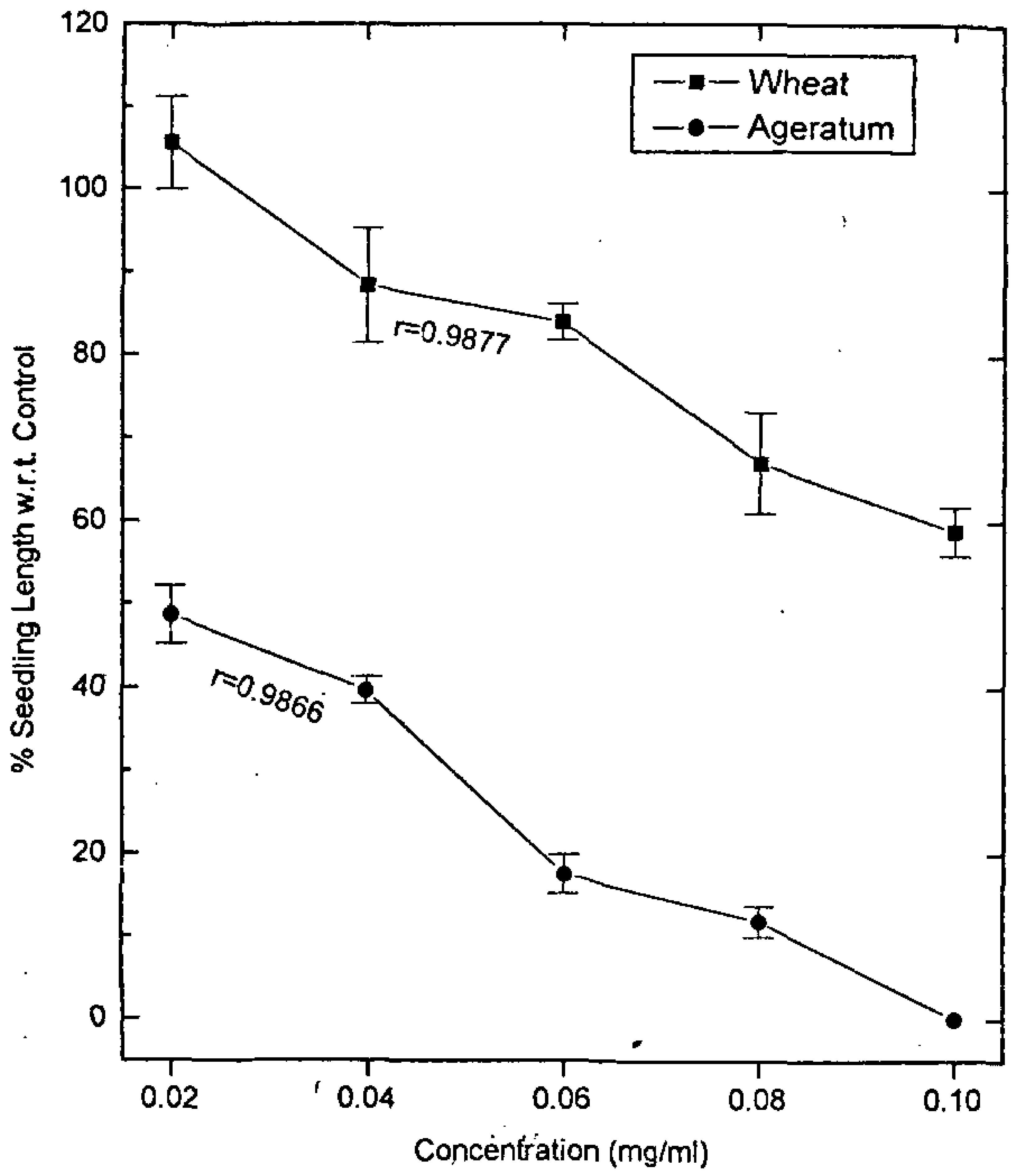

Figure 2. Effect of different concentrations of parthenin on % seedling length. *r* value along each line represents correlation coefficient between concentration and seedling length.

lactones can be attributed to the presence of α-methylene-γ-lactone and/or β-unsubstituted cyclopentenone, functionalization, ability to adopt different spatial arrangements and greater accessibility of groups for alkylations[10]. They react with –SH groups of amino acids and proteins by non-reversible alkylation of key enzymes, thereby modifying their original properties.

Parthenin is known to possess both α-methylene-γ-lactone moiety as well as β-unsubstituted cyclopentenone which enhance its reactivity to various biological nucleophiles, thus imparting an array of properties to it. Its exact mechanism of action is not known but has been reported to change the respiratory metabolism[11], damage cell membrane[4] and even possesses growth regulatory activity comparable to indole-3-acetic acid (IAA)[12]. The observed reduction in radicle elongation and seedling length in the present study could also be due to the effect of parthenin on cell elongation as a number of phytotoxins/sesquiterpenes are reported to inhibit gibberellin and IAA-induced functions[13].

From the present results, it could be concluded that parthenin possesses herbicidal activity which can be exploited but much needs to be done. Simple and easy protocols of its extraction and enhancement in its production by using biotechnological and tissue culture techniques need to be tried. Further, its herbicidal activity can be enhanced by making suitable derivatives since it posesses exocyclic methylene double bond of lactone ring and a cyclopentenone moiety in its skeleton which provide an excellent site for structural modifications[5].

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Failure of brown oak (*Quercus semecarpifolia*) to regenerate in central Himalaya: A case of environmental semisurprise

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The brown oak (*Quercus semecarpifolia* Sm.), a late successional species is the greatest forest-forming species above 2400 m altitude in the Himalaya. The failure of brown oak to regenerate in central Himalaya is a case of environmental semisurprise. Presence of saplings along roadsides and their absence in shaded habitat of forest interior suggest that this oak requires not only canopy gaps but also exposed soil for regeneration. It seems that in the current chronic form of disturbance, gaps formed are too small to enable brown oak to establish seedlings, and in large gaps grazing/browsing does not allow regeneration to progress up to tree size.

ENVIRONMENTAL degradations of global and regional scales generally have an element of surprise[1]. Many of the present front-rank problems, such as global warming and tropical deforestation were not even mentioned in the Stockholm conference on the environment held only two and one-half decades ago. Indeed true surprises, by definition, are beyond the scope of our research, but the likely candidates for semisurprises, that have potential to become outsize problems need to be identified at an early stage[2]. There are a few preliminary studies which suggest that the failure of regeneration of the brown oak (*Quercus semecarpifolia*), the most extensively distributed Himalayan oak, to regenerate at a regional scale may be regarded as one such likely candidate[3-5]. In this article based on population structure of the Himalayan brown oak (*Quercus semecarpifolia*) at a number of sites in Garhwal region, we have addressed questions: (i) Is this oak failing to regenerate in its forests in all sizes of canopy gaps? (ii) What are the factors responsible for its poor regeneration at a regional scale?

The brown oak, a late successional species is the greatest forest-forming species of the entire east-to-west arc, above 2400 m altitude in the Himalaya. Much of brown oak zone and adjacent alpine meadows have been historically under the influence of grazing of migratory livestock such as sheep and goats. It is used for firewood, charcoal, fodder and agricultural implements, and now in tasar sericulture.

The forest sites sampled occurred between 2400 and 3200 m altitude in Akashkamini Catchment (30°28'–30°31'N lat. and 79°13'E long.) of Garhwal region of Himalaya. The main criterion of site selection was gap size because of its importance in regeneration[6], however, the study sites also differed in altitude and distance from edge of the forest (Table 1). The forest edge site (site 1, Table 1) resulted from road construction about 30 years ago. Its ground was disturbed due to cuts and debris deposits. The site with unbroken canopy (site 2) with about 80% crown density (measured with densiometer) represented the forest interior. In the site with large canopy gaps (>0.06 ha, Table 1) livestock grazing had recently begun, which is why its forbs were from both forest as well as meadows. The forest meadow site had large (site 5) meadow patches, with domination of forbs of alpine meadows, such as *Trachydium roylei* and *Potentilla* spp.

At each site, all individuals of brown oak were counted in 5–16 randomly distributed 100 m^2 circular quadrats. Individuals up to 150 cm tall were divided into 50 cm height classes, and those larger than them were divided into 60 cm cbh (circumference at breast height,