HIMALAYAN JOURNAL OF
sciences

Volume 1 | Issue 2 | July 2003 | ISSN 1727 5210

Himalayan Journal of Sciences
Volume 1, Issue 2, July 2003
Pages: viii-xiv + 69-139

(Cover story: p 87, 103)

Rampant poaching, bleak situation, what next? **p 73**

Himalayan Journal of SCIENCES
scientific information for the advancement of society

Published by
Himalayan Journal Publishing Group,
Lalitpur, Nepal
GPO Box No. 2838

editorial

Renovation and reconstruction of universities
The first and foremost responsibility of a university is to meet the needs of society
Sanjay N Khanal
Page 69

correspondence

Flood of discoveries in Nepal!
Access to full text of world's 7000 leading journals will revalue the role of TUCL
Krishna M Bhandary
Page 71

Marketing science journals
The wide circulation of a journal is as important as its publication
Bharat B Shrestha
Page 71

WTO casts a shadow over Nepal's natural legacy
Can't live with it, can't live without it. Confused? The golden rule: Economic priorities should not be allowed to outweigh environmental imperatives
Krishna Roka
Page 72

essay

Basket case science, basket case society
The utter failure of science in Nepal is built into our own system
Udayaraj Khanal
Page 77

Reasoning for results
A huge collection of data is nothing if we cannot make a hypothesis. Thinking over the result is as important as getting the data
Dennis Bray
Page 79

policy

Direct payments to conserve biodiversity
Sometimes it pays to buy what you want rather than try to finesse it
Paul J Ferraro and Agnes Kiss
Page 81

Biodiversity update — Progress in taxonomy
Global inventory of life can facilitate reconstruction of 'Tree of life'
Stephen Blackmore
Page 83

commentary

Poaching: Get a grip on it
To prevent wildlife trade, we are limited by our defective activity
Ravi S Aryal
Page 73

Why we must fight biopiracy
Through the subtle process of 'reverse technology transfer,' rich countries are benefiting unjustly from the knowledge and technology of poor countries
Martin Khor
Page 74

Menacing food commodities
Escalating trends of fraudulent practice in food business has penetrated the 'whole food chain'
Rajendra Uprety
Page 75

special announcement

The Rolwaling Mountain Legacy Institute
Mountain Legacy, creater of The Hilary Medal, purposes a bold initiative in integrated research and development
Page 85

Don't just pile up data; contemplate your results **p 79**

research papers

Evaluation of cultivars and land races of *Oryza sativa* for restoring and maintaining wild abortive cytoplasm
Bal K Joshi, Laxmi P Subedi, Santa B Gurung and Ram C Sharma
Page 87-91

Assessing the land cover situation in Surkhang, Upper Mustang, Nepal, using an ASTER image
Benktesh D Sharma, Jan Clevers, Reitze De Graaf and Nawa R Chapagain, **Page 93-98**

Effect of gibberellic acid on reserve food mobilization of maize (*Zea mays* L. var Arun-2) endosperm during germination
Chandra K Subedi and Tribikram Bhattarai, **Page 99-102**

GIS-based flood risk zoning of the Khando river basin in the Terai region of east Nepal
Keshav P Sharma, Naba R Adhikari, Pawan K Ghimire and Prem S Chapagain, **Page 103-106**

Physiochemical characteristics of soil in tropical sal (*Shorea robusta* Gaertn.) forests in eastern Nepal
Shishir Paudel and Jay P Sah, **Page 107-110**

Control of flea beetle, *Phyllotreta nemorum* L. (Coleoptera: Chrysomelidae) using locally available natural resources
Indra P Subedi and KaminiVaidya, **Page 111-114**

Surface modification of polycarbonate (bisphenol A) by low pressure rf plasma
Deepak P Subedi, Lenka Zajickova, Vilma Bursikova and Jan Janca, **Page 115-118**

Hydrogeological conditions in the southern part of Dang valley, mid-western Nepal
Birendra Sapkota, **Page 119-122**

Silica gel chromatographic study of phenolic compounds in some cultivated cucurbits
Suresh N Baitha and Vijoy S Pandey, **Page 123-125**

Identifying fertility-restoring and sterility maintaining rice varieties, **p 87**

Constructing species-level phylogenetic reltionship is seriously hampered by lagging inventory of life, **p 83**

Invasive alien species can disrupt ecosystems and threaten our native biodiversity, **p 129**

articles

***Quercus semecarpifolia* Sm. in the Himalayan region: Ecology, exploitation and threats**
Bharat B Shrestha, **Page 126-128**

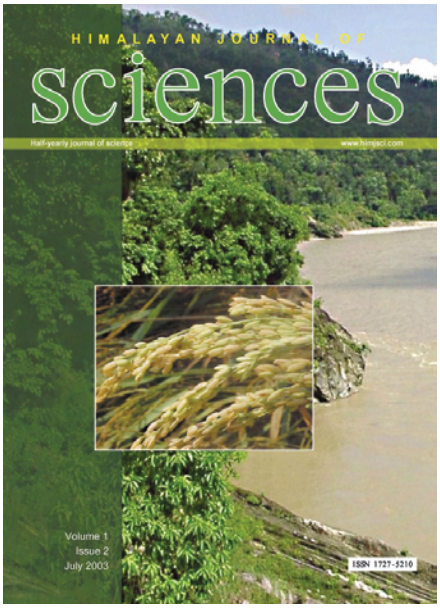
Invasive alien plants and *Eupatorium*: Biodiversity and livelihood
Ripu M Kunwar, **Page 129-133**

GIS-based analysis finds 26 VDCs in Khando river basin in Saptari under severe threat of flood, **p 103**

announcement

National Seminar on Natural Resource Management
November 6-7, 2003; Kartik 20-21, 2060; Biratnagar, Nepal
Page 134

Mighty oaks are over-exploited andfailing to regenerate adequately; how to help them, **p 126**



Anatomy of globalization

Knowledge and technology may seem to have a unidirectional flow: from developed to developing countries. However, indigenous knowledge and technology is flowing in the reverse direction. The knowledge people have gained over centuries and millennia is being patented by the companies and institutions of developed countries. Increasingly, developing countries will have to pay huge sums to foreign patent-holders for products made on the basis of their own indigenous knowledge. Martin Khor (page 74) spells out the consequences of the latest neocolonial rip-off. **[COMMENTARY]**

Jump-starting germination with gibberellic acid

The major storage materials in seeds are carbohydrate, protein and lipid (fat). Soon after germination, the young root and shoot system begin to consume storage materials because the leaves essentials for photosynthesis are not developed yet. During germination, reserve food from the endosperm is mobilized to the growth axis. Greater mobilization of food materials from endosperm to the growth axis ensures a higher rate of successful germination. Many researchers have reported the stimulation of endosperm processes through the application of exogenous gibberellic acid (GA_3). Subedi and Bhattarai (page 99) have found that in the early hours of germination, dry matter in the growth axis decreased in untreated plants, and remained the same in plants treated with a 100 mg/l solution of GA_3. It increased in plants treated with 1 mg/l GA_3. **[RESEARCH]**

It's us!

It is quite obvious that science in Nepal is going nowhere fast. Many people maintain that the government and politicians are fully or mainly responsible for this quandary. But Khanal (page 77) goes beyond that to find out deeper causes. Surprisingly, he finds that politicians are indeed involved, but that scientists are pulling the strings. **[ESSAY]**

Low-pressure radio frequency discharge treatment of polymers

The use of polymers in fields such as thin film technology, adhesion, biomaterials, protective coatings and microelectronics devices, has been increasing rapidly since the past few decades. Special surface properties such as chemical composition, hydrophilicity, roughness, crystallinity and cross linking, are required for the success of these applications. Most polymers do not normally possess these properties, which makes surface modification an essential process. Several methods have been developed for the treatment of polymers to enhance their surface properties. Some of the more common techniques of surface modification are: wet chemical treatments; mechanical roughening; and treatments with flame, corona, plasmas, photons, electrons, ion-beams, X-rays and γ-rays. Treatment of polymers with low temperature plasma has several advantages over other methods of treatment. Subedi et al. (page 115) discuss the treatment of polycarbonate in low-pressure radio frequency discharge. The change in surface properties is characterized in terms of surface free energy, adhesion to thin films and atomic concentrations. The surface free energy is determined by means of contact angle measurement; adhesion is measured by the peel tape test; and atomic concentrations are determined by X-ray photoelectron spectroscopy (XPS). All three diagnostic techniques show a significant enhancement of surface properties. **[RESEARCH]**

You get what you pay for

The most prevalent strategies for conservation of biodiversity in developing nations have entailed indirect incentives to protect natural resources. Examples are support of community forestry and ecotourism; theoretically, such projects should open up sustainable economic opportunities that result in a collective interest in protecting the environment. Unfortunately, the efforts have not lived up to expectations. On the other hand, some conservation initiatives have involved a much more direct approach: land rights are bought or leased and the environment is protected. Ferraro and Kiss (page 81) argue that such strategies are in many cases both cost effective and ethically acceptable.
[POLICY]

New rice hybrids on the horizon

Experiences in China, India and Vietnam have established that hybrids offer an economically more viable option to increase rice yield than semi-dwarf cultivars, which are developed by selfing for 10-12 years. Some varieties of rice contain a 'restorer gene' which can pass through gametes to its offspring. Embryo developed only from such gamete in crossing programme using male sterile lines can give rise to plants capable of bearing seeds. Such varieties are important for farmers. Some other varieties of rice contain a 'maintainer gene'. Embryo developed from gametes containing this gene gives rise to male sterile plant. Such plants are important to breeders since manual hybridization is rather difficult. Joshi et al. (page 87) have identified five fertility-restoring rice varieties and four with sterility maintaining ability, both rare in rice populations of Nepal. These lines can be used to develop potential hybrids suitable for a variety of agro-ecological regions.
[RESEARCH]

Cutting edge cartography reaches Upper Mustang

Land cover mapping is the process of recording and representing cartographically data regarding the land resources of a given area. In recent years, GIS (geographic information systems) digital image classification techniques have gained acceptance for their versatility, reliability, cost-effectiveness. Most previous studies of land cover have been based on aerial photo interpretation. The availability of high-resolution satellite images has made land cover mapping for resource management possible at all scales. Sharma et al. (page 93) evaluate the feasibility of using satellite imagery for land cover mapping in Upper Mustang. They also show how a digital elevation model derived from satellite imagery can be applied to the analysis of variation in landscape and vegetation. **[RESEARCH]**

Renovation and reconstruction of universities

The first and foremost responsibility of a university is to meet the needs of society

Sanjay N Khanal

Universities can be characterized in terms of three philosophical missions. British universities and their derivatives focus on the pursuit of truth, the development of intellectual capabilities and an atmosphere of profound academic freedom. Humboldt's university focuses on research and free exploration of truth, and their application. The Wisconsin model is based on service to society. Present-day universities, particularly in the developing world, should embrace all these concepts in their development and function. Major challenges to this objective include the brain drain, lack of funds, lack of tradition, and instability.

In addition to producing skilled professionals, universities should focus their academic programme and research initiatives on the needs of their own societies, advancing science and technology as part of the national developmental strategy at the same time as they conserve and promote their cultural and traditional heritages. Respected faculty, international student body, research of regional and global significance, service to the national development agenda: these are the cornerstones of a great university. A huge volume of resources, strong commitment and clear policies are required to mold and maintain high academic standards. A university should foster an exchange of ideas at all levels and incorporate a wide range of disciplines.

Society's progress depends largely on the exploration and application of ideas. Worldwide, universities are the chief sources of these ideas. Lagging development is inevitably linked to poorly developed academic institutions. The problem is not just lack of adequate resources. Universities must be committed to the free exchange of ideas, tolerance of dissenting thought, incorporation of the widest possible range of disciplines, and a dedication to both personal growth and national service.

Autonomy, both academic and administrative, is another core feature of the university. Freedom from government and other social institutions will generate effective performance. Self-governance could be ensured by outstanding performance, regular evaluations, and upgrading of standards. Decentralized and transparent decision-making generates trust in the university and facilitates development of functions suitable to local needs. Coordination among different schools, departments and colleges is needed to achieve the goals of the university. In the developing countries, this might be a difficult proposition. However, appropriate governing laws and financial freedom may help improve the situations. Institutions such as university grant commissions and academies may serve as buffer or lubricating mechanisms. Accreditation associations, academic or professional societies and other types of associations could be additional mechanisms to monitor and maintain academic standards and academic autonomy. Allocation of development funds and scholarships from the government and international organizations will help strengthen the capacities of the universities.

Tolerance of critical thinking is essential. There should be no discriminations on any basis including differences of thinking and doctrines to pursue truth among and between academic and administrative professionals along with the students. The freedom to the faculty to conduct research, to teach and to publish promotes and ensures the quality of the individual institution and that of the system as a whole. Academic activities conducted in an easy, free and open environment are invariably seen to produce better results. However, we must not forget that excessive freedom may lead to the breakdown of discipline and order.

Development of an international standard university is a long-term process achieved through a strategic plan. Equally important is the understanding of the societies about its nature and functions. Students, faculty, and staff as well as government officials and citizens share equal responsibility. It is high time that we all focus our energy on this endeavor. ■

Sanjay N Khanal is an associate professor at Department of Biological Sciences and Environmental Science, Kathmandu University, Dhulikhel, Kavre, Nepal.
E-mail: khanalsanjaynp@yahoo.com

Flood of discoveries in Nepal!

Access to full text of world's 7000 leading journals will revalue the role of TUCL

Krishna M Bhandary

S G ALBERT IS REPORTED TO HAVE SAID that research is to see what everybody else has seen and to think what nobody else has thought. And, thinking to generate new ideas should always be preceded by looking at the generated ideas. Since new knowledge is mostly announced via journals, they are indispensable components for scientists and experts both to get generated knowledge and to publish their new ones. Recently, there has been a remarkable progress in the former in Nepal.

In February 2003 the International Network for the Availability of Scientific Publications (INASP), a cooperative network established in 1992 by the International Council for Science (ICSU) as a programme of the Committee for the Dissemination of Scientific Information (CDSI), nominated Tribhuvan University Central Library (TUCL) as National Coordinating Institute for the implementation of its Program for Enhancement of Research Information (PERI). The purpose of this collaboration is availability of new knowledge in digital form to Nepal.

After the PERI is fully implemented in September 2003, the full texts of 7,000 scholarly journals as well as abstracts and contents of 20,000 journals from around the world will be accessible at TUCL and certain other centres designated by TUCL. The journals are primarily technical, and represent a broad range of scientific fields, including medicine, agriculture, forestry, natural resource management, and engineering, as well as other fields in the social sciences, humanities and business administration.

As the increasing gap between haves and have-nots poses an increasing threat to world stability, it is essential that Nepal and other developing countries take steps to strengthen their scientific base. Researchers, academicians and students in Nepal are expected to benefit greatly from the program. At present, they cannot purchase subscriptions to western journals even if they wish to. This availability of full-text database can radically alter the way they think and the way they conduct research, eventually leading to better designed research projects and to more productive application of established ideas. To a significant extent, this program is expected to fulfil the demand for research results in Nepal.

The information resources of PERI would normally cost over one million pounds sterling. PERI pays this sum to the publishers. These resources have been made available to us for £27,500. INASP has made arrangements with Danish Ministry of Foreign Affairs (DMFA) to cover costs for 2003. Bravo, DMFA! Although there is some hope of obtaining funding for 2004 and 2005 from DMFA and the International Department for Foreign Affairs (DFID), it would be wisest to think consider how costs can be met if donors do not materialize. Once the information resource is available, TUCL can offer access to other institutions at no further cost. TUCL is working out details for extension of access to all libraries, research institutions, colleges and not-for-profit educational institutes throughout Nepal.

Promoting quality publications in the countries where the programmme is implemented is also one of the objectives of PERI which puts them on its website for worldwide dissemination. This would benefit Nepalese publication to get international recognition. ■

Krishna M Bhandary is librarian of Tribhuvan University Central Library, Kathmandu, Nepal. E-mail: tucl@healthnet.org.np

List of selected PERI resources for Nepal

EBSCO	Full text of 6000 journals; abstract and content of 7300 journals in all branches of science, technology, medicine, social science, humanities
Blackwell Synergy	Full text of over 600 leading journals in natural, physical, and social sciences; technology; medicine; and the humanities
Springer Verlag	Full text of 432 high-quality journals in many disciplines
Oxford University Press	Full text of over 120 leading journals in science, technology, medicine, humanities and social science
Emerald	Full text of 100 journals in marketing, business, engineering, material science
CAB Compendium	Many journals in agriculture, forestry, management, and conservation of natural resources
Cochrane Library	Good resource for medical and health science

Marketing science journals

The wide circulation of a journal is as important as its publication

Bharat B Shrestha

A HUGE AMOUNT OF INFORMATION IS generated every year in the field of science and technology. Many scientists from different countries are working on similar topics either in co-operation or independently. The research findings of one scientist are important for others in solving many problems. Research communication also avoids overlap in research and saves time and resources. The exchange of information and ideas among them is very important to achieve goals earlier. Regular meeting between them is, however, impossible. Publication in electronic media or in printed form (e.g., journals) and wide circulation is the most appropriate means of communication. Primary information is mostly fragmentary. These fragments should be distributed to the interested peoples. Research results will not have any meaning unless they are published and circulated. A good journal is a forum in which peoples from different regions can communicate, share ideas, discuss and solve problems.

There are a large number of good journals in the international market but very few have found their place in libraries of our university and research centers. This terrible lack of access to such journals hampers our research and education although their availability is not going to make a great contribution to our research and development. This is because there is a huge gap between the studies addressed by such journals and those conducted by our scientists. Journals published in Nepal are therefore critically important, for they can be a platform for our scientists.

When we count the number of science journals published in Nepal, perhaps we are not poor. This is good news. But the bad news is that many of them are very poor in quality, irregular in publication and have very limited distribution. They are printed on low-grade paper with a short lifespan. Many annual journals are published at an interval of several years. For many journals a single issue becomes the first and last. The Ministry of Science and Technology published the first issue of *Scientific World* in 1999 and a second issue has not appeared yet!

Limited distribution of published journals is a major problem in scientific communication. A journal is published, piled up in the publisher's office and ultimately damaged by silverfish or sold to a paper collector as waste paper. A better approach can be sale at reduced price or free distribution to interested people. The proceedings of the first (1988) and second ➔

(1992) National Science Conference organized by RONAST were distributed free of cost to participants of Third National Conference in 1999. Although reduced sales undermine the aim of publication, there is another aspect to this problem. The author visited the office of the dean of the Institute of Science and Technology (IOST, TU) to collect the recent issue of the *Journal of Institute of Science and Technology*. But the store keeper said that he could not give out the journal because it had not been decided to distribute or sell it, even a month after publication. The same was the case with *Banko Janakari*, published by the Forest Research and Information Service Center (FRISC). *Science Reporter*, published by the National Institute of Science Communication and Information Resource (India), is available in the shops of Nepal; why not the publications of RONAST, IOST and FRISC?

If we cannot ensure that a journal is economically self-sustaining, we can know that it is going to perish soon. Peoples are realizing the importance of publication and the number of readers and customer is increasing. Researchers are facing difficult problems and have to waste more time getting information. If it is easily available in time they do not hesitate to pay a minimal price. So the first thing to do is to improve the quality of journals in content and printing. Articles should be reliable and reviewed by experts. A good journal has an expanding market and people can pay a reasonable price. Sometimes it may be necessary to encourage people to buy the journals by highlighting its significance. Journals and other publications of government organizations are distributed free of cost but are not available to all interested people. If you do not have a close relation with officials you have to request several times to get a single copy, and sometimes even then you will not succeed! This situation needs to be corrected promptly. If they are published in sufficient number, sold at price that reflects their actual cost, and made available on the public market (e.g. in book shops) the journals will not lose money, and interested people can get information easily. For this it is necessary to improve the distribution system. Books and journals published by ICIMOD (International Centre for Integrated Mountain Development), IUCN (International Union for Nature Conservation), NEFAS (Nepal Foundation for Advanced Studies) and other organizations are easily available in bookstores, but why not journals published by RONAST, ministry and TU? Major journals published by ministries, RONAST and TU should find a place in every library at academic institutions, research centers, NGOs and INGOs. Publishers can use existing book distributors to make them available to the general public. And, one important thing that is to be remembered from time to time is that a journal not available to those who want and need it is not worth publishing. ■

Bharat B Shrestha is a teaching assistant at Central Department of Botany, Tribhuvan University. E-mail: bhabashre@yahoo.com

WTO casts a shadow over Nepal's natural legacy

Can't live with it, can't live without it. Confused? The golden rule: Economic priorities should not be allowed to outweigh environmental imperatives

Krishna Roka

APART FROM THE CURRENT POLITICAL turmoil, the major debate in our news media focuses on the issue of when Nepal should become a member of the World Trade Organization (WTO). Globalization has erased boundaries among nations through economic, social, and environmental unification. This is a case of "can't live with it, can't live without it." The real question here involves the environmental consequences if Nepal does open its doors, for globalization has paradoxically brought forth new problems rather than solving old ones. The Northern bloc has long squandered the resources of developing countries in the name of economic progress.

Globalization in effect is not a single process but a concatenation of developments involving infrastructure enhancement; economic reforms, trade and market access, resource extraction, production and distribution of goods, and so on. The main thrust of globalization is to increase trade by increasing production. The expansion of urban societies has increased the demand for forest goods, from timber and pulp to medicinal plant, putting ever greater pressure on forest ecosystems. In recent decades, the pressures have intensified. Growing appetites for forest and agricultural products are driving logging and conversion. The Philippines' loss of 90% of its primary forest during the timber boom of the 1970s is a clear example of our shortsightedness (*1*). The loss started after the Second World War. Timber from the Philippines was supplied to markets in Europe and Japan after World War II, as war-ravaged countries rebuilt. Every year, forested areas four times the size of Switzerland are cleared worldwide (*2*). Foreign investment in logging, mining, and energy contributes to this deforestation. These enterprises are the wheels on which the globalization juggernaut careens around the world.

Under the circumstances, Nepal must think twice before opening its borders. As Nobel laureate and former chief economist of the World Bank Joseph Stiglitz says, "the borderless world through which goods and services flow is also a borderless world through which other things can flow that are less positive". Economic priorities should not be allowed to outweigh environmental imperatives. The greatest threat posed by globalization may be in the field of intellectual property rights (IPR). According to WTO rules, foreign companies and individuals may patent products and processes on which Nepalese livelihoods have depended for centuries.

Multinational companies (MNCs) are prying on developing countries with less effective central authority, gaining access to their assets with little effort. Taking advantage of the situation, they swiftly take over the country's business sector in their control. For the MNCs, economic return is all that matters; their role in squandering natural resources has become a sore point in many developing nations.

With economic liberalization, borders are open for the free exchange of ideas, culture, and technology. Via satellite, western products have flooded the screens of developing countries. Traditional ways have been transformed, as we have opted for a McDonaldized (urbanized) culture. McDonaldization of the society demands more food that both aggravates economic problems and increases pressure on the environment. Traditional agricultural practices have proven inefficient in meeting modern demands. Farmers have adapted to using excessive amount of chemical fertilizers and pesticides; the initial gains in production, however, have been followed by rapid declines, and increased dependence on chemical inputs. The damage to the soil has been incalculable.

In view of these facts, Nepal must proceed with caution, making every effort to distinguish short-term from long-term advantages, in order to minimize the adverse impacts of globalization. Although we boast of our wealth of biodiversity, the details are unknown. Myriad species are still undocumented and may wind up in the hands of MNCs. We should learn the lesson from past developmental activities (roads, dams, and so on) undertaken without environmental impact analysis: once we fritter away our resources they are lost forever. Nepal should formulate its own policies and regulations regarding patenting and extraction. Joining the WTO can and should be delayed until completion of this groundwork. Nature is Nepal's trump card, and we should play it wisely. ■

For correspondence to the author, E-mail:roka@sify.com

References

1) JN Abramovitz. 1998. *Taking a stand: Cultivating a new relationship with the world's forests* [Worldwatch Paper 140]. Washington DC: World Watch Institute
2) M Vallianatos and A Durbin. 1998. *Licence to loot: The MAI and how to stop it*. Washington DC: Friends of the Earth. 49 p

Poaching: Get a grip on it

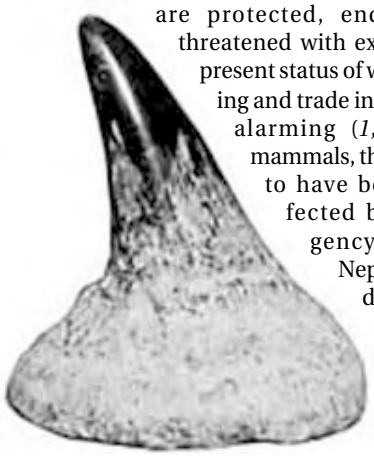
To prevent wildlife trade, we are limited by our defective activity

Ravi S Aryal

One of the causes of critical species depletion in the world is the increasing demand for wildlife products. Poaching, for example of rhinoceros, has long been rampant in Nepal, and has recently been facilitated by the reordered priorities and shifting constraints of the current emergency. The best hope for stopping or reducing the illegal exploitation of protected species lies in the empowerment and involvement of local people in conservation work. Better training, modern communication equipment, and reorganization of the anti-poaching units would prove beneficial in reversing a disturbing trend that threatens to undo even the limited successes of the past three decades of conservation.

Poaching and illegal trade in endangered species and products made from them are serious problems in biodiversity conservation, second only to habitat destruction. Exploitation of "protected" wildlife for profit is not a recent phenomenon. Despite strict legislation, rhino horns, tiger and leopard skins, bones and other animal parts are as profitable as narcotic drugs in international markets. The rapid expansion of human population and, concomitantly, of transport and communication systems have contributed to an increase in the scope of this exploitation. Increasing demand for wildlife products and increasingly ruthless means of supplying them have led to critical species depletions around the world.

The 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), seeks international co-operation to protect listed wildlife species against over-exploitation, including their trade. Nepal as a party to CITES has an obligation to control the trade of products made from any parts of wildlife that are protected, endangered or threatened with extinction. The present status of wildlife poaching and trade in Nepal is most alarming (*1, 2*). Among mammals, the rhino seems to have been most affected by the emergency period in Nepal. Most rhino deaths are attributable to poachers; rhinoceros horn is in great demand primarily as an aphrodisiac, and (in Arab countries) for carved scabbards. In 2000 the Department of National Parks and Wildlife Conservation reported a total of 612 rhinoceros in Nepal (*2, 3*). In July 15, 2000-July 14, 2001 the official tally of deaths, both natural and by poaching, was 30; 55 rhino deaths were reported for July 15, 2001-July 14, 2002. For July 15, 2002-July 14, 2003, the unpublished tally of rhinoceros killed by poachers in Chitwan and Bardiya is 55. The figures represent a fatality rate of nearly 17% for the period July 15, 2001-July 14, 2002, compared with a birthrate of approximately 3.7% (*3*). The real death rate is probably twice as high as the reported incidence.



Is there any prospect of checking the slaughter? Yes, there is hope. For example, 38 army posts in Royal Chitwan National Park were cut back to nine in response to the Maoist insurgency (*2*). Park range posts and patrolling activities were reduced because of factors such as lack of security, budget reduction, and lack of supervision from higher authority; such security measures occurred in most protected areas of Nepal. By the start of 2002 rhino poaching had increased substantially, threatening the sustainability of Nepal's notably successful rhino conservation.What happened? Poachers simply felt more comfortable. Their activity has been facilitated by the reduced numbers of people in the park, and especially by the fact that the wardens responsible for protecting wildlife have been afraid to patrol and take open action against poachers or wildlife traders.

It is well known that the dirty work of poaching in Nepal is carried out by some local residents employed by local businessmen. To reduce the incidence of poaching, it is imperative to empower local communities. Buffer Zone Management Committees as well as Community Forests Users' Groups and Conservation Areas Committees are examples of proven forest management regimes which have effectively controlled wildlife poaching by taking responsibility, protecting rights, and sharing benefits at the community level. The community can and should be involved in conservation work within the protected area, which includes informing authorities of illegal activities. Once basic needs are met these communities will be cooperative with conservation programmes.

The next step that must be taken in order to control poaching is redeployment of the Army in all the previously designated posts inside the National Park. Range posts, personnel and logistical support must also be re-established. Nepal's open border with India, and the lack of specific legislation and co-ordination between the concerned authorities continue to hinder the task of combating wildlife trade. Lack of commitment among the implementing officials is a major hurdle to stop the wildlife trade. We need trained officials equipped with modern communication equipment. The structure and functioning of anti-poaching units is defective, as they generally involve informants who were once poachers themselves. Such people have a tendency to revert to their previous activities when conditions seem more propitious, thereby sharing their insider's knowledge and skills with illegal traffickers. In reality it is helping to wildlife traders for doing their business easily. What we need is a new kind anti-poaching unit, involving both outside experts and local oversight. Ultimately, the best solution is to convince the consumers of illegal wildlife products that their consumption can lead to the extinction of the animals, thereby reducing the demand that drives the entire industry (*4*). Finally, we need a strong law and its effective enforcement that will strike a balance between utilitarian value and protecting wildlife for their own intrinsic value. A law with teeth. ■

Ravi S Aryal is associated with the Commission for Investigation of Abuse of Authority, Kathmandu, Nepal.
E-mail: raviaryal@wlink.com.np

References

1) RS Aryal. 2002. Wildlife trade in Nepal. *Environment* **7**(8): 1-5
2) DNPWC. 2001. *Annual report 2000-2001*. Kathmandu: Department of National Parks and Wildlife Conservation, HMGN. 37 p
3) DNPWC. 2000. *Count rhino report 2000* [unpublished report]. Kathmandu: Department of National Parks and Wildlife Conservation, HMGN. 8 p
4) RS Aryal. 2002. Nepal Chapter. In: Mottershead T (ed), *Environment law and enforcement in the Asia Pacific rim*. Hong Kong: Sweet and Maxwell Asia. p 293-322

This would enable countries of origin either to prevent such patent applications, or to require benefit-sharing arrangements with the applicants. Developed countries should support — not block — this proposal.

As part of the implementation of the Convention on Biological Diversity, developing countries should also establish national arrangements for collecting and using biological resources and the knowledge associated with them, as well as for sharing the benefits from any commercial transactions with those communities which have developed this knowledge.

Unfortunately current efforts by individual countries to review their national laws on intellectual property, in order to bring them in line with their obligations under the TRIPS agreement, is likely to accelerate the biopiracy phenomenon. For this process now requires countries that previously forbade the patenting of life to allow patents on certain types of organisms and living processes.

With careful and intelligent legal and policy choices, developing countries can avoid some of the worst dangers that can arise from the implementation of their obligations under TRIPS. In the long run, however, a fundamental revision of multilateral trade rules is essential if the injustice inflicted by biopiracy on local communities and their indigenous knowledge is to be corrected. ■

* Sub-title and summary not from SciDev.Net; added with the permission by *Himalayan Journal of Sciences*

Martin Khor is director of the Third World Network — a non-profit international network that researches, publishes on, and organises events about issues relating to development — which is based in Malaysia.

This article is available online at
http://www.scidev.net/Opinions/index.cfm?fuseaction=readopinions&itemid=128&language=1.

The Science and Development Network (SciDev.Net) aims to enhance the provision of reliable and authoritative information on science- and technology-related issues that impact on the economic and social development of developing countries. It is supported by the scientific journals ***Nature*** and ***Science***, both of which have agreed to provide free access to a selected articles every week.

Menacing food commodities

Escalating trends of fraudulent practice in food business has penetrated the 'whole food chain'

Rajendra Uprety

Fraudulent practices by our food industry are undermining public health in Nepal. Although news papers and media frequently cover them, fraudulent practices in the food business are becoming more rampant. It is high time that consumers, who spend a sizable proportion of their earnings on food, learn the bitter truth about the adulteration that has become "food business as usual."

Tests reported in the annual bulletin of the Department of Food Technology and Quality Control (DFTQC, HMG Nepal) reveal that food producers and distributors have been playing their dirty games for at least 20 years. A large number of marketed food items have been adulterated or contaminated **(see Figure 1a)**; we will be discussing only a few of the more egregious cases.

According to a report in the DFTQC bulletin for 1998/99, over 90 percent of milk and milk products (as mentioned in the text) were substandard due to the presence of mesophilic contaminants (yeast, mould, coliform, *Salmonella* species and other few microorganisms) which resulted from adulteration of milk with unsafe water. The 2000/2001 bulletin states that 14 dairies have been producing dairy products in Nepal, and that, for the most part, the quality of their products has been deteriorating (**see Figure 1b**). The culprits include Adhunic Dairy, Pushpa Dairy, Sainju Dairy and Kharipati Dairy, out of which the products of Pushpa Dairy and Adhunic Dairy were completely substandard during 1999-2001. In addition, 60 to 80% of the marketed products of Integrated Dairy, Silwal Dairy and Nepal Dairy were adulterated. **FIGURE 1b** gives more details on the quality of dairy products consumed in past seven years.

There was a significant and almost continuous rise in oil adulteration from 1995 to 2001 **(see Figure 1c**). Most mustard and rapeseed oil was found to be adulterated with the toxic Argemone and other cheaper oils. There is no reason to suspect that these oils are any safer today.

Noodles, though comparatively expensive, are widely consumed snacks, especially popular among school children. 48 percent of snack noodles and 42 percent of

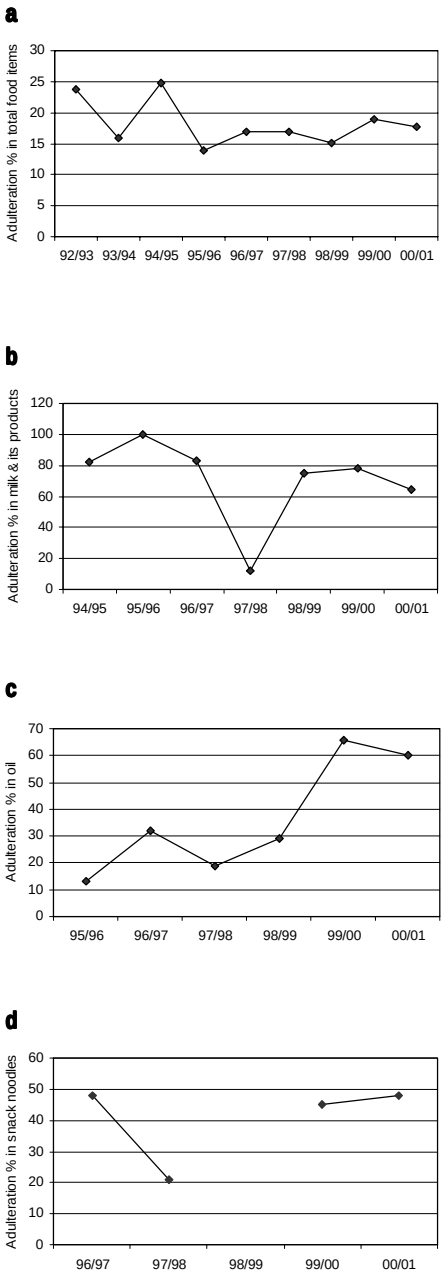


FIGURE 1. Food adulteration in different food products – total food items **(a)**, milk and mild products **(b)**, oil **(c)**, and snack noodles **(d)**. Values in parentheses are the number of samples studied. (CFRL 1998/1999, DFTQC 2000/2001)

TABLE 1. Conflicting values for pasteurized milk and milk products published in two DFTQC bulletins

Year	Marketed items in milk and milk products with adulteration (%)	
	1998/99 bulletin	**2000/01 bulletin**
1995/96	106 (one hundred and six)	100 (one hundred)
1996/97	62.5 (sixty-two point five)	83.3 (eighty-three point three)
1997/98	6.3 (six point three)	12.3 (twelve point three)
1998/99	75 (seventy-five)	7.5 (seven point five)

instant noodles consumed during 1999-2000 were found to be substandard due to the adulteration with inedible colours and other contaminants. The DFTQC bulletin states that noodles have been found substandard since regular monitoring began in 1996 **(see Figure 1d)**. Similarly, nearly one-third of the brands of mineral water consumed in the past four years were substandard due to mesophilic contaminants.

The expanding practice of food adulteration is directly attributable to the negligence of the concerned agencies, officials, and experts. Regular inspection is indispensable. But research is not enough. DFTQC can and should control the appalling situation by promptly releasing evidence of adulteration to the general public via the mass media. In so doing, DFTQC must take steps to present its data and analyses more logically and consistently. For instance, the data on pasteurized milk and milk products of 1998/99 appears differently in the bulletins of 1998/99 and 2000/2001 **(see Table 1)**. The table clarifies the credibility of the reports of responsible organizations. Three different figures are given for the incidence of adulteration of pasteurized milk in 1998/99: 75 (seventy-five) percent in the main table and 90 (ninety) percent in text of the 1998/99 bulletin, 7.5 (seven point five) percent in 2000/01 bulletin.

Food adulteration reports from throughout the country show that the situation is critical. It is up to consumers to insist that something be done, and quickly. ■

Rajendra Uprety is a member of Executive Council, Nepal Chemical Society
E-mail: upretyrajendra@yahoo.com

References

1) CFRL. 1996/1997. Annual bulletin 1996/1997. Kathmandu: Central Food Research Laboratory, Ministry of Agriculture and Co-operative, HMGN. 160 p
2) CFRL. 1997/1998. Annual bulletin 1997/1998. Kathmandu: Central Food Research Laboratory, Ministry of Agriculture and Co-operative, HMGN. 124 p
3) CFRL. 1998/1999. Annual bulletin 1998/1999. Kathmandu: Central Food Research Laboratory, Ministry of Agriculture and Co-operative, HMGN. 50 p
4) DFTQC. 2000/2001. Annual bulletin 2000/2001. Kathmandu: Department of Food Technology and Quality Control, Ministry of Agriculture and Co-operative, HMGN. 160 p

Basket case science, basket case society

The utter failure of science in Nepal is built into our own system

Udayaraj Khanal

It is quite obvious that there is not any significant development in science in Nepal. Many people maintain that the government and politicians are fully or mainly responsible for this quandary, as for every other. But the author digs deeper to discover the underlying causes. He argues that the scientific failure happened 'through' the politicians, not 'by' them.

The ability to learn from mistakes is the most important prerequisite for success. To illustrate this point, I would like to describe an incident involving Thomas Edison, who had tested more than a thousand materials for the filament of his light bulb. A gentleman approached him and said, "Mr Edison, you have failed a thousand times." Edison replied, "I have not failed a thousand times, but discovered a thousand things that do not work." The point is well-taken. However, if one does not learn from experience but repeats mistakes indefinitely, then we can fairly speak of failure. Some mistakes at the beginning of a career may be forgivable, as long as the novice learns from them. But, as the novice advances up the hierarchy to executive status, it is to be expected that experience will result in a reduction of the incidence of error, because mistakes at a higher level become more costly, and a single wrong decision by the chief executive may suffice to pull down the whole institution.

Past and present

Hence, we expect that people who take over the leadership should be those who have exhibited an aptitude for learning from mistakes. This is indeed the foundation of the scientific culture of a society. In my opinion, this basic trait, lacking in Nepalese society, is preventing us from achieving our developmental goals. The leadership that we are burdened with, be it political, social, cultural, scientific, adamantly refuses to learn from past mistakes. The political leaders tell us we should not delve into their past history of rampant corruption and misgovernance, killing and browbeating the downtrodden Nepalese into submission, and follow them blindly as they attempt to make a fresh start. Thus we are prevented from taking any forward step, but make a full circle back to square one, and are effectively pegged to the same spot. Our social leaders, instead of leading us forward to new horizons, encourage us to look backwards and preserve our archaic traditions, even if they entail inhumane behaviour such as the treatment meted out to women accused of witchcraft, castism, drinking fresh blood from necks of struggling sacrificial animals, and what not, so that we remain preoccupied with superstition.

In contrast to dictatorship, multiparty systems have succeeded around the world because competition to develop better policies entails the incorporation of lessons learned from past mistakes. In countries where this system has been implemented successfully, if the incumbent who leads the party into an election is unable to secure a majority, he resigns so that a younger person comes out with new and better ideas to make the party popular by the time of the next election. In countries like ours, we are always saddled with the same failed leadership. Even if they are taking us down the drain, we are forced to consider them our leaders. Now they blame all their misdeeds on the constitution. If intentions are good, then the constitution cannot be a hurdle. After the Second World War, the victorious powers forced a constitution on Japan, which they hoped would prevent Japan from competing with them in any sphere. Japan established itself as the second power with that same constitution, which is still in use.

A bigger hurdle on our path to development is the failure of our academic leadership. If the academia had been true to its profession, gathering and giving appropriate advice to the politicians, I think the situation would have improved greatly. In the rest of the world, the university always appears to be anti-establishment as it voices strong, rational, and convincing criticism of the policies of those in power, and suggests improvements. In the USA, for example, Robert Oppenheimer, who played a leading role in developing the nuclear arsenal, was hounded to death for allegedly being a communist; much later, as Nixon was escalating the war in Vietnam, all the universities were branded as a haven for communists because they opposed this warmongering. Similarly, during the Soviet regime, a person like Sakharov, who was the father of their nuclear weapons programme, was labelled a capitalist agent and sent into internal exile. So it is clear that the academics have the important role in directing the establishment towards rational and liberal thinking. But the story is completely different in our country. The whole academia plays to the fiddle of whoever is in power. If the government revalues the rupee, it is hailed as a great step towards showing the strength of our currency. When the rupee cannot hold its own and is devalued a few weeks later, then the same people hail it as a great step towards revitalizing the economy. With such poor advice and toadyism, they hope to become recruited by the minister as personal assistants, if not as advisors. Thus, the gullible so-called political leaders are continually misguided by those who call themselves the academic leaders, but do not have an iota of academic insight, initiative or achievement to their credit. The general mass has no faith in them. So they hide in their academic offices and proclaim amongst themselves, "We the intellectuals, academics, wisemen …"

Nepalese academics bear sole responsibility for the destruction of our educational system. The New Education Plan was conceived by politicians as a means of controlling education because they thought their grip on power would loosen if the mass became highly educated. The academic circle co-operated whole-heartedly in this conspiracy. Many schools that were doing very well were brought down to the level of the worst. All the well-tried textbooks were thrown away in the name of uniformity, and replaced with books containing gross conceptual and printing errors, with inadequate graded exercises, written by irresponsible educators. Many of these books are still in circulation, and many that have been translated into English for the consumption of boarding schools contain even more errors. One popular science book for sixth grade classifies spinach as a grass, and potatoes and carrots as cereals. Appointments, and even transfers, of school teachers, as well as

The scientific leadership of Nepal has a very unsuccessful history. The NCST never established and formulated any far-reaching policy. Rather, it opted for the idea that research should not be undertaken in educational institutions, despite the fact that academic departments are the major research venues all over the world. Then appeared RONAST, which is vegetating without any clear purpose and without any remarkable activity. It is quite ironic that the institution established to promote scientific development proclaimed in its first publication that research should not be undertaken by a poor country like Nepal, despite the fact that the North–South developmental gap is essentially a scientific gap. The tireless so-called scientific executive then established the Ministry of Science and Technology – which will have a tough time to prove its worthiness!

the conduct of exams, are steeped in corruption. The best results of the final secondary exams are auctioned off to the highest bidder. Then, instead of encouraging the brightest students, the publication of the "toppers list" is discontinued with the lame excuse that it fosters unhealthy competition. A party in power first stopped this publication. Another party that came to power after a few months, undid the decision just because it had to do things differently, only to redo it later on. Now, such corrupt practices are being extended to the lower level district exams. Just as the whole village gathers in front of SLC exam centre to pass cheating material to the examinees, and the invigilators are reported to suggest many of the answers, we hear of similar incidents repeating in the lower level district exams. When school children are taught from the beginning that only such cheating and fraudulent practices can bring success in Nepal, what kind of leadership can we expect from them in the future? A similar disease was transmitted to the university level. Many private colleges like Amrit Science College, which were doing very well, were forcibly reduced to the lowest standards. Wherever the new education vandals thought that science should not be taught, they went around with sledgehammers to destroy even the newly setup labs as they did in Shankar Dev Campus.

The scientific leadership said that science cannot be done in a country with no science policy, and forced the establishment of a National Council for Science and Technology (NCST) in 1976 AD, which they captured without much resistance. No concrete, far reaching policy was ever formulated or implemented. Turning a blind eye to the fact that the academic department is the prime spot where research is done all over the world, that research is an integral part of university education, these so-called scientists said that research should not be done in the department, but only in the privileged centre where all funds were diverted, leaving the departments with just chalk and duster. Now these departments are so deprived that they cannot even buy chalk. In the hands of the same chronically failing scientists, the centre also never conducted any worthwhile research, but wasted itself on pursuing mirages like perpetual machines. Then these same people said that scientific activity was impossible in a country that was devoid of a science academy, thus instigating the establishment of the Royal Nepal Academy of Science and Technology (RONAST) in 1982, which was also taken over by the same clique. Unfortunately, the first ever publication of this institute proclaimed that scientific research should not be undertaken by a poor country like Nepal, in complete contrast with the fact (and, of course, the idea of the Nobel Laureate physicist late Abdus Salam) that the North-South developmental gap was essentially the gap in science. More than a decade was wasted in a feud between RONAST and NCST as to who should be responsible for formulating a national science policy. The quarrel took a destructive turn when NCST was dissolved. In the meanwhile, RONAST had gone through a series of downturns, from gold smuggling, to strikes and lockouts, to defilement of its own VC, and on and on. Has anyone heard of a science academy going on strike? It is still not clear what the purpose of RONAST is.

When Salam visited Nepal in 1989, in the presence of the late King Birendra, he offered to establish an international high technology centre in Nepal. His Majesty took the offer seriously, and a committee was set up to facilitate the establishment. The Education Minister was sent off to meet Salam and work out the details. Sadly, the same leadership that had been misguiding the development of science in Nepal managed to take over the committee. They feared that their stranglehold on the scientific activity of the country would loosen if such an international centre were set up. Leading scientists of the world would come over to train and collaborate with the young Nepali scientists who would soon overtake the old calcified ones. So Salam's offer was rejected. If the offer had been accepted, Nepal would by now have leapt ahead in information technology, genetics, and emerging fields.

Again, the same scientific leadership that had proved a failure throughout, and had exhibited a penchant for recycling old mistakes, convinced the government that Nepal could not do any science until a Ministry of Science was established. A few years ago, this Ministry came out with a draft bill to purportedly develop science. It contained clauses to the effect that anyone contacting foreign scientists without prior approval, or found to be doing unauthorized science, would be punished severely with fines and incarceration. The bill was dropped after a hue and cry was raised at the university, but the intention of the Ministry to control scientific activity rather than encourage it is obvious. This also came to be dominated by the same scientists, and again a feud has developed between RONAST and the Ministry. Every now and then there are threats that the Science Ministry will be dissolved in the near future. So, there is no ground to blame political leaders for the sorry state of science in Nepal. They have invariably taken up the suggestions of the scientists. The whole blame lies with the scientific leadership that holds almost absolute power but has failed in every aspect, whether it be implementation of an effective scientific programme, inspiring the youth with scientific achievements, encouraging the youth to initiate scientific activities, or utilizing and developing national resources.

Future outlook

It appears that the leader of each and every institution in Nepal is bent on destroying the structure. If the institution becomes strong, the leaders will have to behave responsibly, and tough questions will be raised regarding their decisions. Without any institutionalisation, the leader can run it as a fiefdom, where the lower ranks will go down on their knees in front of the leader, and then bite him in the back. It remains only for the youth to remedy this bleak situation. It is high time that they express themselves fearlessly and break new paths. They should refuse to be used as weapons of the ossified old generation, whose method of retaining power has been to keep the youth misinformed and misguided, and the people terrorised and fighting amongst themselves for meagre benefits and even for subsistence.

Perhaps our youth should learn a useful lesson from the youth of South Korea. They successfully forced out the military dictatorship and initiated democratisation. But they did not do this at the cost of their own future. Along with their political struggle, they worked hard in colleges, acquiring all the requisite scientific and technological expertise that is now second to

none, to lead their country through development. These same youth lead their country in world-class sports. Three decades ago, Nepal and S. Korea were at the same stage of development; now the gap has become almost unbridgeable. Our youth has been deceived into believing that there is nothing but politics, and the only politics they understand is destruction. They do not realize that they are striking their own legs with the axe. In history books, we read of marauding foreign armies burning down libraries and other cultural icons of the vanquished. But here, the youth is gleefully torching the departments and libraries, destroying computers and other possessions of the university that were imported at great cost with hard earned foreign exchange, without an inkling that they are cutting their own throats. For some reason, all the political factions have been considering the education sector as the greatest threat to absolute power. Hence, all of them have targeted educational institutions for their political vendettas. Teachers and students are used as mere tools for political gains. The destructive events of the recent past indicate that, finding itself unable to adapt to the new world scenario, the Nepalese society is developing a death wish with suicidal tendencies. Unless the youth can break free from the stranglehold of the senile political and other leadership, the whole society will continue to be taken down the path to extinction.

The utter failure of science in Nepal is attributable more to the academic leadership than to politicians. The so-called academic leaders share three features: illogicality, because they lack a scientific approach; no vision of the future because they lack insight and knowledge of science and society; and (therefore) toadyism towards politicians because they want to keep their grip on power. These pseudo-leaders gave poor advice and convinced the politicians to arrange whatever was beneficial and comfortable for them. This all resulted in the present state of education and science, and to the rejection of Abdus Salam's offer to establish an international high technology centre in Nepal. There is no ground to blame the politicians for this plight because they have taken up the suggestions of scientists. It appears that the only remaining hope for improvement is the energetic and intelligent youth.

So it has become very important that the Nepalese youth forge a new path that will extricate them from this vicious vortex. They should openly and incisively question the intentions, methods and achievements of our so-called leaders who have had many opportunities, but repeated the same mistakes, and failed at every turn. The youth should come out with new ground- breaking ideas to develop our country. They should not compromise in acquiring the necessary expertise. Amartya Sen was awarded the Nobel Prize for proving that poverty, deprivation and famines are results of political manipulation rather than limited resources. Manpower resource is all that is necessary for development. Indeed, if they are serious, our youth will have to work overtime to constructively lead the society as well. Otherwise, as we remain mired in feudalistic darkness and poverty, it will remain inconsequential to us whether Professor Zewail earned his Nobel Prize for the study of chemical bonding using millisecond or femtosecond spectroscopy. ■

Udayaraj Khanal is a professor of physics in Tribhuvan University, Kathmandu, Nepal.
E-mail: khanalu@yahoo.com

Reasoning for results

A huge collection of data is nothing if we cannot make a hypothesis. Thinking over the result is as important as getting the data*

Dennis Bray

If biology were just a matter of gathering data about a fixed reality, there would probably be no need for theory in biology. But, basically it is a new idea that makes some significance to the society. Now, more than ever, we need to acknowledge the need for what Bush Père referred to as "the vision thing." We're not just talking about discoveries, new techniques, and Big Ideas – all of which require thought, and often hypothesis. Now we are entering a new phase in biology, where computer modeling can create virtual realities – and even predict and shape real reality. It's a brave new world, and without theorists to reflect on where it's all going, it could get scary.*

Let's start on safe ground. We all agree, surely, that theory — the formulation of hypotheses — is important in biology. Techniques are essential, as is the careful collection of quantitative data. But without ideas to give them shape and meaning, those endless successions of base sequences, expression profiles, electrical recordings and confocal images are as featureless as a plate of tofu. All really big discoveries are the result of thought, in biology as in any other discipline. Allostery, genes, DNA structure, chemiosmosis, immunological memory, ion channels were all once just a twinkle in someone's eye. And the work of most contemporary research laboratories still takes place within a framework of hypothesis, although practitioners may not always recognize this fact. As Charles Darwin once remarked: "How odd it is that anyone should not see that all observation should be for or against some view if it is to be of any service."

But assuming that biological theory ➔

The Rolwaling Mountain Legacy Institute

Mountain Legacy, creator of The Hillary Medal, proposes a bold initiative in integrated research and development

Proposal from the Namche Conference

From May 24-26 this year, fifty-five delegates representing 15 different nations from as far away as New Zealand, Canada, South Africa, and Sweden, converged on Sagarmatha National Park for an international symposium conferred with members of the host community entitled "The Namche Conference: People, Park, and Mountain Ecotourism." (Namche Bazar, 3350 m) and other stakeholders at the "Namche Conference: People, Park, and Mountain Ecotourism." The event was organized by United Nations University (UNU), Bridges: Projects in Rational Tourism Development (Bridges-PRTD), and HMG's Department of National Parks and Wildlife Conservation (DNPWC), and scheduled as part of the closing festivities marking the Mount Everest Golden Jubilee Celebration.

The Hillary Medal

One of the acts of the Namche Conference was the initiation of the Sir Edmund Hillary Mountain Legacy Medal, to be presented every two years "for remarkable service in the conservation of culture and nature in remote mountainous regions." On May 29th 2003, fifty years after the first ascent of Mount Everest, the first Hillary Medal was presented by Peter Hillary on behalf of Sir Edmund to Michael Schmitz and Helen Cawley. For the past decade Schmitz and Cawley have been working on keystone cultural and ecological projects in Solu-Khumbu including the Tengboche Monastery Development Plan, the Thubten Choling Monastery Development Project, and the Sacred Lands Initiative.

Mountain Legacy

At the close of the Namche Conference, a set of resolutions was adopted by unanimous assent of the assembled participants, including local stakeholders and visitors. Point 12 was a recommendation to establish Mountain Legacy, a new association that will organize future Namche Conferences, continue to grant the "Sir Edmund Hillary Mountain Legacy Medal" on a regular basis, and undertake other projects in support of tourism and volunteerism in remote mountainous destinations.

One of the first projects of this new organization, proposed by the *Himalayan Journal of Sciences* and Bridges-PRTD, is the Rolwaling Mountain Legacy Institute (RMLI), a center for research to be located in the upper Rolwaling Valley (Dolakha district, just west of Khumbu). RMLI would bring together researchers in a broad array of disciplines, assembling a database of integrated studies, monitoring development, and assisting in the preservation of Rolwaling's natural and cultural legacy. Research results would be published in the *Himalayan Journal of Sciences*.

Why Rolwaling?

This remote valley in north central Nepal presents an unusual combination of problems and opportunities linking biodiversity and tourism development (Sicroff and Alos 2000). Rolwaling's value as a biological sanctuary derives partly from its location and physical isolation. Running east-west for approximately 30 km, it is separated from Tibet by a stretch of the Himalayas that includes Gauri Shankar (7134 m), which for some time was thought to be the highest peak in the world. It can be reached by a 4 or 5 day trek from Barabise, which lies on the road to Tibet in the next valley to the west, or by a 2 or 3 day trek from Dolakha, the district administrative seat, located on a short branch off the Swiss road that connects Lamosangu with Jiri. To the east of Rolwaling is Khumbu district, home of Sagarmatha National Park. The wall of peaks between Rolwaling and Khumbu is breached by the formidable Tashi Lapsta pass; with good weather, one can make the crossing between Na in Rolwaling and the Thame in Khumbu in about four days. Altogether, access to Rolwaling is not quite impossible, but definitely more inconvenient than the most popular trekking routes, several of which can now be approached by air.

Cultural factors have contributed to the conservation of species in Rolwaling. According to Tibetan Buddhist tradition, about 1250 years ago Padmasambhava [aka Guru Urgyen Rinpoche] plowed the valley out of the mountains in order to serve as one of eight beyul, refuges that were to remain hidden until, in a time of religious crisis, they would serve as sanctuaries, protecting dharma until the danger passed. The neighboring Khumbu was one such zone, but, unlike Khumbu, Rolwaling remained unvisited and unimpacted until the nineteenth century, and then by a very few wanderers and outcasts. Due to the limited amount of arable land and the unsuitability of this east-west valley as a trade route between Tibet and India, Rolwaling's inhabitants remained poor and few, but devoutly mindful of their spiritual heritage. The Buddhist bans on hunting and slaughter, elsewhere observed less scrupulously, have protected the fauna; even plants are considered living creatures which ought not to be harmed if possible.

A third general factor contributing to the relatively unimpacted state of Rolwaling Valley has been the government's limitation of tourist access. Until recently, visitors needed both a trekking peak permit and a regular trekking permit. The trekking peak permit involved costs and other factors that essentially excluded the possibility of independent trekking. All visitors arrived in self-contained tented caravans which contributed virtually nothing to the economy of Rolwaling villages. Therefore there has been very little development of infrastructure, and not much impact on the environment. The permits are no longer required, due primarily to the fact that Maoist activity makes enforcement impossible; however, this activity has itself deterred tourism.

In terms of biodiversity, Rolwaling is worthy of close attention. Janice Sacherer estimated that there are approximately 300 different plant species (Sacherer 1977, 1979). The atypical east-west orientation of the valley creates conditions unlike those in any other valley of the Himalayas. Partially shielded by its southern wall from the monsoon, Rolwaling has characteristics of the dry inner Himalaya; a good part of the flora derives from the Tibetan steppe and, in Nepal, is more typical of eastern valleys. As in other Himalayan valleys, Rolwaling's ecosystems vary dramatically from the broad glaciated valleys to the

chiseled fluvial channel downstream; to a much greater extent than in other valleys, the sharp contrast between north- and south-exposed slopes affects the distribution of species. The east-west orientation of the valley also makes it a convenient corridor for mobile fauna. Rolwaling is visited by quite a few of the charismatic mammals, including wolves, fox, several species of goat, bear, jackal, langur, and several members of the cat family (including snow leopard). Every resident that we interviewed on the subject is convinced that yeti frequent the valley. In short, Rolwaling's biological assets are clearly worth studying; their conservation should also be accorded high priority as the valley's protective isolation breaks down. Furthermore, one cannot consider development scenarios in the high Rolwaling Valley without assessing the implications for the rich subtropical ecosystems of the Tamba Valley into which it feeds.

If isolation has had a benign effect on the natural ecosystem, the human residents of Rolwaling have observed the tourism boom with envy. In next door valleys, every family could throw open its doors to backpackers and cash in on the amenity values of their homeland; in Rolwaling, the stakeholders stare wistfully as organized trekking caravans deploy their tents by the river, cook up their burrito and quiche feasts, and buy nothing from the local residents. In Khumbu, their relatives enjoy the benefits of prosperity: schools, upscale monasteries, telephone, electricity, numerous clinics, a hospital, post office – even Internet, saunas, pool halls and chocolate croissants: none are available in Rolwaling. Many young men have found employment with trekking and climbing services. Such work entails extended absence from Rolwaling, and even emigration to Kathmandu or Khumbu. The result is a brain and manpower drain that leaves the villages of Rolwaling populated by women, children, and those no longer capable of strenuous labor. Agricultural fields have been abandoned, livestock ineffectively tended, trails poorly maintained. Alcohol, the only recreational option, is a serious health problem.

This disparity between the neighboring districts has created in Rolwaling (as in the access routes) an intense demand for free access to backpackers and economic opportunity. A couple of years ago, due to the threat of Maoist attacks, the police checkpost in Simigaon was removed. At this point, Rolwaling is officially open to general trekking, and, as the prospects for peace improve, the valley will become an important trekking destination.

Research opportunities

At the western end of Rolwaling Valley,Tsho Rolpa, one of the highest and largest lakes in the Himalayas, has been growing over the past decades due primarily to the recession of Trakarding Glacier. Attempts to mitigate the danger of a glacial lake outburst flood (GLOF) have included siphoning, installation of a warning system, and reduction of the lake level by 3 meters through an artificial drainage channel. Due to depletion of project funding, the drainage efforts have stopped far short of the recommended objective. Particularly as there is a real threat of a catastrophic GLOF, Tsho Rolpa is an appropriate place to begin long-term study of glacial melting, runoff hydrology, and moraine stability.

Rolwaling is also a good location for ecological research. Zonation is extremely compressed. The east-west orientation results in unusually sharp differences on the northward and southward facing slopes; it also means that the valley is probably an important wildlife corridor. Numerous ethnobotanical resources have been identified; now would be a good time to study them in the wild, and also to begin efforts to cultivate them as cash crops.

Serious anthropological studies by Sacherer and Baumgartner in the 1970s provide useful baseline data against which the current changes, especially the impact of tourism, can be measured and monitored. Specific studies that are urgently needed: the Rolwaling dialect of Sherpa, and Rolwaling traditions of song and dance.

Rolwaling Mountain Legacy Institute

In the initial phase, we would propose an institute of opportunity rather than infrastructure. That is, researchers would use existing facilities (lodges and homes) rather than constructing new infrastructures. This would permit

- rapid initiation of programs
- significant ongoing economic contribution to the village economy
- minimization of impact on the object(s) of study

We would also propose to assist researchers in recruiting volunteers. We envisage this as an opportunity for tourists to stay for prolonged periods, making contributions to research and practical projects, and also injecting expenditures for living expenses into the local economy. International students could be recruited either as study-abroad program participants or as interns. These students could either assist established researchers or design and implement their own programs consistent with the aims of the RMLI.

A parallel objective of this research institute would be to develop a special type of community-base ecotourism in Rolwaling. RMLI would encourage long-term stays at very low per-diem rates, as opposed to so-called "quality tourism," which aims to extract the maximum profit over the course of short stays. We think that such an institute, well-publicized, would be a magnet not only for prospective participants but also for other tourists. Just as tourists go out of their way to visit cheese-making factories, they will visit Rolwaling to see the world-famous research center and to contribute to whatever on-going projects might need their help.

Implementation

The first step is to form an ad hoc committee that will establish a Mountain Legacy NGO in Nepal. This committee will locate researchers who are interested in initiating projects in Rolwaling. Parallel Mountain Legacy groups would be organized around the world, and these would take the lead in sponsoring Namche Mountain Legacy Conferences and Mountain Legacy Institutes in remote mountainous destinations in their own countries. All those who are interested in participating in the Mountain Legacy agenda should contact the editors of this journal (email: editors@himjsci.com). ■

Related websites

1) www.namche.info for Namche Conference
2) www.mountainlegacy.org for Mountain Legacy, Hillary Medal
3) www.tengboche.org for Tengboche Monastery Development Project
4) www.sacredland.net for The Sacred Land Initiative
5) www.rolwaling.com for Rolwaling, The Sacred Valley

References

J Sacherer. 1977. *The Sherpas of Rolwaling valley, north Nepal: A study in cultural ecology* [dissertation]. Paris: The Ecole Pratique des Hautes Edudes. Ann Arbor, MI. University Microfilms

J Sacherer. 1979. The high altitude ethnobotany of the Rolwaling Sherpas. Contributions to Nepalese Studies, Vol. VI, No. 2. Kathmandu: CNAS, Tribhuvan University

S Sicroff and EA Alabajos. 2000. Biodiversity and Tourism in the Sacred Valley. In: Watanabe T, S Sicroff, NR Khanal and MP Gautam (eds), *Proceedings of the International Symposium on the Himalayan Environments: Mountain Sciences and Ecotourism/Biodiversity*; 2000 Nov 24-26; Kathmandu, Nepal. p 52-63

Evaluation of cultivars and land races of *Oryza sativa* for restoring and maintaining wild abortive cytoplasm

Bal K Joshi†*, Laxmi P Subedi‡, Santa B Gurung‡ and Ram C Sharma‡

†*Agricultural Botany Division, Nepal Agricultural Research Council (NARC), Lalitpur, PO Box 1135, Nepal*
‡*Institute of Agriculture and Animal Science, Tribhuvan University, Rampur, Chitwan, Nepal*

**To whom correspondence should be addressed. E-mail: joshibalak@rediffmail.com*

Identification of restorers and maintainers from cultivars and landraces through test crossing and their use in further breeding programme are the initial steps in three-line heterosis breeding. Two experiments, one in the greenhouse for F_1 hybrid seeds production and another in the field for parental screening, were conducted during the 1999 rice growing season at the Institute of Agriculture and Animal Science (IAAS, TU), Rampur, Nepal. Three cytoplasmic male sterile (CMS) lines, eight improved cultivars and six landraces of rice were studied for their fertility restoring and sterility maintaining abilities. Pollen sterility was studied based on their stainability with potassium iodide iodine (I-KI) solution. On the basis of their interaction with I-KI, pollens were categorized as unstained withered sterile (UWS), unstained spherical sterile (USS), stained round sterile (SRS) and stained round fertile (SRF). For each hybrid, the percentage of spikelet fertility was estimated. The test lines were categorized as restorers, partial restorers, maintainers, and partial maintainers on the basis of pollen sterility and spikelet fertility. The male sterile lines had mostly UWS and USS types of pollen, whereas the restorer lines had more SRS and SRF types. There was no strong evidence for a relationship between pollen fertility and spikelet fertility. Five restorers, three partial restorers, two partial maintainers and four maintainers were identified. These restorers can be used to develop the hybrid seed while maintainers to maintain and/or to develop new CMS lines, because these are locally adapted cultivars. Pedigree analysis revealed that, for some of these test lines, TN-1 and CR94-13 might be the donors of maintainer and restorer gene(s), respectively.

Key words: CMS line, maintainer, restorer, rice

Him J Sci **1**(2): 87-91
URL: www.himjsci.com/issue2/oryzasativa

Received: 9 Feb 2003
Accepted after revision: 15 Apr 2003

Introduction

In Nepal, rice accounts for about 50% of the total cropped area and food production (Upadhaya 1996). Efforts to improve rice productivity in Nepal have resulted in the introduction of a large number of improved cultivars with varying yield potentials. To meet the demand created by increasing population and rising incomes, it is important to increase the yield potential of rice beyond that of semi-dwarf cultivars. Experiences in China, India, and Vietnam have established that hybrid rice offers an economically viable option to increase cultivar yield. The usual method for raising hybrids is to establish many inbred lines, perform inter-crosses and determine which hybrids are most productive in a given locality. As the female parents have to be male sterile, they should be maintained in every generation and male sterile lines have to be developed. They should be locally adapted and should perform well in hybrid combinations. The basic requisites for successful hybrid rice production are development of male sterile lines (A), maintainers (B) and restorers of fertility (R). Lin and Yuan (1980) reported the use of an effective restorer in China in commercial F_1 hybrids involving the wild aborted (WA) cytosterility system in 1973. Effective restorer lines for WA, Gam and Bt cytosterility systems have been identified among cultivated rice cultivars and elite breeding lines (Shinjyo 1969, 1972, Lin and Yuan 1980). For the CMS-WA system hundreds of effective restorer lines have been identified among cultivated rice cultivars and elite breeding lines bred in China (Lin and Yuan 1980, Yuan et al. 1994), International Rice Research Institute (IRRI 1983, Govinda Raj and Virmani 1988, Virmani 1994), Indonesia (Suprihatno et al. 1994), India (Rangaswamy et al. 1987, Siddiq et al. 1994), and the Philippines (Lara et al. 1994). The restorer lines for WA cytosterility were found more stable and their restoration ability was stronger (Virmani 1996). The frequency of restorer lines was higher among late maturing Indica cultivars and negligible among Japonica cultivars (Lin and Yuan 1980). The varieties IR24, IR26, IR661 and IR665, restorer of the most widely cultivated hybrids in China were developed at the IRRI (Virmani and Edwards 1983).

Identification of maintainers and restorers from elite breeding lines and landraces through test crossing (Ikehashi and Araki 1984, Virmani 1996) and their use in further breeding programme are the initial steps in three-line heterosis breeding (Siddiq 1996). The objectives of this study therefore, were to identify rice landraces and cultivars with fertility restoring ability and to identify maintainers of sterility among the test lines.

Materials and methods

Plant materials

This experiment was conducted in a greenhouse and experimental farm at the Institute of Agriculture and Animal Sciences (IAAS), Tribhuvan University, Rampur, Chitwan, Nepal, during the dry and wet seasons of 1999. The IAAS is located at 84° 29' E and 27° 37' N (224 m asl). Details of the 9 improved cultivars, 6 landraces and 3 wild aborted cytoplasmic male sterile (CMS) lines of rice used in this study are given in **Table 1**. The improved cultivars and landraces were obtained from the National Rice Research Program (NRRP), Hardinath, and IAAS, Rampur, respectively. The CMS lines were

obtained from the IRRI, Philippines.

F_1 seeds production

Crossing was performed in a greenhouse, using cylindrical crossing chambers made of 2.5 m plastic sheet. The top portion of the chamber was open. The pollen parents were seeded three times to ensure a continuous supply of pollen to the female parent during the period of flowering, while the CMS lines were seeded only once. Before crossing, each CMS plant was tested for pollen sterility. This was determined by staining pollen grains in 1% potassium iodide-iodine (I-KI) solution. At heading, about 10 spikelets from each plant were collected in the morning just prior to blooming and fixed in 70% alcohol. All the anthers from 6 spikelets were excised with the help of forceps and placed in the stain. The pollen grains were released with a needle and gently crushed. After the debris was removed, a cover slip was placed over the pollen material and it was observed under a microscope (10x). The method is similar to that described by Virmani et al. (1997) and Chaudhary et al. (1981). The CMS plants showing complete sterility were used for crossing. The F_1 seeds were produced in the greenhouse using the Approach method (Erickson 1970).

Screen nursery

A field experiment involving 14 F_1's, 14 pollen parents, and 3 CMS lines was conducted to screen the cultivars/landraces. The block was divided into 31 plots of 0.8 m^2 size each. The pollen parent was

TABLE 1. Improved rice cultivars, landraces and CMS lines used in this study

A. Improved cultivars

Cultivar	Pedigree	Parentage	Origin	Grain type	Reaction to diseases	
					Bl	BB
Bindeswari	IET1444	TN1/Co29	India	Medium	MR	MS
Chaite-6	NR274-7-3-3-1	NR6-5-46-50/IR28	Nepal	Medium	R	R
Janaki	BG90-2	Peta *3/TN1//Remadja	Sri Lanka	Coarse	R	MR
Sabitri	IR2071-124-6-4	IR 1561/IR1737// CR94-13	IRRI	Coarse	MR	MR
Radha-11	TCA80-4	Local selection	India	Medium	S	MR
Kanchan	IR39341-4PL-P28	CR 126-42-5/IR 2061-213	IRRI	Medium	MR	-
Khumal-4	NR10078-76-1-1	IR 28/Pokhreli Masino	Nepal	Fine	R	-
Khumal-7	IR7167-33-2-3-3-1	China1039DWF-MUT/Kn-1B-361-1-8-6-10	IRRI	Coarse	R	-

Bl-Blast, BB-Bacterial blight, MR- Moderately resistant, M- Moderately susceptible, R-Resistant, S- Susceptible

Source: NRRP 1997

B. Landraces

Landrace	Origin	Remarks
Deharadune	Nepal	All landraces are popular local cultivars of hilly area of Nepal and have intermediate stature. They mature earlier than local cultivars of the Tarai and are field resistant to blast and bacterial leaf blight
Ratodhan	Nepal	
Gogi	Nepal	
Kature	Nepal	
Chiunde	Nepal	
IAR-97-34	Nepal	

C. CMS lines of wild aborted type

CMS line	Origin	Parentage	Remarks
IR58025A	IRRI	IR4843A/8*Pusa167-120	Stable in sterility, best combiner for yield, has aromatic long slender grains; using this line more than 50 hybrids have been developed in India.
IR62829A	IRRI	IR46828A/8*IR29744-94	Stable in sterility, has functional male sterility, very good combiner; using this line more than 20 hybridshave been developed in India.
IR68888A	IRRI	IR62829A/6*IR62844-15//IR629744-94	Stable in sterility, good combiner

Source: DRR 1996

planted beside their F_1 and CMS planted after the pollen parent. The field was fertilized at the rate of 120 kg N, 60 kg P_2O_5 and 60 kg K_2O per ha. Half of the nitrogen was applied as a basal dose and half top-dressed one month after transplanting. The 21-day-old seedlings were transplanted in the field in two rows with 10 hills per row at spacing of 20 cm between rows and 20 cm between plants. A single seedling was planted in each hill. Pollen and spikelet fertility were measured from each plot.

Pollen sterility

Pollen sterility of the F_1s was determined by staining pollen grains in 1% I-KI solution (Dalmacio et al. 1995, Virmani et al. 1997, Chaudhary et al. 1981, Sohu and Phul 1995, Young et al. 1983). The pollen grains in 3 randomly selected microscopic fields were counted. The pollen grains were classified based on their shape, size and extent of staining (Virmani et al. 1997, Young et al. 1983, Chaudhary et al. 1981) as shown in **Box 1**.

In the case of CMS lines and some hybrids, the patterns of pollen abortion were classified as follows (Chaudhary et al. 1981):

Type 1: Almost all pollen grains appear as UWS and USS.

Type 2: The majority of pollen grains appear as USS (51%), followed by SRS (36%) and UWS (14%).

Type 3: The majority of pollen grains are SRS (52%); UWS and USS are 20-25%.

Spikelet fertility

Five panicles from each experimental unit were bagged before flowering for spikelet fertility analysis. At maturity, the bagged panicles were examined for seed set. Spikelet fertility was determined by dividing the total number of seeds by the total number of spikelets. Test lines were classified on the basis of pollen fertility and spikelet fertility **(Table 2)**.

F_1s were also classified on the basis of seed set as male parent or weaker than male parent, anthers whether plumpy yellow or white shriveled.

Results and discussion

The pollen and spikelet fertility of hybrids are given in **Table 3**. In hybrids, pollen fertility ranged from 1 to 82% and spikelet fertility varied from 0 to 87%. Pollen fertility varied from 28 to 97%, while spikelet fertility ranged from 73 to 91% in pollen parents **(Table 4)**.

Our data indicates that pollen's susceptibility to staining with I-KI solution does not correlate with spikelet fertility. This may be due to the ability of single fertile pollen to fertilize a spikelet. It

BOX 1. Categories of rice pollen and their features

Category of pollen	Shape and staining behaviour	Classification
Unstained withered sterile (UWS)	Withered and undeveloped, unstained	Sterile
Unstained spherical sterile (USS)	Spherical and smaller, unstained	Sterile
Stained round sterile (SRS)	Round and small, lightly or incompletely stained, rough surface	Sterile
Stained round fertile (SRF)	Round and large, darkly stained, smooth surface	Fertile

TABLE 2. Classification of test lines into maintainers and restorers

Pollen fertility (%)	Category	Spikelet fertility (%)
0-1	Maintainer	0
1.1-50	Partial maintainer	0.1-50
50.1-80	Partial restorer	50.1-75
>80	Restorer	>75

Source : Virmani et al. 1997

TABLE 3. Pollen and spikelet fertility of hybrids

SN	Hybrid	Pollen fertility (%)	Spikelet fertility (%)	Seed set as	F/S	Test line	Inference on test line
1	IR68888A/Radha-11	80	87	MP	F	Radha-11	R
2	IR58025A/Janaki	49	33	W	F	Janaki	PM
3	IR58025A/Kanchan	81	75	MP	F	Kanchan	R
4	IR58025A/Khumal-4	32	57	MP	F	Khumal-4	PR
5	IR58025A/Sabitri	82	84	MP	F	Sabitri	R
6	IR58025A/Chaite-6	55	58	W	F	Chaite-6	PR
7	IR68888A/Bindeswari	1	0	W	F	Bindeswari	M
8	IR68888A/Khumal-7	1	0	W	S	Khumal-7	M
9	IR62829A/Deharadune	1	0	W	F	Deharadune	M
10	IR62829A/Ratodhan	82	79	MP	F	Ratodhan	R
11	IR68888A/Gogi	59	26	W	F	Gogi	PM
12	IR62829A/Kature	81	76	MP	F	Kature	R
13	IR68888A/Chiunde	1	0	W	F	Chiunde	M
14	IR58025A/IAR-97-34	56	49	MP	F	IAR-97-34	PR
	Range	1-82	0-87				
	Mean	47	45				
	SE	9.04	9.15				

MP-male parent, W-weaker than MP, F-plumpy yellow anthers, S-white shriveled anthers on visual basis, R-restorer, PR-partial restorer, PM-partial maintainer, M-maintainer

suggests that pollen fertility is independent of the spikelet fertility. Therefore even a low number of fertile pollen counted in this study can give a higher seed set. However, the sterility of the inter-varietal rice hybrids is due primarily to pollen sterility. Guiquen et al. (1994) reported that sterility in the inter-varietal hybrids of cultivated rice is caused by the allelic interaction at the F_1 pollen sterility loci. Six loci of genes controlling F_1 pollen sterility in rice have been reported (Guiquen et al. 1994). Our study is in agreement with Guiquen et al. (1994) in that among F_1 hybrids, the higher the incidence of the heterozygote S^i/S^j at the six loci, the higher the incidence of pollen sterility and spikelet sterility.

Three CMS lines had a higher percentage of UWS and USS than that of rest lines. IR68888A had no SRF at all while the other two had some fertile pollen **(Table 4)**. The higher percentage of SRS in hybrids IR68888A/Bindeswari, IR68888A/Khumal-7, IR62829A/Deharadune and IR68888A/Chiunde was associated, on average, with 1% SRF. The hybrids having higher SRS were associated with high frequency of SRF as in IR68888A/Radha-11, IR58025A/Janaki, IR58025A/Kanchan, IR58025A/Khumal-4, IR58025A/Sabitri, IR58025A/Chaite-6, IR62829A/Ratodhan, IR62829A/Kature and IR58025A/IAR-97-34. **Table 4** shows that hybrids with some SRF pollen had fewer filled grains in the panicles. It indicates that hybrids having higher UWS and USS will be more useful for developing new CMS lines from their sterile hybrids.

The hybrids were classified as semi-sterile on the basis of spikelet fertility of 40-80%. The male parents of these hybrids were designated as partial restorers. In these hybrids, SRS had dominated the other pollen categories. The partial restorer IAR-97-34 had

TABLE 4. Pollen categories and types of male sterility in male sterile lines, hybrids and test lines

SN	CMS/ hybrid/test line	Total pollen examined	Frequency (%)				Type	Pollen sterility (%)	Spikelet fertility (%)
			UWS	USS	SRS	SRF			
1	IR68888A	238	47.27	50.77	1.96	0.00	I	100.00	0.00
2	IR58025A	385	29.67	68.25	0.69	1.38	I	98.62	0.00
3	IR62829A	268	27.77	38.85	21.67	11.70	I	88.30	0.00
4	IR68888A/Radha-11	455	4.94	5.49	31.14	58.43		41.57	86.82
5	Radha-11	493	0.14	1.49	24.36	74.02		25.98	83.96
6	IR58025A/Janaki	374	12.13	18.11	20.79	48.97		51.03	32.98
7	Janaki	521	3.78	2.18	14.08	79.96		20.04	75.34
8	IR58025A/Kanchan	426	2.35	4.77	27.91	64.97		35.03	75.00
9	Kanchan	427	0.86	0.86	14.74	83.54		16.46	73.13
10	IR58025A/Khumal-4	289	3.92	15.11	51.10	29.87	III	70.13	57.27
11	Khumal-4	553	0.00	0.00	20.51	79.26		20.74	88.92
12	IR58025A/Sabitri	440	1.29	7.65	21.05	70.02		29.98	84.43
13	Sabitri	587	0.57	2.44	29.51	67.48		32.52	86.34
14	IR58025A/Chaite-6	304	4.93	8.88	31.36	54.83		45.17	57.54
15	Chaite-6	283	1.18	0.71	3.53	94.59		5.41	86.02
16	IR68888A/Bindeswari	288	12.49	38.27	48.25	1.00	III	99.00	0.00
17	Bindeswari	468	0.00	2.99	0.36	96.66		3.34	82.94
18	Masuli (check)	266	0.63	16.44	54.96	27.98	III	72.02	84.23
19	IR68888A/Khumal-7	193	10.02	28.67	60.32	1.00	III	99.00	0.00
20	Khumal-7	457	0.22	1.31	21.79	76.68		23.32	79.26
21	IR62829A/Deharadune	401	4.91	21.36	73.15	1.00	III	99.00	0.00
22	Deharadune	338	4.14	17.24	9.07	69.56		30.44	81.84
23	IR62829A/Ratodhan	462	0.22	2.74	19.48	77.56		22.44	78.73
24	Ratodhan	455	0.37	3.59	12.68	83.36		16.64	78.15
25	IR68888A/Gogi	394	4.82	22.51	13.96	58.71		41.29	26.15
26	Gogi	440	0.30	2.20	16.00	81.50		18.50	66.99
27	IR62829A/Kature	352	7.76	10.89	25.00	56.34		43.66	76.00
28	Kature	547	0.43	4.20	32.66	62.71		37.29	87.45
29	IR68888A/Chiunde	228	26.28	48.18	25.50	0.50	II	99.50	0.00
30	Chiunde	403	0.99	12.33	31.02	55.67		44.33	73.45
31	IR58025A/IAR-97-34	451	6.35	13.52	23.71	56.43		43.57	49.34
32	IAR-97-34	496	0.60	6.51	25.52	67.36		32.64	90.56
	Range	193-587	0-47.27	0-68.25	0.36-73.15	0-96.66		3.34-100	0-90.56
	Mean	396.31	6.92	14.95	25.25	52.9		47.09	57.59
	SE	18.12	1.93	3.01	3.01	5.48		5.49	6.07

UWS, unstained withered sterile, USS, unstained spherical sterile, SRS, stained round sterile, SRF, stained round fertile, Type I- almost all pollen appears as UWS and USS, II-majority of pollen as USS (51%) followed by SRS (36%) and UWS (14%), III-majority of pollen SRS followed by USS and UWS

TABLE 5. Restorers and maintainers for three CMS lines

CMS line	Restorers	Maintainers
IR58025A	Kanchan, Sabitri	-
IR62829A	Kature, Ratodhan	Deharadhune
IR68888A	Radha-11	Bindeswori, Khumal-7, Chiunde
Frequency (%)	36	29

more spikelet sterility than the other two partial restorers, Khumal-4 and Chaite-6. Spikelet fertility percentage varied widely among hybrids, and many hybrids had a lower spikelet fertility percentage than the high-yielding cultivars. Therefore, it is of practical importance to understand the causes of high spikelet sterility in hybrids for possible increase in spikelet fertility.

Restorers and maintainers identified in the study are summarized in **Table 5**. Among these lines, five were restorers, three were partial restorers, four were maintainers and two were partial maintainers. Radha-11 was found to be an effective restorer for IR68888A, Kanchan and Sabitri for IR58025A and Ratodhan and Kature for IR62829A. Bindeswari and Khumal-7 were found to be maintainers for IR68888A, and Deharadune for IR62829A. No maintainer for IR58025A was found. With respect to maintaining ability, all maintainers appeared to function effectively in maintaining sterility. All F_1 of these pollen parents with CMS showed a rate of 0% spikelet fertility and 0.5 to 1% pollen fertility. The frequency of restorers (36%) was higher than that of maintainers (21%). The frequency of restorer lines was higher among rice cultivars originating in lower latitudes. Virmani and Edwards (1983) reported that effective restorer cultivars were mainly distributed in the tropics where Indica rice was exclusively grown. Virmani (1996) found a lower incidence of restorer lines in northern China, eastern Europe, Japan, and Korea. The restoring ability of rice cultivars has been found to be, to some extent, related to their origin (Govinda Raj and Virmani 1988). Among Indica rice cultivars the frequency of R gene is higher in late maturing cultivars than in early maturing ones (Ahmed 1996). The restorer frequency is very low in typical Japonica rice cultivars (Lin and Yuan 1980, Virmani et al. 1981). It suggests that origin and pedigree of test lines are important characters to be considered in evaluating the rice genotypes for restoring and maintaining WA cytoplasm. Maintainer line, Bindeswari had been derived from the Taichun Native 1 (TN-1). Therefore, Bindeswari may have received its maintaining property from TN-1. Similarly the restorer gene in Sabitri might have come from CR94-13. Since the restorers and maintainers identified here are locally adapted, these cultivars and landraces may have value in heterosis breeding. Restorers can be improved (Liu et al. 1998) by using various procedures. Among the approaches used in developing new restorers, recombination breeding is the most common (Ahmed 1996). New restorers can be developed through cross breeding, which can enlarge the genetic base of R lines by pyramiding complementary traits from various sources in order to meet the breeding objectives. The CMS-WA system has been used extensively to transfer cytoplasmic male sterility traits in various genotypes both within and outside of China. The intensive use of a single source of male sterile cytoplasm in developing hybrid cultivars was found disastrous in the cases of Texas cytoplasm in maize and Tift cytoplasm in pear millet (Pokhriyal et al. 1974). It was therefore, considered wise to diversify sources of the cytoplasm. The maintainer and restorer lines identified here may be useful in increasing genetic diversity. The restorers can be used to develop hybrids and the maintainers to maintain and/or to develop new CMS lines. ■

References

Ahmed HI. 1996. Outlines of heterosis breeding program in rice. In: Ahmad MI, BC Viraktamath, MS Ramesha and CHM Vijaya Kumar (eds), *Hybrid rice technology*. Hyderabad: ICAR, Directorate of Rice Research. p 55-65

Chaudhary RC, SS Virmani and GS Khush. 1981. Patterns of pollen abortion in some cytoplasmic-genetic male sterile lines of rice. *Oryza* **18:** 140-2

Dalmacio R, DS Brar, T Ishii, LA Sitch, SS Virmani and GS Khush. 1995. Identification and transfer of a new cytoplasmic male sterility source from *Oryza perennis* into indica rice (*O. sativa*). *Euphytica* **82**: 221-5

DRR. 1996. *Final report (1991-96): Development and use of hybrid rice technology.* Hyderabad: ICAR/UNDP/FAO project, ICAR, Directorate of Rice Research. 87 p

Erickson JR. 1970. Approach crossing of rice. *Crop Sci* **10**: 610-1

Govinda Raj K and SS Virmani. 1988. Genetics of fertility restoration of WA type cytoplasmic male sterility in rice. *Crop Sci* **28**: 787-92

Guiquen Z, L Yonggen, Z Hau, Y Jinchang and L Guifu. 1994. Genetic studies on the hybrid sterility in cultivated rice (*Oryza sativa*) IV: Genotypes for F_1 pollen sterility. *Chin J Genet* **21**: 35-42

Ikehashi H and H Araki. 1984. Varietal screening of compatibility types revealed in F_1 fertility of distant crossed in rice. *Jpn J Breed* **34**: 304-13

IRRI. 1983. *Annual report for 1981.* Manila: IRRI

Lara RJ, IM Dela Cruz, MS Ablaza, HC Dela Cruz and SR Obien. 1994. Hybrid rice research in the Philippines. In: Virmani SS (ed), *Hybrid rice technology: New developments and future prospects* [Selected papers from the International Rice Research Conference]. Manila: IRRI. p 173-86

Lin SC and LP Yuan. 1980. Hybrid rice breeding in China. In*: Innovative approaches to rice breeding.* Manila: IRRI. p 35-51

Liu XC, SS Virmani and BC Viraktamath. 1998. Improving parental lines to increase efficiency of hybrid rice breeding: Some new approaches. In: Virmani SS, EA Siddiq and K Muralidharan (eds), *Advances in hybrid rice technology*. Proceedings of the 3rd International Symposium on Hybrid Rice; 1996 Nov 14-16; Hyderabad, India. Manila: IRRI. p 99-110

NRRP. 1997. *25 years of rice research in Nepal (1972-1997).* Kathmandu: National Rice Research Programme, NARC. 41 p

Pokhriyal SC, RR Patil, R Dass and BC Singh. 1974. Combining ability of new male sterile lines in pearl millet. *Ind J Genet Plant Breed* **34**: 208-15

Rangaswamy M, K Natarajamoorthy, GS Palnisamy and SR Sreerangaswamy. 1987. Isolation of restorers and maintainers for two Chinese male sterile lines having wild abortive cytoplasm. *Int Rice Res Newsletter* **12**: 13

Shinjyo C. 1969. Cytoplasmic-genetic male sterility in cultivated rice *Oryza sativa* L. II: The inheritance of male sterility. *Jpn J Genet* **44**: 149-56

Shinjyo C. 1972. Distributions of male sterility-inducing cytoplasm and fertility-restoring genes in rice I: Commercial lowland-rice cultivated in Japan. *Jpn J Genet* **47**: 237-43

Siddiq EA, PJ Jachuck, M Mahadevappa, FU Zama, R Vijaya Kumar, B Vidyachandra et al. 1994. Hybrid rice research in India. In: Virmani SS (ed), *Hybrid rice technology: New developments and future prospects* [Selected papers from the International Rice Research Conference]. Manila: IRRI. p 157-71

Siddiq EA. 1996. Current status and future outlook for hybrid rice technology in India. In: Ahmed MI, BC Viraktamath, MS Ramesha and CHM Vijaya Kumar (eds), *Hybrid rice technology.* Hyderabad: ICAR, Directorate of Rice Research. p 1-27

Sohu VS and PS Phul. 1995. Inheritance of fertility restoration of three sources of cytoplasmic male sterility in rice. *J Genet Breed* **49**: 93-6

Suprihatno B, B Sutaryo and TS Silitohnga. 1994. Hybrid rice research in Indonesia. In: Virmani SS (ed), *Hybrid rice technology: New developments and future prospects* [Selected papers from the International Rice Research Conference]. Manila: IRRI. p 195-206

Upadhyaya HK. 1996. Rice research in Nepal: Current state and future priorities. In: Evenson RE, RW Herdt and M Hossain (eds), *Rice research in Asia: Progress and priorities.* Manila: IRRI. p 193-215

Virmani SS and IB Edwards. 1983. Current status and future prospects for breeding hybrid rice and wheat. *Adv Agron* **36**: 145-214

Virmani SS, BC Virakamath, CL Laral, RS Toledo, MT Lopez and JO Manalo. 1997. *Hybrid rice breeding manual*. Manila: IRRI. 151 p

Virmani SS, RC Chaudhary and GS Khush. 1981. Current outlook on hybrid rice. *Oryza* **18**: 67-84

Virmani SS. 1994. Prospects of hybrid rice in the tropics and subtropics. In: Virmani SS (ed), *Hybrid rice technology: New developments and future prospects* [Selected papers from the International Rice Research Conference]. Manila: IRRI. p 7-19

Virmani SS. 1996. Hybrid rice. *Adv Agron* **57**: 328-462

Young JB, SS Virmani and GS Khush. 1983. Cyto-genic relationship among cytoplasmic-genetic male sterile, maintainer and restorer lines of rice. *Philip J Crop Sci* **8**: 119-24

Yuan LP, ZY Yang and JB Yang. 1994. Hybrid rice in China. In: Virmani SS (ed), *Hybrid rice technology: New development and future prospects.* Mania: IRRI. p 143-7

Acknowledgements

The Department of Botany, IAAS, Nepal provided laboratory facilities for pollen analysis.

Assessing the land cover situation in Surkhang, Upper Mustang, Nepal, using an ASTER image

Benktesh D Sharma†*, Jan Clevers‡, Reitze De Graaf§ and Nawa R Chapagain¶

† *King Mahendra Trust for Nature Conservation, Kathmandu, Nepal*
‡ *Laboratory of Geo-Information and Remote Sensing, Wageningen University, The Netherlands*
§ *Forest Ecology and Forest Management Group, Wageningen University, The Netherlands*
¶ *King Mahendra Trust for Nature Conservation, Kathmandu, Nepal*

* *To whom correspondence should be addressed. E-mail: bdsharma@kmtnc-acap.org.np*

This paper describes the remote sensing technique used to prepare a land cover map of Surkhang, Upper Mustang Nepal. The latest ASTER image (October 2002) and an ASTER DEM were used for the land cover classification. The study was carried out in Surkhang Village Development Committee (area 799 km^2) of Upper Mustang region. The study area falls within the Annapurna Conservation Area. Field surveys for training data, ground truthing and spectral signature collection were carried out during May-June 2002. Various image classification algorithms were tested, and the one that yielded the best result was used for image classification. The land cover situations with their aerial extents were identified and topographic analysis was carried out to study the variations of different land covers types in the region. Various species of grasses covered about 36 %; shrubs covered about 32%; bare land, which includes area from completely bare to less than 10% vegetation, constituted about 20% of the land resources of the study area. Grassland was found abundant in east- to south-facing slopes, while shrub species were abundant in flat regions and west- to north-facing slopes.

Key words: ASTER image, DEM, land cover mapping, Mustang, Nepal, GIS, remote sensing

Him J Sci **1**(2): 93-98
URL: www.himjsci.com/issue2/landcover

Received: 26 Apr 2003
Accepted after revision: 12 June 2003

Introduction

Land cover maps record the structure and make-up of a landscape. A map structure related directly to real features on the ground can help to understand and interpret the environment. It shows the inter-connectivity of landscape features, their immediate context and the wider neighborhood in which environmental influences operate. This type of map helps to see how ecological principles can explain patterns of landscape diversity.

Recent improvements in satellite image quality and availability have made it possible to perform image analysis at much larger scale than in the past. This will likely lead to a wider use of satellite imagery at the regional level as a reliable source of timely and accurate spatial data. In recent years, Geographic Information System (GIS) technologies have greatly increased ability to map and model land cover, providing resource managers and researchers with a tool to analyze data and address specific problems at a variety of spatial scales, in less time, and in a more cost-effective manner (Ramsey et al. 1999).

Land cover classification involves grouping of components into homogeneous units on the basis of characteristics significant to the management of land resources. Through remote sensing techniques supplemented with field surveys, an accurate land cover map can be prepared in cost effective manner than manual survey land cover mapping, and both biotic and abiotic surface features, including vegetation composition and/or density and local landforms, can be interpreted (Best 1984).

The changing land cover conditions can be quantified using change detection remote sensing techniques. Remote sensing techniques, together with ground truth data, are widely used to collect information on the qualitative and quantitative status of natural resources in protected areas. With the advent of satellite technology and GIS, it has been now well-accepted tools to establish and model spatial information (Mongkolsawat and Thirangoon 1998).

Satellite imagery interpretation is one way of obtaining information on land use resources that has also been emphasized in the Management Information Systems (MIS) plan of the Annapurna Conservation Area Project (ACAP) (Chapagain 2001). Once these resources are assessed and integrated with other bio-physical and socio-economic information of management relevance, land cover mapping being an activity for resource assessment, the MIS would support decision making in the project area. This study was carried out with the objective of assessing land resources in the Upper Mustang Biodiversity Conservation Project (UMBCP) of King Mahendra Trust for Nature Conservation (KMTNC) and preparing an accurate and up-to-date land cover map of Surkhang, Upper Mustang.

Materials and methods

Study area

The study was carried out in Surkhang, the largest of the seven Village Development Committees (VDCs) in Upper Mustang (In Nepal the VDC is the smallest administrative unit.) The geographic coverage ranges approximately from 28^{0}50'19"-29^{0}09'10" N and 83^{0}49'41"-84^{0}15'16" E. The land cover classification and mapping for this VDC was carried out over an area of about 784 km^2; the remaining 15 km^2 was not included in this research due to unavailability of satellite data. This VDC borders on Tibet in the east, and is one of the most remote areas of Nepal **(Plate 1)**.

The region is situated in the Himalayan rain shadow and ➔

PLATE 1. A landscape view of Upper Mustang

receives less than 100 mm rainfall annually (HMGN 1999). More than 40 percent of Mustang's area is rangeland and pasture at altitudes of 3,000 to higher than 5,000 m asl (Blamont 1996); the elevation of our study area ranges from 3000 to more than 6000 m asl. The wholeVDC remains under snow for 4-5 months (November to March). The Upper Mustang region is said to be the southern extension of the Tibetan plateau. The climate and landscape of Upper Mustang are similar to that of Tibetan plateau. Alluvial fans, jutting sandstone ridges, abandoned glacial moraines and broad sandy terraces are among the more conspicuous elements of this highly accidented landscape. Mean annual daytime temperatures are around 21°C, but mean annual nighttime temperatures may fall to 5°C. Only herders and pastoralists visit the northern area of this VDC, often for 2-3 months in summer (**Figure 1**).

Remote sensing data

A surface radiance image of Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) taken on October 2002 and ASTER Digital Elevation Model (DEM) (ASTER 2001) were used for the land cover classification. ASTER covers a wide spectral region with 14 bands from visible to thermal infrared with high spatial, spectral and radiometric resolution. An additional backward-looking near-infrared band provides stereo coverage (Abrams and Hook 2001), which is generally used for the preparation of DEM. The spatial resolution varies with wavelength: 15 m in the visible and near-infrared (VNIR) region, 30 m in the short wave infrared (SWIR) region, and 90 m in the thermal infrared (TIR) region. This ASTER image was geo-referenced with the help of topographic maps of the study areas by locating 18 conspicuous ground control points (GCPs), such as ridges and confluences. For the sake of computational simplicity, a first order polynomial transformation with the nearest neighbour resampling technique was used (Lillesand and Kiefer 2000); this entailed directly assigning the digital number (DN) in the input file that overlaps the pixel in the output file, avoiding the necessity of altering the original input pixel values (Richards 1993). For the analysis a spatial resolution of 30 m was used. The root mean square error was 0.21 pixels.

Although the original ASTER image had 14 bands, for this study only nine bands covering visible to short wave infrared were used. The thermal bands were not used because of their coarse resolution (90 m).

The image acquisition date was in winter when the cultivated fields of Upper Mustang were devoid of crops. The roofs of houses in UM regions are made mostly of mud. The agricultural fields are found in the surrounding of houses. The field survey phase identified that in winter the vegetation cover on agricultural fields was limited to grasses and shrubs, and many were completely barren. Such fields were not correctly distinguished as a separate class in satellite images. Therefore, cultivated areas were digitized from topographic maps. Eleven such agricultural areas were identified on the available topographic maps. These fields were masked in the original image and excluded from classification. For statistical estimates and map preparation, these areas were reincorporated into the classified image.

Principal components analysis (PCA) allows compaction of redundant data into fewer bands thereby reducing the dimensionality. The bands of PCA data are noncorrelated and independent, and are often more interpretable than the source data, yielding better classification results (ERDAS Inc 1999). Nine principal components were derived from the original 9 bands of the ASTER. The information contained in each component was checked and the components containing most information were used for the analysis.

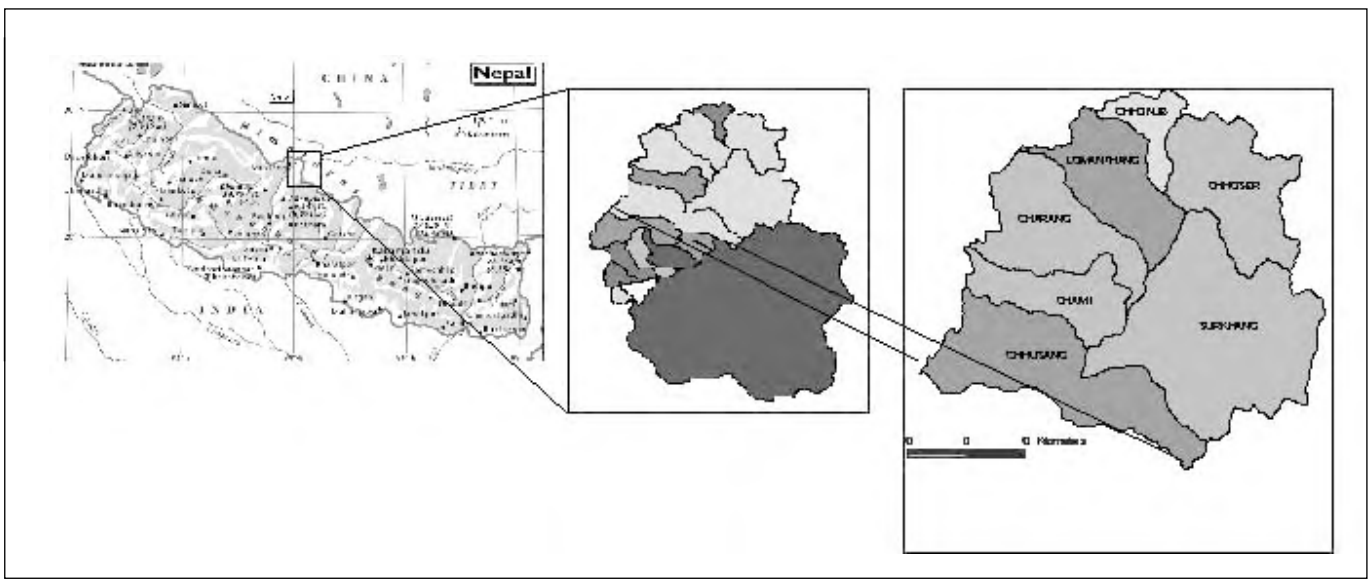


FIGURE 1. Map of the study area: Nepal (left), Annapurna conservation area showing the different VDCs of Mustang (middle) and Upper Mustang showing Surkhang, the study area (right)

BOX 1. Description of land cover classes used to classify the study area

Cover class	Description
Agriculture and settlement	This class includes villages and community settlements, as well as adjoining crop fields and tree stands. Usually trees and crop fields are along the periphery of clustered houses. Almost all of this class lies along riverbanks. This is the pattern of settlement throughout the Upper Mustang region.
Bare land	This class includes the land surface with little or no cover (i.e. less than 10% vegetation cover). The region of rock-falls is also included in this class.
Water bodies	Rivers, streams, and rivulets constitute this class. Lakes formed by glaciers are frequently found above 5000 m elevation. Perennial rivers, glacial lakes and permanent water bodies are included in this class while the small rivers which remained dry during the time of image acquisition are not included
Grassland	This is the most prevalent land cover of the area, usually above 4000 m. All high altitude pastures with smooth slopes consist of alpine grasses. The habitat is highly favored by blue sheep and other grazers.
Shrub land	This is the second most prevalent land cover class above 3000 m. *Lonicera obovata* and *Caragana* spp. dominate this class, associated in some locales with *Berberis* spp.
Snow cover	This class includes those peaks with permanent snow cover. They are usually found above 6000 m elevation.

The normalized difference vegetation index (NDVI) is calculated from the reflected solar radiation in the near-infrared (NIR) and red (RED) wavelength bands via the algorithm.

The NDVI is a nonlinear function, which varies between –1 and +1 but is undefined when RED and NIR are both zero. The NDVI can be used as an indicator for the amount of green biomass. It is used to discriminate vegetated and non-vegetated regions in image analysis to improve classification results.

Aspect in general has greater significance in vegetation characteristics as it determines the amount of radiation available for the plant. Around the world, aspect and slope are used as predictors of vegetation types (Hamilton et al. 1997). The aspect and slope images were derived from the available DEM and used to test if they contribute significantly in cover type discrimination.

A review of studies carried out by Koirala and Shrestha (1997) and Raut (2001) were undertaken in order to obtain a general picture of land cover classes of the region. Taking into consideration these earlier studies as well as the feasibility of cover discrimination by image analysis, we developed a classification scheme **(Box 1)**.

An unsupervised classification, the iterative self-organizing data analysis (ISODATA) clustering algorithm, which operates by initially seeding a specified number of cluster centroids in spectral feature space (Debinski et al. 1999), was used to get an idea of possible cover classes of the region. It served as an aid for the supervised classification and selection of appropriate sites during the training stage.

Supervised classification is an essential tool for extracting quantitative information from remotely sensed image data (Richards 1993). For this technique, a number of mathematical approaches have been developed (Lillesand and Kiefer 2000). We tested four common algorithms on the first 3 bands (in VNIR region) of the ASTER image: minimum distance to mean (MDM), mahalanobis distance (MHD), parallelepiped (PPL) and maximum likelihood (MLH). The algorithm that gave best results in terms of accuracy was chosen for the final classification.

Training data were collected in order to obtain good representatives of each vegetation type (Lillesand and Kiefer 2000). Field observations, aerial photographs, topographical maps, Global Positioning System (GPS) survey and the image of the unsupervised classification were used to collect data from 70 training sites, which included all types of land cover designated for the work. Spectral signatures were collected from a wide range of elevations (3000 to 5600 m asl). Signatures were also collected from sites with differences in topographic slope and aspect in order to normalize differences in radiance. Two sets of data, one for the classification and another for the evaluation of the classified image, were collected.

The collected spectral signatures were evaluated by plotting the mean spectral signature and checking if the classes could be discriminated using the given set of bands in the image. We also plotted the signature ellipses in the feature space. The spectral mean plot was calculated for a composite of 17 bands: 9 original ASTER bands, 4 PC bands, DEM, slope, aspect and NDVI image. This helped to determine which bands to include for the classification.

Results and discussion

Results of principal component analysis

PC 1 contained 80% of the information of the 9 original ASTER bands. The combination of 4 principal components constituted more than 99% of the information **(Table 1)**. This means that 4 PCs can give 99.89% of the information that the 9 original bands could do. Therefore these 4 bands were used to determine the optimum band combination for land cover classification.

Obtaining an optimum number of land cover classes

The results of the classified image of the unsupervised (ISODATA) classification were used to create a histogram. The result of the histogram is presented in the form of a line graph of the classes **(Figure 2)**. If a sharp decrease is present in the histogram, it could represent the point where additional clusters are irrelevant (Tatham and O'Brien 2001). Since there is a sharp fall in the number of pixels

TABLE 1. Principle components (PC) and % information contained

PC	% explained variance	Cumulative %
1	80.66	80.66
2	18.57	99.23
3	0.55	99.77
4	0.11	99.89
5	0.06	99.95
6	0.02	99.97
7	0.02	99.99
8	0.01	99.99
9	0.01	100

after the seventh class, it is concluded that seven classes would be sufficient. However, during the field survey and ground truthing work it was found appropriate to make a land cover map comprising only 6 classes (as per the management relevance of the scope of this work) **(Box 1)**.

Spectral signature evaluation

The spectral signatures of five classes (excluding agriculture and settlements) were plotted against the 17 bands to evaluate and determine which band combinations could best discriminate the cover classes **(Figure 3)**. Bands 3, 5, 7, 8 and 9 could easily discriminate the classes. PC 1 can discriminate the classes as well. Aspect and NDVI image could discriminate the vegetated classes from the non-vegetated ones. The PC 1 image, which contains only 88.66% of the information of the original 9 bands, could differentiate the cover classes better than original 1, 2, 4, and 6 bands. We tested our hypothesis that the inclusion of this PC 1 image could compensate for the loss of information of the excluded bands 1, 2, 4 and 6. A combination including PC 1 and another combination without PC 1 were compared to find out if this hypothesis was valid.

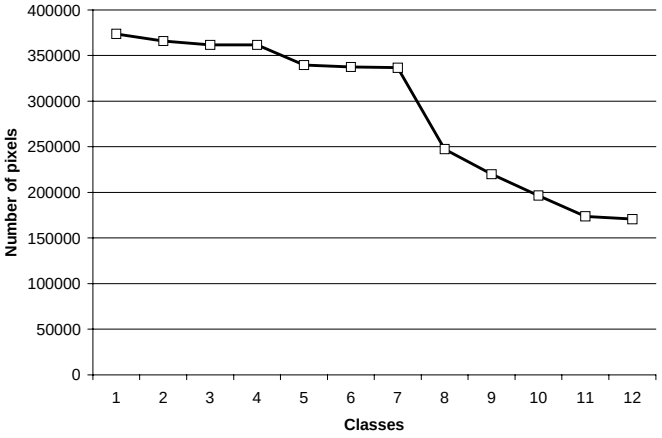


FIGURE 2. Line graph of histogram analysis of 12 clusters (results of ISODATA unsupervised classification)

Use of DEM as a separate band did not give usable results. In the spectral plot, the DEM could discriminate the classes, but that is not meaningful as the values are the locations of the pixel for which the classes were taken. Eiumnoh and Shrestha (1997) reported that DEM enhanced the classification techniques in their studies. An unsupervised classification was run in the original bands with DEM and the result was not as expected. Rather, the inclusion of DEM as a separate band resulted in a rough classification of elevation zones in the image.

Selection of appropriate classifier

The results of supervised classification carried out over the three bands (in VNIR region to test the classification algorithms) using four different classification algorithms **(Table 2)**. These accuracy assessments were done by using an independent set of ground data i.e., other than that used for classification.

Among these 4 tested classifiers, the maximum likelihood classifier gave superior results in terms of accuracy. Therefore, this

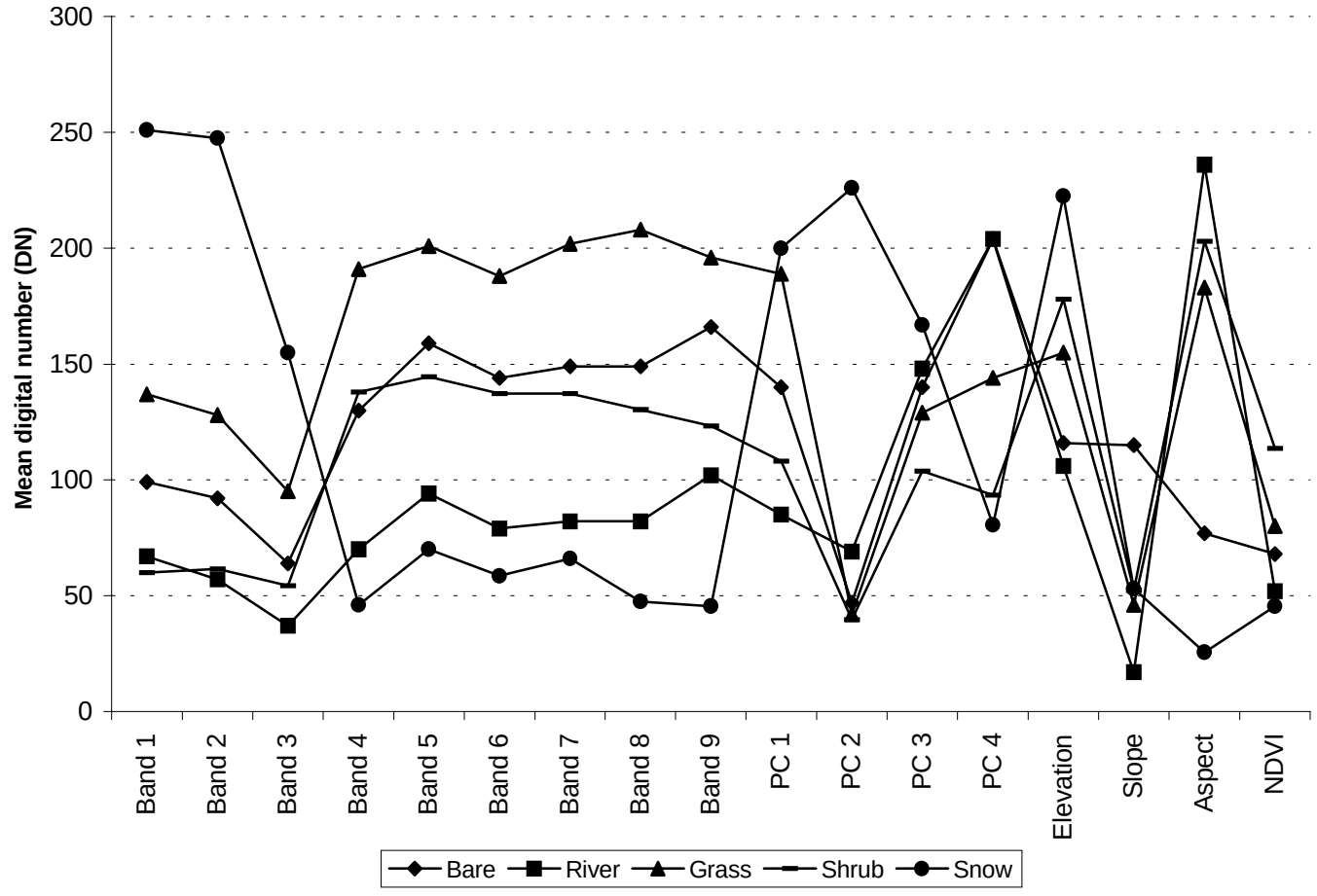


FIGURE 3. Spectral signatures mean plot of the classes

classifier was used for all subsequent studies including the final classification.

Selection of appropriate band combinations for classification

Detailed analysis of the available spectral and DEM information showed that 4 combinations were promising for discriminating the six classes (Sharma 2003). To find out the most suitable bands for classification, these combinations were classified using maximum likelihood classifier with a 95% confidence interval. The results in terms of classification accuracy for the bands tested are given in **Table 3**.

Since the classification of BC 4 which constituted bands 3, 5, 6, 7, 8, 9, NDVI and aspect gave the best overall classification accuracy, this combination was used for final classification. The users' and producers' accuracy are given in **Table 4**. It was found that the inclusion of PC bands when other original bands suffice to discriminate the classes did not enhance the classification accuracy.

A 3 by 3 majority filter was applied in order to smoothen the salt-and-pepper appearance in the classified image according to the methods and rational described by Eastman (1997). The land cover map and its information are presented in **Figure 4** and **Table 5** respectively.

Vegetation patterns and their characteristics in Upper Mustang

The spatial analysis carried out using GIS showed that the agriculture and settlement class was found between 3036 and 4212 m asl. Cultivated fields and settlements were scattered and constitute only a small portion of the total land cover in the region. Snow was observed at elevations as low as 5172 m asl. Grasslands were found up to 7101 m asl, while shrub lands were found up to 7166 m asl. (Interpretation of the values related to elevation should take into account the release notes of DEM given in ASTER 2001).

In the study of the general distribution of vegetation in the study area by aspect, grass species which were generally more light-demanding were found primarily on east- to southwest-facing slopes, while shrub species, which are shade tolerant, were found on cooler north-, west-, and northwest-facing slopes, which received fewer hours of sunlight **(Figure 5)**.

The NDVI analysis showed that the shrub lands had higher biomass (NDVI values) than grasslands. The NDVI, which varies between -1 and +1 in general, was found to be between -0.46 to 0.32 for shrub land and -0.34 to 0.23 for grassland. The NDVI image within each of the grassland and shrub land was classified into 3 classes to represent low, moderate and high density. The results showed that the study area contained, for the most part, a low density of grasslands and a moderate density of shrub land **(Table 6)**.

Conclusions

A classification of land cover with a high level of accuracy was obtained from an ASTER image with maximum likelihood classifier. Inclusion of ancillary data such as NDVI and aspect images increased the classification accuracy. Based on the October 2002 image, we found that cultivated land and settlements cover 0.31%, bare land 20.19%, water bodies 1.82%, grassland 36.01%, shrub land 32.57% and snow 9.11% of the total area of Surkhang. Grass species were abundant in east- to south-facing slopes while shrub species were abundant in flat and west- to northwest-facing slopes. The vegetation analysis showed that Surkhang contains a low density of

TABLE 2. Classification accuracy of different classifiers

SN	Classification algorithm	Overall accuracy
1	Minimum distance to mean (MDM)	64.38 %
2	Mahalanobis distance (MHD)	66.93 %
3	Parallelepiped (PPL)	62.03 %
4	Maximum likelihood (MLH)	67.44 %

TABLE 3. Description of band combinations (BC) and the accuracy obtained

Band combination	Constituent bands	Overall accuracy
1	Bands 1, 2, 3, 4, 5, 6, 7, 8, 9	77.78 %
2	Bands 1,2,3, 4, 5, 6, 7, 8, 9 and Aspect	79.07 %
3	Bands 3, 5, 7, 8, 9, PC1, NDVI and Aspect	91.73 %
4	Bands 3, 5, 7, 8, 9, NDVI and Aspect	92.25 %

TABLE 5. Area of land cover classes

Class	Percent	Area (km^2)
Agriculture and settlements	0.31	2.44
Bare land	20.19	158.31
Water body	1.82	14.25
Grassland	36.01	282.34
Shrub land	32.57	255.38
Snow cover	9.11	71.40
Total	100.00	784.11

TABLE 6. NDVI characteristics of two vegetation types

Category	Grassland		Shrub land	
	NDVI	%	NDVI	%
Low	-0.345 to -0.152	68.36	-0.462 to –0.20	4.78
Moderate	-0.152 to 0.041	31.62	-0.20 to 0.062	91.67
High	0.041 to 0.234	0.01	0.062 to 0.324	3.55

TABLE 4. Producers' and users' accuracy of classified image using BC 4

Class name	Reference total	Classified total	Number correct	Producers accuracy	User's accuracy
Bare land	104	102	97	93.27%	95.10%
Water bodies	30	32	28	93.33%	87.50%
Grassland	99	118	97	97.98%	82.20%
Shrub land	92	73	73	79.35%	100.00%
Snow cover	62	62	62	100.00%	100.00%
Totals	387	387	357		

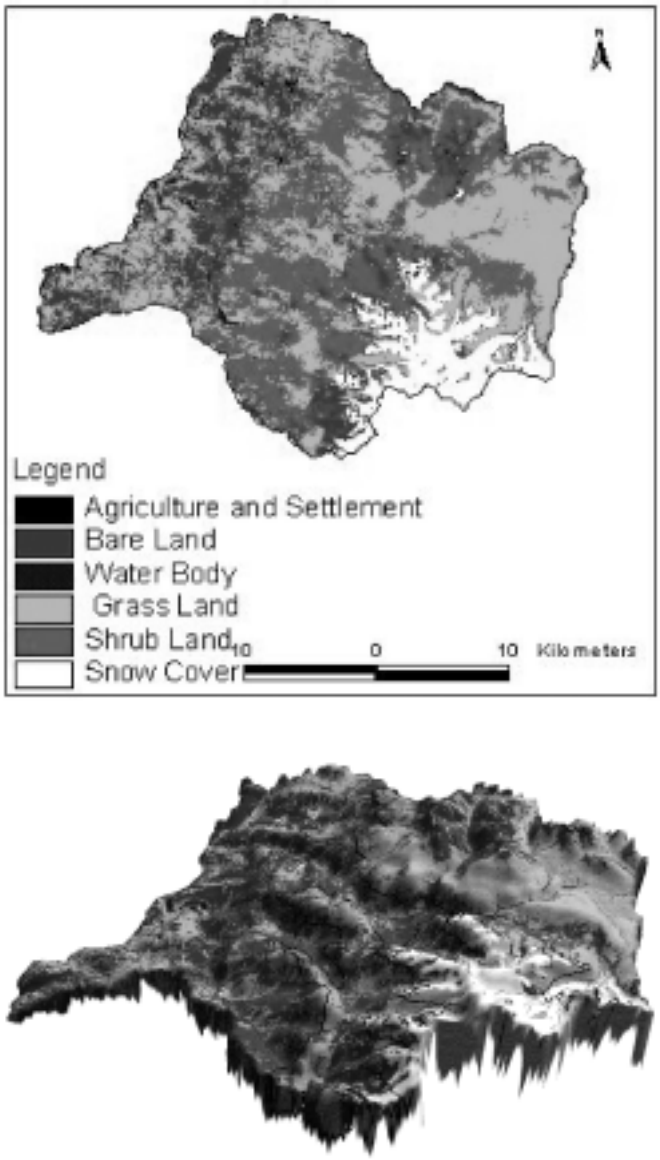


FIGURE 4. Land cover map of Surkhang (upper) and a 3 dimensional perspective view created by draping the land cover map over the Digital Elevation Model of the of the same study area (lower)

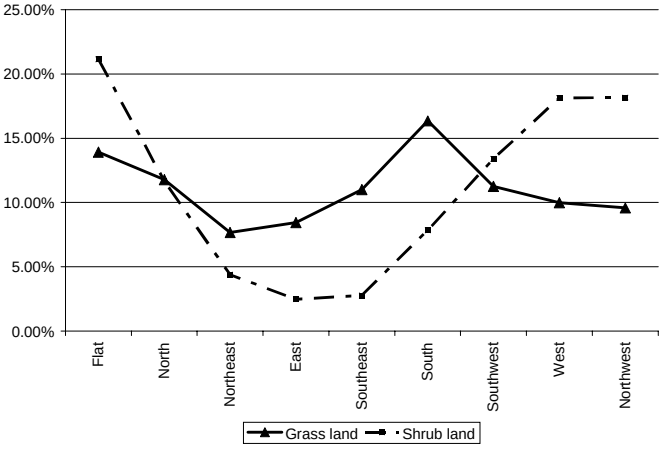


FIGURE 5. The distribution of vegetation at different aspects

grass species and a moderate density of shrub species. The output of this study is the data regarding land cover and spatial relationships, which may contribute to any spatial analysis related to the study area for the Management Information Systems. ■

References

Abrams M and S Hook. 2001. *ASTER user's handbook*, Version 2. Pasadena (CA): Jet Propulsion Laboratory. 135 p

ASTER. 2001. ASTER DEM release notes: ASTER digital elevation model – AST14DEM-relative, Version 2.00. In: *ASTER higher level products user guide*. Pasadena (CA): Jet Propulsion Laboratory. p 27-8

Best R. 1984. Remote sensing approaches for wildlife management. In: *Renewable resource management: Application of remote sensing*. Proceedings of the RNRF Symposium on the application of remote sensing to resource management; 1983 May 22-27; Seattle (WA). p 55-96

Blamont D. 1996. *Upper Mustang's shifting animal husbandry practices in rangelands and pastoral development in the Hindu Kush-Himalayas*. Proceedings of a regional experts' meeting; 1996 Nov 5-7; Kathmandu, Nepal

Chapagain NR. 2001. GIS based management information system for Annapurna Conservation Area, Nepal. http://www.gisdevelopment.net/application/nrm/mountain/mount0005.htm

Debinski DM, K Kindscher and ME Jakubaskas. 1999. A remote sensing and GIS based model of habitats and biodiversity in the Greater Yellostone Ecosystem. *Int J Remote Sensing* **20**(17): 3281-91

Eastman JR. 1997. *IDRISI for windows: User's guide*, Version 2.0. Worcester (MA): Clark University

Eiumnoh A and RP Shrestha. 1997. Can DEM enhance the digital image classification? In: *Proceeding of the 18th Asian Conference on remote sensing (ACRS)*; 1997 Oct 20-24; Malaysia. Asian Association on Remote Sensing (AARS). http://www.gisdevelopment.net/aars/acrs/1997/ts9/ts9007pf.htm

ERDAS Inc. 1999. *ERDAS field guide*, 5th ed. Atlanta. 698 p

Hamilton LS, DA Gilmour and DS Cassels. 1997. Montane forests and forestry. In: *Mountains of the World: A global priority*. New York: Parthenon. p 281-311

HMGN. 1999. Daily precipitation records of Bheri, Rapti and Dhaulagiri zone through 1996. Kathmandu: Department of Hydrology and Meteorology, HMGN

Kazuhiro N, BK Baniya, SR Upadhyay, M Minani and A Ujihara. 1995. Buckwheat cultivation and its utilization in Upper Mustang, Nepal. http://soba.shinshu-u.ac.jp/contents/102.html

Koirala RA and R Shrestha. 1997. Floristic composition of summer habitat and dietary relationships between Tibetan argali (*Ovis ammon hodgsonii*), naur (*Pseudois nayaur*) and domestic goat (*Capra hircus*) in the Damodar Kunda region of Upper Mustang in Nepal Himalaya [thesis]. Agricultural University of Norway

Lillesand TM and RW Kiefer. 2000. *Remote sensing and image interpretation*, 4th ed. New York: John Wiley and Sons. 724 p

Mongkolsawat C and P Thirangoon. 1998. Application of satellite imagery and GIS to wildlife habitat suitability mapping. In: *Proceeding of the 19th Asian Conference on Remote Sensing*; 1998 Nov 16-20; Manila. Asian Association on Remote Sensing (AARS). http://www.gisdevelopment.net/aars/acrs/1998/ts11/ts11008pf.htm

Ramsey RD, AT Black, E Edgley, and N Yorgason. 1999. *Use of GIS and remote sensing to map potential Columbian sharp-tailed grouse habitat in southeastern Idaho*. Idaho: US Department of Interior Bureau of Land Management. 12 p

Raut Y. 2001. *The status of rangeland resources in Upper Mustang*. Upper Mustang Biodiversity Conservation Project/Annapurna Conservation Area Project/King Mahendra Trust for Nature Conservation (UMBCP/ACAP/KMTNC). Research report series 5. 129 p

Richards JA. 1993. *Remote sensing digital image processing: An introduction*, 2nd ed. Berlin: Springer-Verlag. 340 p

Sharma BD. 2003. *Land cover classification and Equus kiang habitat mapping in Surkhang Nepal* [thesis]. Wageningen University and Research Center, The Netherlands

Tatham B and D O'Brien. 2001. *Bringing raster GIS to the district of North Vancouver*. District of North Vancouver (CA): GIS Department. BCIT GIS student project report. 70 p

UNDP. 2000. Preserving biodiversity and culture in Upper Mustang, Nepal. In: *Newsfront*. UNDP Communication Office. http://www.undp.org/dpa/frontpagearchive/september00/19sept00

Acknowledgements

This paper is based partly on the first author's M.Sc. thesis, which was carried out at Forest Ecology and Forest Management Group; and Laboratory of Geo-Information and Remote Sensing at Wageningen University, the Netherlands. We are grateful to Karan Shah, Natural History Museum, TU, Frits Mohren and Harm Bartholomeus, Wageningen University, for reviewing the paper and for providing methodological and technical assistance. Many thanks to Kishor Shrestha, Hira KC, Kaji R Adhikari and Basu D Neupane for their help during data collection. UMBCP of KMTNC provided logistic support during the fieldwork.

Effect of gibberellic acid on reserve food mobilization of maize (*Zea mays* L. var Arun-2) endosperm during germination

Chandra K Subedi†* and Tribikram Bhattarai‡

† *Research Centre for Applied Science and Technology (RECAST), Tribhuvan University, Kathmandu, Nepal*
‡ *Amrit Campus, Kathmandu, Nepal*

* *To whom correspondence should be addressed. E-mail: chandraks2000@yahoo.com*

In the first 24 hrs of germination, the dry matter of the growth axis decreased in the control while in 1 mg/l GA_3 solution it increased and in 10 mg/l and 100 mg/l the amount remained the same. Exogenous GA_3 overcomes the dry matter loss in the growth axis during the initial stage and results in an increase in the amount of dry matter. GA_3 application probably mobilized more soluble sugar to the growth axis, which results in an increase in the amount of soluble sugar in the growth axis as compared to caryopsis grown under control. 1 mg/l GA_3 enhanced the amount of soluble sugar and decreased the ether extract. In protein mobilization, 1mg/l and 10mg/l GA_3 solution appeared as effective as other treatments during the period from 48 to 96 hrs after sowing. The germination of seeds correlated directly with the mobilization of endosperm reserve. The seeds treated with 1 mg/l GA_3 solution showed higher mobilization of endosperm reserve, which ultimately showed the higher germination percentage.

Key words: GA_3 mobilization, *Zea mays*, reserve food, protein, soluble sugar, ether extract

Him J Sci **1**(2): 99-102
URL: www.himjsci.com/issue2/ga3

Received: 24 Apr 2003
Accepted after revision: 15 July 2003

Introduction

Germination of seeds involves a rise in general metabolic activity and initiates the formation of a seedling from the embryo. The first step in germination is imbibition of water, which results in swelling of the seed. This water uptake is accompanied by a rapid increase in the respiratory rate of the embryo. Shortly after the absorption of water by the seed, enzyme becomes active. Enzymes such as lipases, proteinases, phosphatases and hydrolases, which help to break down the storage materials, are either activated or synthesized *de novo* (Bewley and Black 1985). The breakdown products are later transported from one part of the seed to another and new materials are also synthesized (Arteca 1997).

The major storage materials in the seed are lipids, proteins and carbohydrates. These storage materials, to a considerable extent, characterize the seeds and they are of course economically the most significant part of the seed. The stored food materials are enzymatically broken down to simpler components and translocated to the embryo, the process known as mobilization, where they provide an energy source for growth.

Most of the physiological activities and growth of plants are regulated by hormones such as gibberellins, auxins and cytokinin. GA_3 was found to enhance root growth, shoot growth, shoot dry weight and accumulation of protein, carotenoids and tissue nitrates in Mangrove species (Kathireasan and Moorthy 1994). The use of exogenous GA_3 also accelerates germination.

Many workers have reported stimulation of endosperm metabolism by the addition of exogenous gibberellic acid. Paleg (1960, 1961) has described the dependence of loss of dry weight, starch hydrolysis and protein release in excised barley endosperm in the presence of added GA_3. Studies with many varieties of barley, wheat and oat have confirmed the generality of this effect (Paleg 1962).

Various studies on maize germination have been carried out by many researchers. Ingle et al. (1964) observed the changes in various chemical components such as sugars, proteins, lipids and nitrogen without exogenously applied GA_3. In the present work various concentrations of exogenous GA_3 (1mg/l, 10 mg/l and 100 mg/l) were applied to test the hormonal effect on germination, dry matter content and mobilization of endosperm reserve.

Materials and methods

Germination of caryopsis

Maize caryopses were obtained from the National Maize Research Programme, Rampur, Chitwan. The maize grains were sun dried. Healthy seeds of uniform size were used for the experiment.

After surface sterilization with 0.1% NaOCl, the caryopses were soaked in distilled water or in varying concentrations of GA_3 solution for 24 hrs and sown in a plastic box (250 mm x 160 mm x 110 mm) containing a double layer of filter paper moistened with distilled water or GA_3 solution. For 120 hrs (5 days), the seedlings were left in the incubator in complete darkness at 28±1°C.

Sample preparation

Twenty seedlings were removed at intervals of 24, 48, 72, 96 and 120 hrs following each treatment. The endosperms and growth axis (parts of seedling besides endosperm were separated by dissection. The dissected endosperms were crushed vigorously with mortar and pestle to form a fine powder that was used to determine the amount of dry matter and reserve food of the endosperm (soluble sugar, protein and ether extract). The growth axes were also dried to determine their dry matter. After drying, the samples were kept in plastic bags and stored at 4°C for further analysis. The dry matter in the sample was determined by using the method described by Bajracharya (1999).

Chemical analysis of endosperm

The amount of water soluble mono- and disaccharides in the sample was determined by anthrone reagent and standard calibration techniques (Welcher 1966) using glucose as the standard.

Total nitrogen was determined by the modified Kjeldhal method (PCARR 1980). The protein content of the sample was determined by multiplying the total amount of nitrogen by 6.25 (cf Bajracharya 1999). The amount of ether extract in each sample was determined by using Soxhlets apparatus, following Paech and Tracey (1955).

The amount of dry matter and endosperm reserve, and the germination percentage of different treatments obtained in this work were the average of three replications.

Results and discussion

Effect of gibberellic acid on seed germination

The percentage of germination increased up to 72 hrs and remained constant afterwards in all treatments and control. Among the various concentrations used in the experiment, 1 mg/l showed the highest percentage of germination (98%) **(Figure 1)**. The stimulatory effect of GA_3 on seed germination has been reported by many researchers (e.g. Lang 1965, Stokes 1965). GA_3 has also been reported to overcome the inhibitory effect induced by abscisic acid on rice germination (Bajracharya and Gupta 1978).

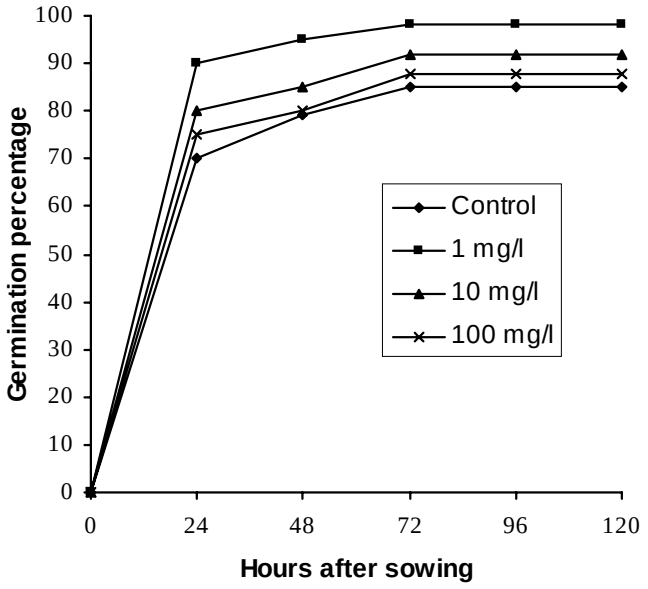


FIGURE 1. Effect of gibberellic acid on seed germination
ANOVA (variance ratio, treatment concentration)
CD = 1.45 at 0.05 level of significance

Effect of exogenous gibberellic acid on dry matter content

For all treatments as well as the control, the dry matter of endosperm decreased gradually with time **(Figure 2)**. The dry matter loss of endosperm was higher in GA_3-treated caryopsis than in the caryopsis grown under control, which indicates that GA_3 enhanced the mobilization of reserve materials from endosperm. GA_3-induced mobilization of reserve materials was also observed by Ingle and Hageman (1965). The greatest loss of endosperm dry matter was observed with 1 mg/l GA_3 treatment. The loss of dry matter decreased as the concentration of GA_3 increased. This shows that GA_3 can enhance the mobilization only up to a certain concentration, above which it appears to be less effective.

In the growth axis, there was loss of dry matter during the initial 24 hrs of germination in caryopsis grown under control **(Figure 3)**. This may have been due to the high rate of respiration in the seedlings after imbibition of water. This respiration was independent of protein synthesis but dependent on substrates stored in the embryonic axis (Abdul-Baki 1969). On the other hand, the dry matter in the growth axis increased during that same initial period with the 1 mg/l GA_3 treatment or remained same with the 10 mg/l and 100 mg/l treatments and decreased under control. This indicates that GA_3 application during germination overcomes the dry matter loss in growth axis during the initial stage and results in an overall increase in the amount of dry matter. After 24 hrs there

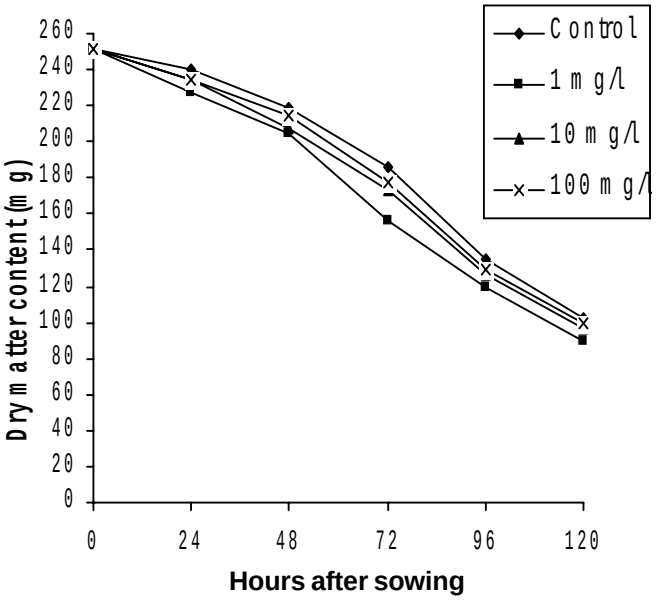


FIGURE 2. Effect of gibberellic acid on dry matter content of endosperm
ANOVA (variance ratio, treatment concentration)
CD = 2.05 at 0.05 level of significance

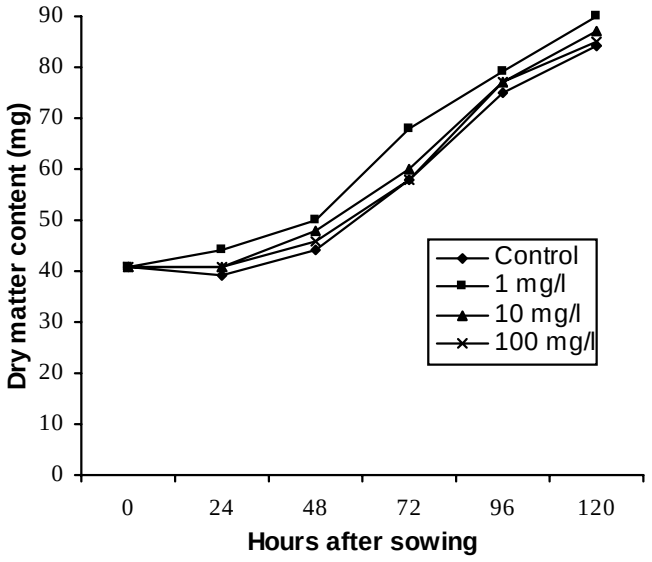


FIGURE 3. Effect of gibberellic acid on dry matter content of growth axis
ANOVA (variance ratio, treatment concentration)
CD = 1.66 at 0.05 level of significance

was a gradual increase in the amount of dry matter in growth axis both in the control and the GA_3-treated plants. This gradual gain in the amount of dry matter was due to the mobilization of food reserves from endosperm. The increase or no change in dry matter of growth axis in GA_3 treated caryopsis in early 24 hrs could be due to the mobilization of reserve food from endosperm to growth axis. The mobilization in the control plants should have started later only after synthesis of endogenous gibberellin, so it showed loss in weight in early 24 hrs as carbohydrate of growth axis was used in its metabolism.

Both in the control and treated plants, the total dry matter gradually decreased during germination **(Figure 4)**. This loss of dry matter is due to the respiratory process. A similar result was also reported by Malhotra (1934) and Ingle et al. (1964).

Effect of GA_3 on mobilization of endosperm reserve

In all treatments and in the control there was a gradual increase in the amount of soluble sugar during germination (**Figure 5)**. GA_3 application accelerated the hydrolysis of starch to soluble sugar by enhancing the hydrolytic enzymes such as α-amylase, β-amylase, maltase and invertase. A similar result was also observed by Salla et al. (1991) in rice. However the soluble sugar concentration was higher in GA_3 treated sample than control in all observations of this work, where endosperm treated with 1 mg/l hormone showed the highest amount of soluble sugar. Endosperm with 100 mg/l GA_3 treatment showed results more or less similar to those of the control. The formation of more soluble sugar in caryopsis treated with 1 mg/l GA_3 as compared to higher concentration treatments suggest that lower concentrations may be more effective in the hydrolysis of starch. The fall in the amount of soluble sugar during the early hrs in the control, followed by an increase after 24 hrs indicates that the conversion of starch to soluble sugar may commence at that point, presumably with the onset of synthesis of endogenous gibberellin. By contrast, caryopsis treated with 1 mg/l GA_3 solution showed a slight increase in the amount of soluble sugar in endosperm in the first day after sowing while at 10mg/l and 100mg/l the amounts remained the same.

As germination progressed the amount of protein stored in the endosperm gradually diminished in the control and in all treated plants (**Figure 6)**. This trend is similar to that observed by Ingle et al. (1964) and Paul and Singh (1981) in lentil seed. The decrease in the amount of protein during germination is explained by the fact that the protein is degraded into soluble nitrogenous compounds through the action of proteolytic enzymes, which in turn are utilized by various parts of the seedling (Mayer and Mayber 1982). The present study indicates that a 1 mg/l GA_3 solution may be more effective in the mobilization of protein (as of sugar) than the higher concentrations tested.

During germination the ether extract was depleted

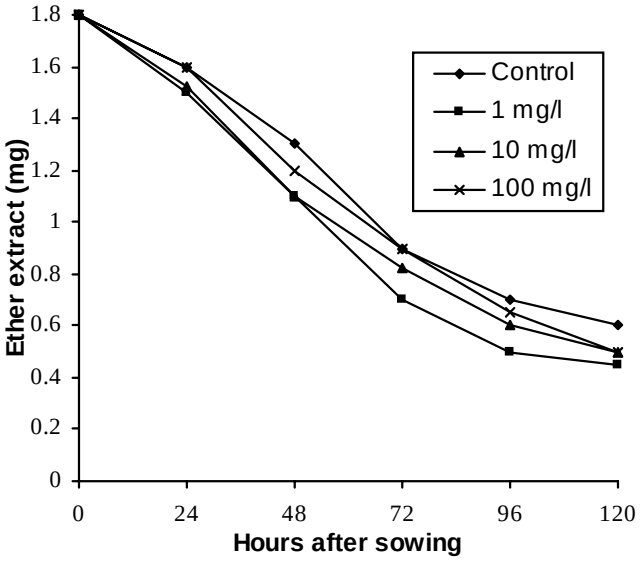


FIGURE 4. Effect of gibberellic acid on dry matter content of seedling as a whole: ANOVA (variance ratio, treatment concentration) CD = 2.14 at 0.05 level of significance

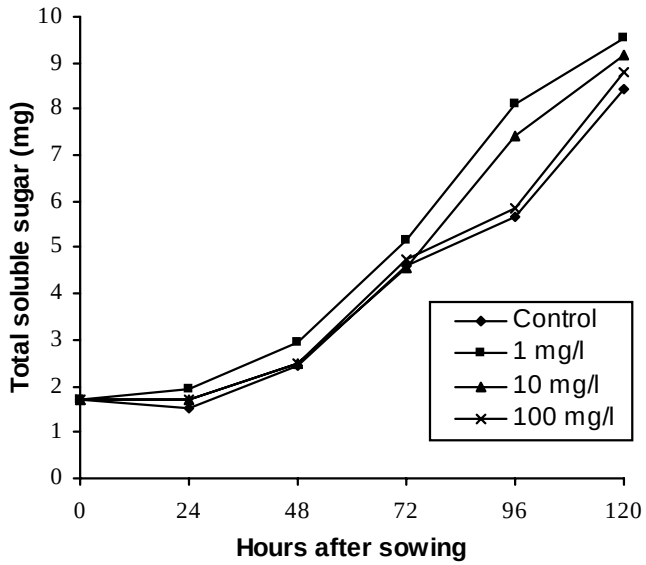


FIGURE 5. Effect of gibberellic acid on solouble sugar mobilization of endosperm: ANOVA (variance ratio, treatment concentration) CD = 0.216 at 0.05 level of significance

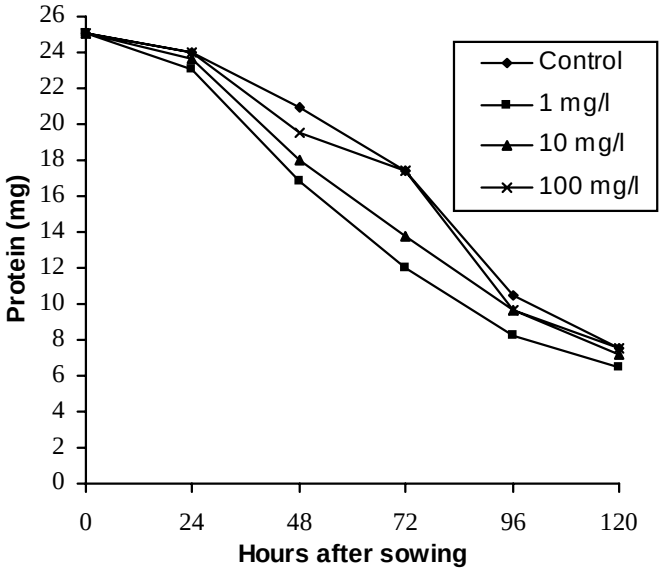


FIGURE 6. Effect of gibberellic acid on protein mobilization of endosperm: ANOVA (variance ratio, treatment concentration) CD = 0.515 at 0.05 level of significance

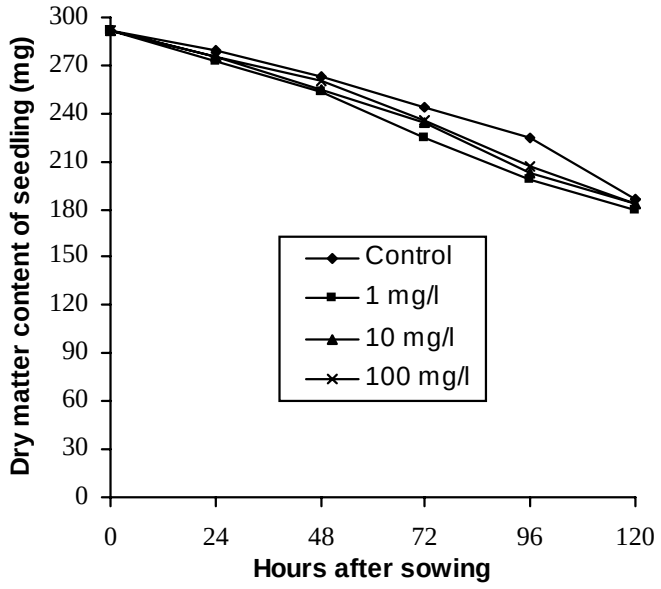


FIGURE 7. Effect of gibberellic acid on ether extract mobilization of endosperm: ANOVA (variance ratio, treatment concentration) CD = 0.02 at 0.05 level of significance

gradually **(Figure 7)**. This depletion of ether extract is possibly due to the conversion of fat into fatty acids and glycerol. Fatty acids are metabolized by glyoxylate cycle to carbohydrate by ß-oxidation. The glycerol is then converted into pyruvic acid or sugars (Stumpf and Bradbeer 1959).

From this investigation, it becomes evident that reserve food mobilization during germination is affected by GA_3 application. GA_3 appears to be effective in dry matter loss also. The loss of increased quantities of dry matter from the endosperm was observed in GA_3-treated caryopsis. This loss was related to the gain of dry matter in the growth axis. But the gain in the amount of dry matter in the growth axis was lower than the loss in the endosperm. This may be due to the consumption of dry matter as a result of respiratory processes in the germinating caryopses (Noggle and Fritz 1991). The increase in the amount of soluble sugar is consistent with the decrease in the amount of protein and fat; their breakdown contributes to the formation of more sugar (Jann and Amen 1977, Stumpf and Bradbeer 1959). Of those concentrations of GA_3 tested, we found 1 mg/l to be most effective in mobilizing the reserve carbohydrates, lipids and proteins. ■

References

Abdul-Baki AA. 1969. Metabolism of barley seed during early hours of germination. *Plant Physiol* **44**: 733-8

Arteca RN. 1997. *Plant growth substances: Principles and application*. New Delhi: CBS Publication. xvi+ 332 p

Bajracharya D and VNP Gupta. 1978. The effect of growth hormones on the germination and dormancy behavior of developing rice (*Oryza sativa* L.) seeds. *J Inst Sci* **I**: 9-14

Bajracharya D. 1999. *Experiments in plant physiology*. New Delhi: Narosa Publishing House. xii+ 186 p

Bewely JD and M Black. 1985. *Seeds: Physiology of development and germination*. New York: Plenum Press

Ingle J and RH Hageman. 1965. Metabolic changes associated with the germination of corn III: Effects of GA_3 on endosperm metabolism. *Plant Physiol* **30**: 672-5

Ingle J, L Beever and RH Hageman. 1964. Metabolic activities associated with the germination of corn: Changes in weight and metabolites and their redistribution in the embryo axis, scutellum and endosperm. *Plant Physiol* **39**: 735-40

Jann RC and RD Amen. 1977. What is germination? In: Khan AA (ed), *Physiology and biochemistry of seed dormancy and germination*. New York: North Holland Company. p 7-28

Kathireasan K and M Moorthy. 1994. Hormone induced physiological response of tropical Mangrove species. *Botanica Mariana* **37**(2): 139-41

Lang A. 1965. Effects of some external and internal conditions on seed germination. In: Ruhland W (ed), *Encyclopedia of plant physiology* **XV**(2): 848-93

Malhotra RC. 1934. Chemistry of corn seed germination. *Cereal Chem* **11**: 105

Mallik CP. 1992. *Plant physiology*. New Delhi: Kalyani Publisher. ix+ 676 p

Mayer AM and AP Mayber. 1982. *The germination of seeds*. New York: Pergamon. ix+ 211 p

Noggle GR and GJ Fritz. 1991. *Introductory plant physiology*. New Delhi: Prentice Hall. xii + 627 p

Paech K and MV Tracey (eds). 1955. *Modern methods of chemical analysis*. Berlin: Springer-Verlag. xv+ 766 p

Paleg LG. 1960. Physiological effects of Gibberellic Acid: On carbohydrate metabolism and amylase activity of barley endosperm. *Plant Physiol* **35**: 293-9

Paleg LG. 1961. Physiological effects of GA_3 - III: Observation on its mode of action on barley. *Plant Physiol* **36**: 829-37

Paleg LG. 1962. Physiological response of GA_3 - V: Endosperm response of barley, wheat and oats. *Plant Physiol* **37**: 798-803

Paul Y and R Singh. 1981. Biochemical changes during germination of lentil seed. *J Res Punjab Agric Univ* **24**(4): 715-9

PCARR. 1980. *Standard method of analysis for soil, plant tissue, water and fertilizer.* Los Banos (Laguna): Farm Resource and Systems Research Division, Phillippine Council for Agriculture and Research. 194 p

Salla M, P Iikka and J Sanna. 1991. Mobilization of storage protein in germinating barley grain. *Luonnon Tutkija* **95**(1/2): 109-13

Stokes P. 1965. Temperature and seed dormancy. In: Ruhland W (ed), *Encyclopedia of plant physiology* **XV**(2): 746-803

Stumpf PK and C Bradbeer. 1959. Fat metabolism in higher plants. *Ann Rev Pl Physiol* **10**: 197-203

Welcher FJ (ed). 1966. *Standard method of chemical analysis*, Vol 3, Part B. New York: D van Nostard Company Inc. xi+ 975-2018 p

Acknowledgements

The authors are thankful to the Central Department of Botany, Tribhuvan University, Kathmandu, Nepal, for providing the opportunity to conduct this study and to Nepal Agricultural Research Council (NARC) and Research Center for Applied Science and Technology (RECAST) for the chemical analysis of the endosperm.

GIS-based flood risk zoning of the Khando river basin in the Terai region of east Nepal

Keshav P Sharma†*, Naba R Adhikari†, Pawan K Ghimire‡ and Prem S Chapagain§

† *Department of Hydrology and Meteorology, PO Box 406, HMG, Kathmandu, Nepal*
‡ *Geographic Information System and Integrated Development Centre, Kathmandu, Nepal*
§ *Department of Geography, Tribhuvan University, Kathmandu, Nepal*

* *To whom correspondence should be addressed. E-mail: kpspoudel@yahoo.com*

Khando River, a rain-fed river originating in the Siwalik, is responsible for severe flood damage every year in southeast Nepal as well as in India. The present study, GIS-based analysis of settlement areas lying in the flood plain indicated that 16 out of the 26 Village Development Committees (VDCs) lie in the high-risk zone. People in 32 settlements in these 16 VDCs were found to be dependent on the flood zones, meaning that a significant population is vulnerable to flood hazards. Analysis of land use within the basin showed that 80% of the total area is used for agricultural purposes.

Key words: Floodplain, flood risk, GIS, Khando, Terai

Him J Sci **1**(2): 103-106
URL: www.himjsci.com/issue2/floodrisk

Received: 13 May 2003
Accepted after revision: 15 July 2003

Introduction

The dynamic Himalayan rivers flowing southward through the steep topography suddenly face a different physiographic regime when they reach the Terai. This plain, stretching east-west in the southern part of Nepal is actually the northern margin of the Gangetic plain, where it interfaces with the Himalayan upthrust.

The rivers flowing through the Terai may be grouped according to their sources: large snow-fed rivers from the high Himalayas, medium-sized rain-fed rivers from the middle Mountains, and smaller rivers dominated by flash floods from the Siwaliks.

Notwithstanding their smaller size, the small rivers originating in the Siwalik pose substantial hazards, particularly in terms of flood-damage and sediment deposition. Despite these problems, the region has been attracting a large agrarian population because of the fertility of the land, which is primarily a result of the flood-related alluvial deposits. Furthermore, increasing economic activity, rapidly developing communications and establishment of industrial infrastructure have been responsible for population growth in the Terai at a rate much higher than that of the adjacent hilly and mountainous areas. Although the Terai occupies only about one fifth of the area of Nepal, almost half of the country's population is exposed to the flood hazards of this region.

Study area

The Khando River basin covers 191 km^2 in the Saptari District (Eastern Development Region of Nepal), between 26°25'15" – 26°42'45" N and 86°40'40"– 86°48'30"E **(Figure 1)**. The Khando River, flowing from north to south, is about 47 km from its source to where it crossed the Nepal-India border. The maximum width of the basin is only about five kilometres. Within Nepal, the maximum elevation of the basin is 585 m asl and the lowest elevation (at the Nepal-India border) is 61 m asl.

Climatically the basin lies in a subtropical zone with average temperatures varying from about 15°C in winter to 30°C in summer. Annual precipitation in the region is 1000-1500 mm, with more than 80% occurring during the summer monsoon months (June to September). Loosely formed conglomerate of the Siwalik and alluvial deposits of the Terai cover the Khando River basin. Intense monsoon precipitation and fragile geological conditions are the major influences on the flood regime of the basin.

There are 26 Village Development Committees (VDCs) and one municipality, namely Rajbiraj, in the Khando River basin. As of 1998 the population of the Khando basin stood at 152,000 (NDP 1999). Most of the population inhabits the southern part of the watershed. Two percents of the total basin in the headwater region is covered by forest, while the remainder of the basin is dominated by agriculture (80%). There are extensive areas of dry sand (10% of the total basin area) indicating the extreme variation of streamflow paths as a result of the huge sediment transport and deposition. The rest of the basin area (7%) is occupied by built-up areas, water bodies, canal, and grassland including bamboo.

Materials and methods

The major source of data used in this study is the Topographic Map of the study area at 1:25000 scale published by the survey department of His Majesty's Government of Nepal in 1996. The drainage system, contours, settlement areas, built-up areas, roads, and other features were digitized as different thematic layers for GIS analysis. ArcView, a window-based GIS software (ESRI 1996) was used for most of the analysis.

Field data were collected for the cross sections of the river at 6 different locations. Additional information regarding the past observations of flood extents and flood damage was obtained from local inhabitants of the study area in various villages by means of interviews and group discussions.

Assessment of flood risk areas

The first approach used for determining the flood risk zone was a simple approach using easily available basin maps and channel ➔

information. The assumption made in this approach was that the area under flood risk should broaden from upstream to downstream due to the increasing discharge and the flattening of a floodplain. To define the floodplain, the basin was divided into seven homogeneous segments. The catchment widening factor was obtained for each zone based on the river length, intervening catchment area and the gradient of the intervening catchments, using the following formula.

$$WF = Log\frac{DR + CAR + RGR}{3}$$

where,
WF is the Widening Factor,
DR is the Distance Ratio,
CAR is the Catchment Area Ratio, and
RGR is the River Gradient Ratio.

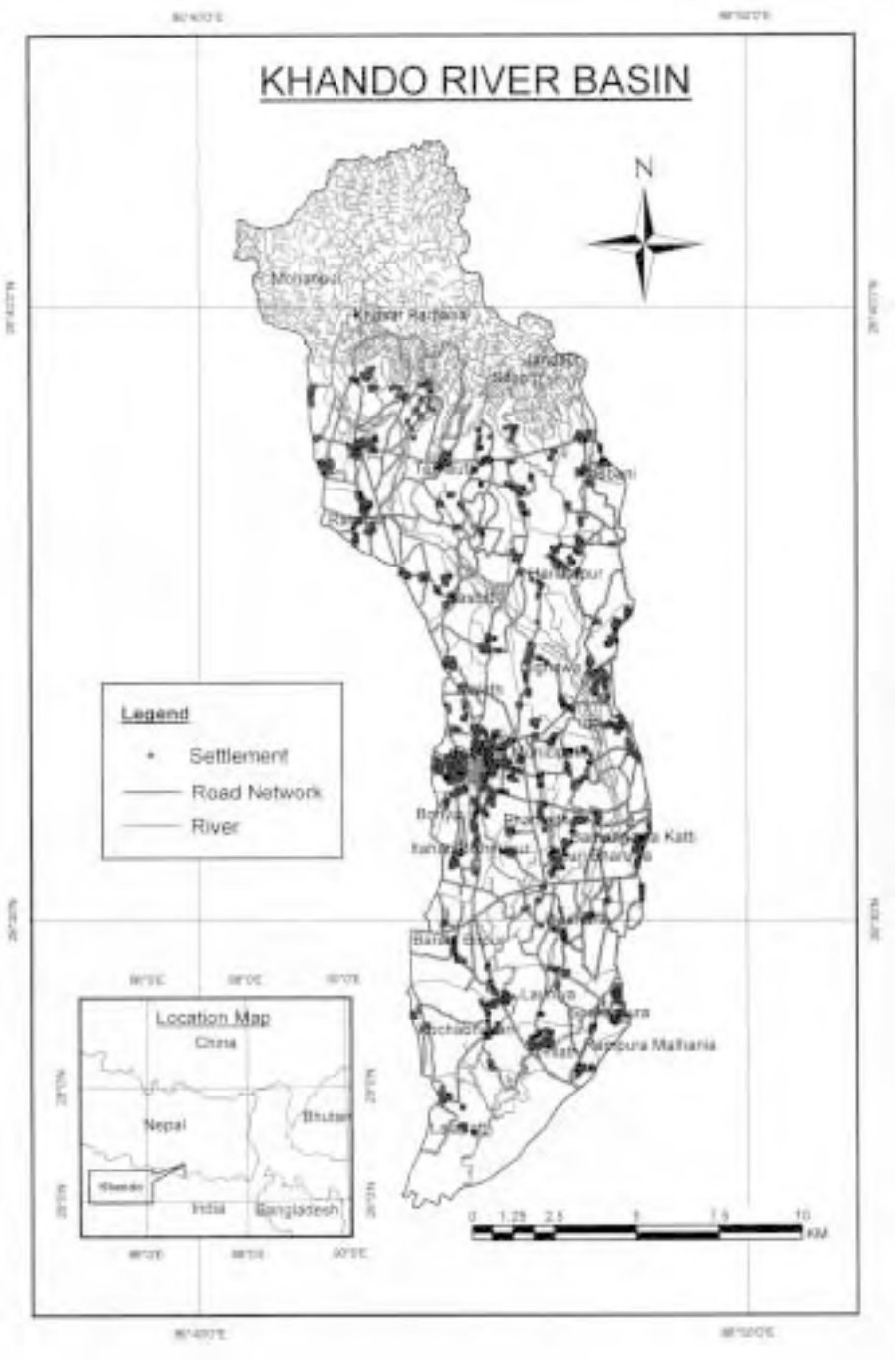


FIGURE 1. Location map

The ratios were obtained using cumulative values for the respective sections from upstream to downstream direction. The equation has been proposed here for the purpose of buffering on the basis of the following criteria:

a) Catchment Area Ratio reflects the effect of increased catchment area on widening of a river. Assuming that rainfall is distributed evenly over the watershed, the river is expected to widen with increasing distance from the origin, due to input from a larger contributing area.

b) As gradient increases, the river is capable of doing more widening work.

The buffering of the flood area obtained with the proposed equation was satisfactory when compared with field information.

Based on field observations and information about past flooding, it was judged that in the first segment of the river, given the actual channel width, distances of up to 300 m from the river entailed high risk, while the area between 300 m and 600 m from the river banks was considered to be at low risk. Widening factors were for the remaining six downstream sectors of the Khando floodplain were taken into account in order to obtain the flood risk zones using a buffering approach in GIS. The flood risk zone map, thus obtained, is presented in **Figure 2a**.

Figure 2b presents the flood risk zones obtained from detailed field information collected at several locations on major roads and along the banks of the main river channel. High-risk zones considered in this assessment were the areas that, in most years, were inundated frequently. Data from local informants constituted the primary basis for this delineation of flood risk zones.

Figure 2c presents the flood zones in the study basin using an approach based on hydrological computation. Cross sections of the riverbed were measured at six different locations on the main river. Since no regular hydrometric station existed in the basin, discharges at the measured cross-section sites were estimated using a regional approach (WECS/DHM 1990). In this technique, the floods for 2-year and 100-year return periods are obtained as:

$$Q_2 = 1.88\ (A+1)^{0.88} \quad (1)$$

$$Q_{100} = 14.6\ (A+1)^{0.73} \quad (2)$$

where,
A is the area in km^2,
Q_2 and Q_{100} are the 2-year and 100-year return period
discharges (m^3/s) respectively.

Discharge values for other return periods were obtained using standard normal variates applicable for a given return period (WECS/DHM 1990).

The hydrological estimates were applied to the measured cross section to obtain

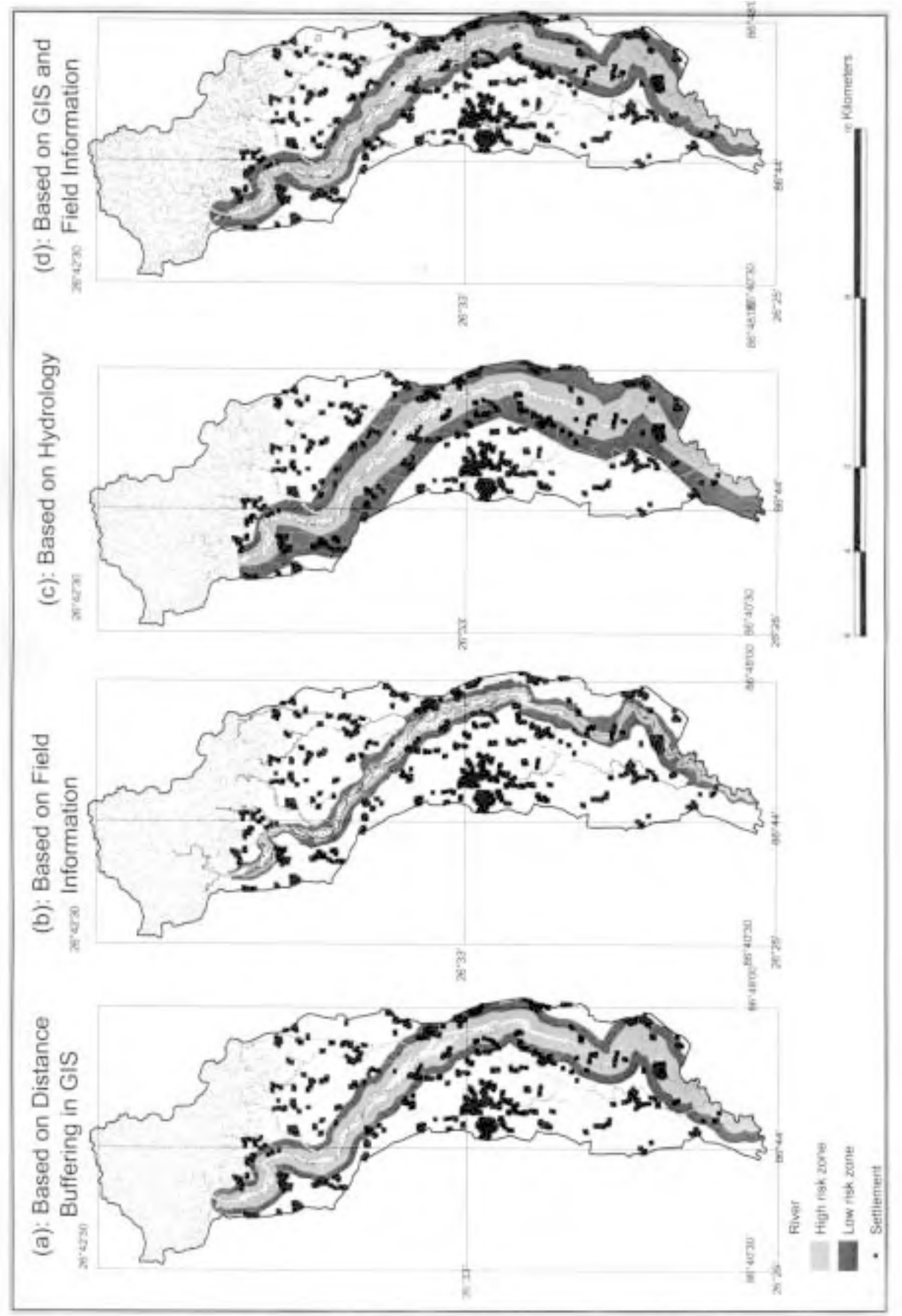


FIGURE 2. Flood risk zones in the Khando River basin based on: (a) distance buffering in GIS, (b) field information, (c) hydrology, and (d) integration of GIS and field information

flood water level. A method and software developed by PAGASA/JICA (1996) were used to compute the water level and inundation area. The method, based on non-uniform flow, assumes constant discharge between two cross sections. Another limitation of this technique is the accuracy of discharge estimates based on **Equation 1** and **Equation 2** as the regional equations are derived mainly from data from medium-sized mountainous catchments in Nepal.

Figure 2d was obtained by using the overlay analysis method available in the ArcView GIS system. This final flood risk map of the Khando River basin draws on the flood risk maps developed from GIS and the map based on field data analyses (**Figure 2a** and **Figure 2b**).

Despite its importance, the slope factor could not be used in this study, as the slope of the entire floodplain is less than one degree. To take slope into account would require a better resolution Digital Elevation Model (DEM). Similarly, because of inadequate information, the study did not take into account human impacts on flood propagation through such infrastructure as roads, embankments and canals.

Results and discussion

The final flood map **(Figure 2d)** was prepared with two categories of flood risk: high-risk zone and low risk zone. The computation of areas in each categories showed almost half of the area lay in the low risk zone and another half in the high-risk zone. In total, 32% of the catchment area lay in the flood risk zone.

The flood map of **Figure 2d** compared well with the flood map based on hydrology in **Figure 2c**. The flood risk zone with a 50-year return period **(Figure 2c)** covered 40% of the catchment area compared to 32% in **Figure 2d**. The lower flood risk zone with 10-year return period was 18% **(Figure 2c)** compared to 15% in **Figure 2d**.

GIS-based analysis of settlement areas lying in the flood plain indicated that 16 out of the 26 VDCs lay in the high-risk zone. People in 32 settlements of these 16 VDCs were found to be dependent on the flood zones, meaning that a significant population was vulnerable to flood hazards.

Analysis of land-use within the basin revealed that 80% of the total area was used for agriculture purpose. Less than two percent of the flood risk zone was covered by forest with a similar percentage of grassland. Hence, the significant sharing of the Khando floodplain by agriculture land, settlements and built-up areas indicated an alarming situation, which needed special effort in floodplain management.

The application of field observations along with hydrologic and hydraulic information indicated that more than 60% of the VDCs were vulnerable to different scales of flooding every year. Existence of higher percentage of agriculture land in the flood zones in the basin indicated the higher economic risk to the agrarian population in the basin.

The flood risk zone delineation using GIS was applied in a vulnerable area for which limited flood related information was available. In view, also, of the poor resolution of DEM for the Terai, the resulting map should be used with caution. Nevertheless, it gave a broad assessment of the hazard. It is recommended hazard assessment efforts be expanded with better data; in particular it would be useful to add GIS layers representing slope and edaphic conditions.

Identification and delineation of flood risk zones are essential aspects of any floodplain management scheme. GIS has been found to be an excellent tool for such task as it can incorporate many disparate variables and parameters in a two-dimensional or three-dimensional spatial field. Application of GIS in this study of a relatively small basin in the Terai of Nepal showed that such studies could be extended to the entire Gangetic floodplain, which is shared by one of the most populous areas of the world. ■

References

ESRI. 1996. *ArcView GIS : The geographic information system for everyone.* California: Environmental System Research Institute

Georgakakos KP. 2000. *Areal flash flood guidance with global applicability: A summary report.* Geneva: World Meteorological Organization (WMO). 6 p

NDP. 1999. *Nepal district profile.* Kathmandu: National Research Associate. 908 p

PAGASA/JICA. 1996. *User's manual of computer programme: Non-uniform flow calculation*. Seminar/Workshop on Flood Loss Mitigation; 1996 Feb 28-Mar 8; Quezon City. Philippine Atmospheric Geophysical Astronomical Services Administration (PAGASA), Japan International Cooperation Agency (JICA) and ESCAP/WMO Typhoon Committee

WECS/DHM. 1990. *Methodologies for estimating hydrological characteristics of ungauged locations in Nepal.* Kathmandu: Water and Energy Commission Secretariat and Department of Hydrology and Meteorology, HMGN. 77 p

Acknowledgments

We thank Madan L Shrestha (Department of Hydrology and Meteorology) for encouragement and guidance, and Mandira Shrestha for her useful comments. The study was supported by the Flood Forecasting Section, DHM, HMG Nepal.

Physiochemical characteristics of soil in tropical sal (*Shorea robusta* Gaertn.) forests in eastern Nepal

Shishir Paudel†* and Jay P Sah‡

† *Brookfield International College, Kathmandu, Nepal*
‡ *Central Department of Botany, Tribhuvan University, Kathmandu, Nepal;*
Present address- Southeast Environmental Research Center, Florida International University, Miami, FL 33199, USA

* *To whom correspondence should be addressed. E-mail: paudel84@yahoo.com*

The physiochemical properties of soils of two different types of forests (pure *Shorea robusta* and mixed *Shorea robusta*) were analyzed. Soil samples were collected from both types of forest and analyzed for texture, pH, organic matter, humus content, water holding capacity, nitrogen, phosphorous and potassium. In both the pure and mixed forest, soil was sandy loam (60.12% and 50.58% sand, 28.59% and 35.24% silt and 11.12 and 22.41% clay, respectively). The pH value was lower in pure forest (4.33) than in the mixed forest (5.26), and so were phosphorus and water holding capacity. The higher values of humus, organic matter, nitrogen and potassium (7.34%, 2.42%, 0.117%, 267.73 kg/ha, respectively) were found in pure forest. The higher levels of soil nutrients in the pure forest were due partly to reduction in the loss of top soil and partly to the increased supply of nutrients in the form of leaf litter and biomass from the larger number of sal trees and their saplings.

Key words: *Shorea robusta*, soil texture, nitrogen, soil pH, Udayapur

Him J Sci **1**(2): 107-110
URL: www.himjsci.com/issue2/salforest

Received: 16 Apr 2003
Accepted after revision: 20 June 2003

Introduction

Forest soils influence the composition of the forest stand and ground cover, rate of tree growth, vigor of natural reproduction and other silviculturally important factors (Bhatnagar 1965). For instance, growth of *Shorea robusta* (sal) and other tree species, such as *Terminalia alata* and *Syzygium cumini*, in tropical forests is highly influenced by nitrogen, phosphorus, potassium, and soil pH (Bhatnagar 1965). Physiochemical characteristics of forest soils vary in space and time due to variations in topography, climate, physical weathering processes, vegetation cover, microbial activities, and several other biotic and abiotic variables. Vegetation plays an important role in soil formation (Chapman and Reiss 1992). For example, plant tissues (from aboveground litter and belowground root detritus) are the main source of soil organic matter (OM), which influences physiochemical characteristics of soil such as pH, water holding capacity (WHC), texture and nutrient availability (Johnston 1986). Nutrient supply varies widely among ecosystems (Binkley and Vitousek 1989), resulting in differences in plant community structure and production (Ruess and Innis 1977, Chapin et al. 1986). Organic matter supplies energy and cell building constituents for most microorganisms (Allison 1973) and is a critical factor in soil fertility (Brady 1984).

The vegetation zones in Nepal clearly reflect edaphic variations (Bhatta 1981). The Terai region is characterized by alluvial soil, which is transported by the river systems. River deposits more sand and silt than clay in the flood plains of the Terai that support the dense forests of sal and other valuable timber trees. However, the sal forests are in a degraded state in terms of both density as well as ground vegetation because of indiscriminate cutting, recurring forest fire and uncontrolled grazing. In fact, more than half of the tropical soil in the world is highly weathered, leached and impoverished, and therefore mechanisms to conserve nutrient in the ecosystem are important (Sanchez 1976, Jordan 1985). The objective of the present study was to document the physiochemical characteristics (WHC; pH; soil texture; N, P, K, OM and humus content) of soil in two separate and dissimilar sal forests: a pure stand of *S. robusta* managed by the local community, and a mixed *S. robusta* forest managed by the government.

Materials and methods

Study area

The study was carried out in April and May 1998 in Ward 6 of Triyuga Municipality in Udayapur district of eastern Nepal (86°9'-87°10' E, 26°39'-27°11' N), and comprised the pure *S. robusta* Sanua Sukanahi community forest as well as the mixed Banke Danda national forest. The elevation of the site ranges from 210 to 250 m asl. The soils are non-sticky sandy loam because the geological formation of the district lies in the Siwalik zone (Nepal District Profile 1997). Though the study area has a tropical monsoon climate and receives a great deal of rain, the area seems somewhat arid because most of the rainfall flows away quickly as surface run-off, allowing the soil to dry quickly. These are ideal conditions for sal (*S. robusta*), which grows poorly in water logged soil (Stainton 1972).

Soil sampling

Soil was taken from 15 cm deep cores. It was collected from 30 randomly distributed sites in each of the pure and mixed forests. The collected soil samples were packed in polythene bags and taken to the laboratory for analysis. Soil analyses were performed at the Central Department of Botany, Tribhuvan University, and the Nepal Agriculture Research Council (NARC), Kathmandu. Soil texture was determined by the hydrometer method (PCARR 1980) and the texture group was determined by means of a texture triangle (USDA system). Organic matter and humus content were determined using

the methods described in PCARR (1980). Total nitrogen content was determined by means of the Kjeldalel method. Phosphorus was determined using the Truog method; potassium content by flame photometer; and soil pH by the potentiometric method, using a digital pH meter and sampling soil and water in a 1:1 ratio (PCARR 1980). Humus content and WHC were calculated by using the following formula (cf Zobel et al. 1987).

$$\text{Humus content (\%)} = \frac{\text{Weight of humus}}{\text{Weight of soil}} \times 100$$

$$\text{Water holding capacity (\%)} = \frac{\text{Water retained by the soil at saturation}}{\text{Weight of dry soil}} \times 100$$

Data analysis

To find the relationships between the parameters of soils of these forests, the correlation coefficient was calculated following the formula used by Pearson (1957).

$$\frac{\sum xy - \frac{\sum x . \sum y}{n}}{\sqrt{\left(\sum x^2 - \frac{(\sum x)^2}{n}\right)\left(\sum y^2 - \frac{(\sum y)^2}{n}\right)}}$$

Results

Vegetation of the study area was dominated by the *S. robusta*. Both forests had similar types of plant species composition. The pure *S. robusta* was forest composed predominantly of *S. robusta*, in association with *Adina cordifolia, Schleichera oleosa, Swida oblonga, Semecarpus anacardium*, and other species. In the mixed *S. robusta* forest, *S. robusta* and *Terminalia alata* were equally dominant. Other associated species included *Syzygium cumini, Bombax ceiba, Acacia catechu, Schleichera oleosa,* and *Semecarpus anacardium*.

Both forests had sandy loam type of soil texture. The soil of pure *S. robusta* forest was composed of sand (60.12%±3.59%), silt (28.59%±3.18%), and clay (12.24%±1.62%); while the proportions for the mixed *S. robusta* forest were 50.58%±5.84%, 35.24%±4.54%, and 22.41%±3.20%, respectively **(Figure 1)**.

Soil in both forests was acidic. It was more acidic in the pure *S. robusta* forest (pH = 4.33±0.39) than in the mixed *S. robusta* forest (5.26±0.58) **(Figure 2)**. The soil in mixed *S. robusta* forest had higher WHC (49.80%±6.30%) than that in pure *S. robusta* forest (43.03%±3.02%).

The humus content of the soil in the two forests was not noticeably different: the value was only slightly higher in the pure *S. robusta* forest (7.34%±1.47%) than in the mixed *S. robusta* (5.5%± 0.99%) forest **(FIGURE 2)**.

The average organic matter content in the soil of the pure *S. robusta* forest was 2.42%±0.39%, compared to 1.74%±0.31 in the mixed *S. robusta* forest **(Figure 2)**.

The mean soil nitrogen content in both forests was more or less similar, slightly higher in pure *S. robusta* forest (0.117%±0.01%) than in mixed *S. robusta* forest (0.111%±0.01%) **(Figure 3)**.

The mean value of available phosphorus in the soil of the pure *S. robusta* forest was 76.64±4.95 kg/ha, slightly less than the 79.29±3.92 kg/ha found in mixed *S. robusta* forest **(Figure 3)**. The mean value for potassium was higher in the pure *S. robusta* forest than that in the mixed S. *robusta* forest, available potassium in the soil of the *S. robusta* forest was 267.73±29.93 kg/ha, compared with 233.86±18.43 kg/ha in the mixed S. *robusta* forest was **(Figure 3)**.

The correlation analysis among the different soil parameters showed that the pH was negatively correlated with organic matter (r = –0.311) and nitrogen (r = –0.422), whereas there was positive correlation between pH and all other parameters such as humus content, water holding capacity, phosphorus and potassium content **(Table 1)**. However, none of these correlations were found statistically significant.

Organic matter was slightly negatively correlated with potassium (r = –0.052) and WHC (r = –0.030), while it was slightly positively correlated with nitrogen, phosphorus and humus content. However, these correlations were not found statistically significant either. Nitrogen showed significant negative correlation with phosphorus (r = –0.610) and positive correlation with potassium (r = 0.903). It also showed positive correlation with WHC and negative correlation with humus content. Phosphorus showed significant positive correlation with potassium (r = 0.519).

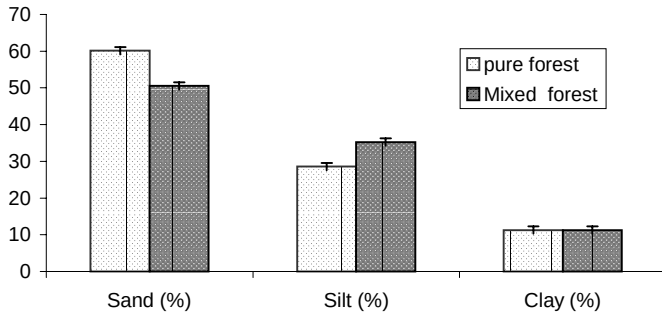


FIGURE 1. Soil texture in the forest

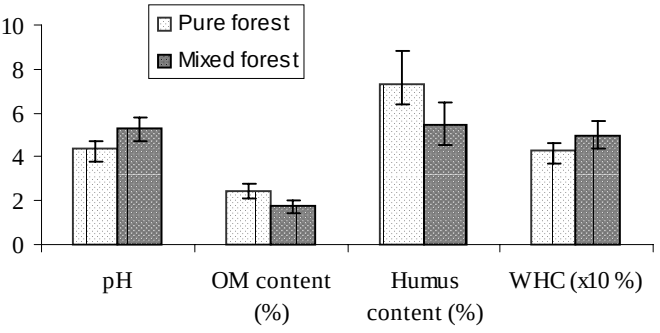


FIGURE 2. Different soil parameters

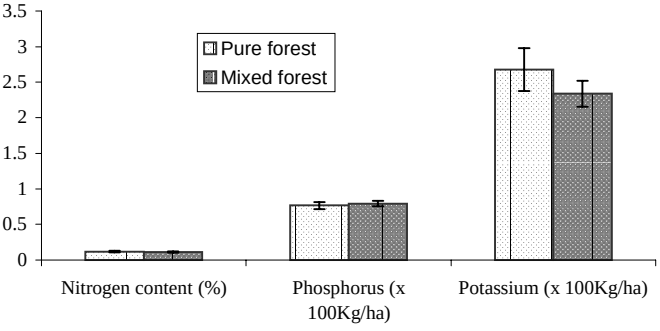


FIGURE 3. Different soil parameters

Discussion

On the basis of vegetation composition and dominance of different plant species, forests were categorized into pure and mixed *S. robusta* forests. The pure *S. robusta* forest (managed by the local community) was highly dominated by *S. robusta*, while the mixed *S. robusta* forest (government managed, with free access for local people), was heterogenous and equally dominated by *S. robusta* and *Terminalia alata*. Other major associated species were *Semecarpus anacardium*, *Adina cordifolia*, *Syzygium cumini*, *Bombax ceiba* and *Acacia catechu*.

Soil texture in both the forests of the study area was of the sandy loam type, suitable for good sal regeneration and high quality trees (Gupta 1951). This sandy loam texture is very common in the Terai, and in Siwalik and Dun valleys, all of which support dense sal forests and other valuable timber trees (Shah 1999). The supply of water to plants usually is greater as the texture becomes finer (Black 1968). Soil texture also affects the nutrient supply of the soil. The present result is similar to the finding of Shrestha (1997) in Chitrepani, Sigdel (1994) in Royal Chitwan National Park (RCNP), Rana et al. (1988) and Gupta and Shukla (1991) in sal forests in India. This may be due to the similar type of forest vegetation, i.e., *S. robusta* dominated forest.

Soils in the forests were acidic in nature. Shrestha (1992) reported that in the Terai most of the soils are acidic. However, in the present study pure *S. robusta* forest soil was found to be more acidic than that of mixed *S. robusta* forest. The pH range in the present study was lower than the values reported by Sigdel (1994) in Royal Chitwan National Park (5.90-6.42), by Karki (1999) in Koshi Tappu Wildlife Reserve (6.4-7.1), or by Singh and Singh (1985) in *S. robusta* dominant central Himalaya forests (6.7-6.8). This may be due to local environmental factors such as aspect, rainfall, and vegetation composition. However, the values observed in this study were more or less similar to those reported by Singh and Singh (1989). They reported a pH range of 4.5-5.5 in the sal forest and concluded that this range is propitious for sal sapling growth. Good sal regeneration areas have low pH in soils (Bhatnagar 1965). The finding of higher acidity in the sites is consistent with other observations (Banerjee et al. 1986, Singh et al. 1987). Soils with higher pH generally have poorer capacity for regeneration (Suoheimo 1995). The low pH value in the present study area may be due to the continuous decomposition of surface litter over six years. The lower pH in the pure *S. robusta* forest than in the mixed *S. robusta* forest is probably due to higher number of sal trees and their saplings (Bhatnagar 1965), and the accumulation of leaf litter as well. The acidic nature of the soil at our study site may be attributed to the high rainfall, which is sufficient to leach basic cations from the surface horizons of the soils. Similar result was reported by Miller (1965).

Humus content was more or less similar in both forests, as was organic matter content. The latter ranged from 1.74 to 2.42%, comparable to the 1.74-2.33 range that, according to Suoheimo (1995), is indicative of low soil fertility. Brady (1984) mentioned that the higher soil organic matter occurred more commonly in cooler than warmer climates such as that of our study area. This may explain the occurrence of relatively low organic matter content in the soil despite the fact that litter had been accumulating over six years, especially in the pure *S. robusta* forest. Out of these two studied sites, pure *S. robusta* forest had higher organic matter content than the mixed *S. robusta* forest which may be because of more litter accumulation and decomposition in the former. Tamhane et al. (1964) mentioned that decomposing litter adds organic matter to the soil. It was seen that local people frequently visit the mixed *S. robusta* forest to collect forest products because in the pure *S. robusta* forest restrictions have been imposed on the exploitation of forest products. While, organic matter in the present study area was lower than the value (1.8-4%) reported from the forests in Riyale (Shrestha 1996), but within the range (0.23-1.8%) reported by Sigdel (1994) for Royal Chitwan National Park. Aweto (1981) reported that organic matter content increases with the maturation of forest. The mixed *S. robusta* forest is more mature, and might therefore be expected to contain more organic matter, than that of the pure *S. robusta* forest, but our data does not confirm this expectation, probably because the pure *S. robusta* forest had been protected for the previous six years, and litter collection had not been as intensive as in the mixed forest, and also due to the low organic input from the vegetation cover in the mixed *S. robusta* forest.

The value of WHC for both forests ranged from 43.03 to 49.80%. According to Bhatnagar (1965), the WHC of soils from sal regeneration areas is higher. WHC in the present study area was higher than that in the *Pinus roxburghii* forest (9%) and in Oak forest (17%) in Garhwal Himalaya (Sah et al. 1994). Despite the higher organic matter and humus content in the pure *S. robusta* forest than in the mixed *S. robusta* forest, the WHC value was less in the former, probably because of the coarser soil texture; the pure *S. robusta* forest had more sand than the mixed *S. robusta* forest.

The nitrogen content of soil did not differ significantly in the two forests, and was similar to the values reported in other forests such as Chitrepani (0.04-0.09%) (Shrestha 1997). The value of soil nitrogen was less than the value reported from the forests in Nagarkot (0.18-0.28%; Juwa 1987), in Namchi, Sikkim (0.57%; Gangopadhayaya et al. 1992) and in the Royal Chitwan National Park (0.13%; Sigdel 1994). The fact that the nitrogen content in the soil was relatively low (according to the soil fertility rating system developed by NARC, 1998/1999) was probably due to the dominance of *S. robusta*. According to Bhatnagar (1965), there is low nitrogen content in good sal dominant and regeneration areas. In the floodplains, sandy loam soil is deficient in nitrogen (Sah 1997). The low nitrogen content in soil at our study site may have been due to the continuous losses through leaching and run-off (Allen 1964).

Our two study forests had high phosphorus ratings, according to the soil fertility rating system, NARC (1998/99). The soil in the pure *S. robusta* forest had higher phosphorus content than that in the mixed *S. robusta* forest; higher than the 22.59-44.28 kg/ha reported in the Riyale forest (Shrestha 1996), and higher than the 3-4 kg/ha in the Nagarkot forest (Juwa 1987). However, it was very close to the value reported for the Chitrepani forest (Shrestha 1997). It was coincided with the findings of Bhatnagar (1965).

Potassium content was higher in the pure *S. robusta* forest than in the mixed *S. robusta* forest. The value varied from 233.86 kg/ha to 267.73 kg/ha. According to Bhatnagar (1965), potassium in soil is higher in good sal regeneration areas. The sites of the present study had a higher rate of regeneration of sal, probably due ➔

TABLE 1. Correlation coefficient among different soil parameters

	PH	OM	N	P	K	WHC
OM	-0.311					
N	-0.422	0.356				
P	0.196	0.262	-0.610			
K	0.210	-0.052	0.903	0.519		
WHC	0.197	-0.030	0.104	0.330	-0.225	
Humus	0.163	0.015	-0.125	0.063	-0.314	-0.241

OM= Organic matter, N= Nitrogen, P= Phosphorus, K= Potassium, WHC= Water holding capacity

to the presence of higher proportion of potassium. The value was within the range of 86.40-262.8 kg/ha as reported in *S. robusta* forest in Chitrepani (Shrestha 1997), but less than that (329.57-399 kg/ha) reported in Koshi Tappu Wildlife Reserve (Karki 1999) and higher than the value (41.01-87.79 kg/ha) reported in two sal forests in the hills of Kavreplanchowk (Pant 1997).

The forest soils in our study area contain significant quantities of all the nutrients except nitrogen. According to the soil fertility rating system of NARC (1998/99), phosphorus had a high value and potassium a medium value, while nitrogen had a low rating value. Overall, the pure *S. robusta* forest had higher soil nutrients than the mixed *S. robusta* forest, probably due to higher organic matter input from the tree cover as it had over six years' litter decomposition.

Conclusion

Soils in the forests were sandy loam. There was low nitrogen, high phosphorus and medium potassium content. Soil characteristics seem to have strong influence on the vegetation of the present study area and *vice versa*. The pure *S. robusta* forest had relatively good soil characteristics as compared to the mixed *S. robusta* forest. On the whole the nutrient-poor status of the soils found under these forests represents the degraded status of the forest. Degradation may be partly natural and partly deliberately induced by the local people for fulfilling their household needs through various strategies. Hence, the conservation of sal forests is an urgent need. The proper management of the forests will increase the quality of soils and the forest. ■

References

Allen SE. 1964. Chemical aspects of heather burning. *J Appl Ecol* **1**: 347-67

Allison FA. 1973. *Soil organic matter and its role in crop production*. Amsterdam: Elsevier

Aweto AO. 1981. Secondary succession and soil fertility restoration in Southwestern Nigeria II: Soil fertility restoration. *J Ecol* **69**: 609-14

Banerjee SK, SB Singh, S Nath and SP Banerjee. 1986. Comparison of some physicochemical properties of soils of varying age plantations of *Cryptomeria japonica*. *J Ind Soc Soil Sci* **34**: 357-61

Bhatnagar HP. 1965. Soils from different quality sal (*S. robusta*) forests of Uttar Pradesh. *Trop Ecol* **6**: 56-62

Bhatta DD. 1981. Nepal Himalaya and change. In: Laal JS (ed), *Himalaya: Aspects of change*. New Delhi: Oxford University Press. p 253-77

Binkley D and PM Vitousek. 1989. Soil nutrient availability. In: Pearey RW, J Ehleringer, HA Mooney and PW Rundel (eds), *Plant physiological ecology: Field methods and instrumentation*. London: Chapman and Hall. p 75-96

Black CA. 1968. *Soil plant relationship*, 2nd ed. New Delhi: Wiley Eastern

Brady NC. 1984. *The nature and properties of soils*. New York: Mac Millan

Chapin FSH, K Van Cleve and PM Vitousek. 1986. The nature of nutrient limitation in plant communities. *Am Nat* **127**: 148-58

Chapman JL and MJ Reiss. 1992. *Ecology: Principles and applications*. Cambridge: Cambridge University Press. 294 p

Gangopadhyaya SK, PK Das, S Nath, SP Banerjee and SK Banerjee. 1992. Characteristics of some lower and middle hill soil of south Sikkim forests. Sikkim, Namchi. *Ind For* **118**: 662-71

Gupta OP and RP Shukla. 1991. The composition and dynamics of associated plant communities of sal plantations. *Trop Ecol* **32**(2): 296-309

Gupta RS. 1951. Recurrence in drought conditions in mortality in sal forests of Uttar Pradesh. *J Ind Bot Soc* **40**(1): 25-33

Johnston AE. 1986. Soil organic matter; effects on soil and crops. *Soil Use Manage* **2**: 97-105

Jordan CF. 1985. *Nutrient cycling in tropical forest ecosystems*. Chichester: John Wiley

Juwa GB. 1987. *Soil and sites of selected plantation areas in the Kathmandu project area of the hill forestry development project*. Kathmandu: Forest Research Division, Department of Forestry and Research, HMGN. 66 p

Karki S. 1999. *Ecological study of riverine forest in Koshi Tappu Wildlife Reserve (KTWR)* [thesis]. Kathmandu: Central Department of Botany, Tribhuvan University. 56 p

Miller CE. 1965. *Soil reaction and liming soil fertility*. New York: John Wiley and Sons Inc. 436 p

NARC. 1998/99. *Annual report 1998/99*. Kathmandu: Nepal Agricultural Research Council, Soil Science Division. 112 p

Nepal District Profile. 1997. *A district wise socio-economic profile along with a comprehensive national profile*. Kathmandu: National Research Associates

Pant A. 1997. *A comparative study of vegetation and natural regeneration of two hill forests: Community forest and degraded forest* [thesis]. Kathmandu: Central Department of Botany, Tribhuvan University. 57 p

PCARR. 1980. *Standard method of analysis for soil, plant tissue water and fertilizer*. Los Banos (Laguna): Farm, Resource and Systems Research Division, Philippine Council for Agriculture and Research. 194 p

Pearson K. 1957. *The grammar of science*. New York: Meridian Books, Inc. 453 p

Rana BS, SP Singh and RP Singh. 1988. Biomass and productivity of central Himalayan sal (*S. robusta*) forest. *Trop Ecol* **29**(2): 1-5

Ruess JO and GS Innis. 1977. A grassland nitrogen flow simulation model. *Ecology* **58**: 348-57

Sah JP. 1997. *Koshi tappu wetlands: Nepal's ramsar site*. Kathmandu: IUCN Nepal. 254 p

Sah VK, AK Saxena and V Singh. 1994. Seasonal variation in plant biomass and net primary productivity of grazing lands in the forest zone of Garhwal Himalaya. *Trop Ecol* **35**: 115-31

Sanchez PA. 1976. *Properties and management of soil in the tropics*. New York: John Wiley. 618 p

Shah R. 1999. Soils: Their problems and management. In: Majupuria TC (ed), *Nepal: Nature's paradise*. Kathmandu: Hillside Press Ltd. p 64-8

Shrestha A. 1992. Physical and chemical properties of soil in Nepal. *J For Inf Nep* **3**(4): 27-29

Shrestha S. 1996. *Ecological study of degraded, regenerating and natural forests in Riyale Kavrepalanchowk district, central Nepal* [thesis]. Kathmandu: Central Department of Botany, Tribhuvan University. 127 p

Shrestha R. 1997. *Ecological study of natural and degraded forests of Chitrepani, Makawanpur district, Nepal* [thesis]. Kathmandu: Central Department of Botany, Tribhuvan University. 113 p

Sigdel ER. 1994. *Physico-chemical properties of soil in Royal Chitwan National Park* [thesis]. Kathmandu: Central Department of Botany, Tribhuvan University. 49 p

Singh B, S Nath, PK Das, SB Singh and SK Banerjee. 1987. Soil characteristics under introduced *Cryptomeria japonica* (Dhupi) in Darjelling Himalayan Region. *Ind For* **113**(3): 191-201

Singh SP and JS Singh. 1989. Ecology of central Himalayan forest with special reference to sal forest ecosystem. In: Singh JS and B Gopal (eds), *Perspective in ecology*. New Delhi: Jagamander Book Agency. p 193-232

Singh SP and JS Singh. 1985. Structure and function of the forest ecosystem of central Himalayas: Implication for management. In: Singh JS (ed), *Environmental regeneration in Himalayas*. Nainital: The Central Himalayan Environment Association and Gyanodya Prakashan. p. 83-113

Stainton JDA. 1972. *Forests of Nepal*. London: Camelot Press Ltd. 181 p

Suoheimo J. 1995. *Natural regeneration potential of mixed sal (S. robusta) forests in Nepal*, Vol II. FMUDP working paper no 18. Kathmandu: National Forest Division, Department of Forests, Ministry of Forest and Soil Conservation, HMGN

Tamhane RV, DP Motiramani, YP Bali and RL Donahue. 1964. *Soils: Their chemistry and fertility in tropical Asia*. New Delhi: Prentice Hall of India Private Limited

Zobel DD, PK Jha, MJ Behm and UKR Yadav. 1987. *A practical manual for ecology*. Kathmandu: Ratna Book Distributors.149 p

Acknowledgements

We are thankful to IFRI for providing financial support and to the staff for their companionship in the field study; and to the Central Department of Botany, Tribhuvan University, and NARC for providing laboratory facilities to analyze soil.

Control of flea beetle, *Phyllotreta nemorum* L. (Coleoptera: Chrysomelidae) using locally available natural resources

Indra P Subedi* and Kamini Vaidya

Central Department of Zoology, Tribhuvan University, Kathmandu, Nepal

***** *To whom correspondence should be addressed. E-mail: indrasubedi@hotmail.com*

Aqueous extracts of six different plants (*Acorus calamus, Ageratum conyzoides, Azadirachta indica, Duranta repens, Spilanthes acmella* and *Urtica dioca*) and diluted animal urine (buffalo and cow) were tested for mortality rate of flea beetle (*Phyllotreta nemorum*) in the laboratory. Results were compared with the effects of commercial neem product (neem azal) on flea beetle mortality. The host plant taken for the study was radish (*Rhaphanus sativus*). Three concentrations of aqueous plant extracts (1kg/5 l, 1kg/10 l and 1kg/20 l of water), three concentrations of animal urine (20%, 15% and 10%) and two concentrations of neem azal (0.1% and 0.01%) were tested in three replications. Observations on the beetle mortality were made at 24 hrs and thereafter on alternate days for a week (168 hrs). All tested concentrations of *S. acmella,* buffalo urine and cow urine were effective in flea beetle control; *A. calamus, A. indica* and *U. dioca* were significantly better in controlling flea beetle ($P<0.05$), but only at the highest concentrations tested. The best treatments from *in-vitro* experimentation (the highest concentrations of *S. acmella*, buffalo urine and cow urine) were evaluated further *in vivo*. Results showed that all three treatments were effective in controlling the flea beetle ($P<0.05$).

Key words: Cattle urine, marati, neem, neem azal, radish

Him J Sci **1**(2): 111-114
URL: www.himjsci.com/issue2/fleabeetle

Received: 10 May 2003
Accepted after revision: 21 July 2003

Introduction

The flea beetle (*Phyllotreta nemorum*) is a widespread and common pest of cruciferous plants. Frequently it is serious pest in seedbeds and on newly transplanted vegetables. The adults feed on the cotyledons and leaves of young plants; feeding produces a shot hole effect. Occasionally seedlings may be completely destroyed. The larvae live in the soil and feed upon the roots of the host plants but do little damage.

Three species of flea beetles are reported from Nepal: *P. cruciferae, P. nemorum* and *Monolepta signata* (Vaidya 1995). Control of the flea beetle is a problem in many parts of the world. Fan and Huang (1991) included *Phyllotreta* species as serious pest in Taiwan. Various control measures, such as seed dressing with BHC or treatment with DDT, BHC or Derris dust, are in practice for the control of the flea beetle. Turnoc and Turnbill (1995) reported the development of resistance by the cruciferous flea beetle (*P. cruciferae*) towards insecticides including carbofuran, carbaryl, oxanyl, methamidofos and endosulfan. Fan and Huang (1991) also have noted the development of resistance by the insect. Along with resistance problems, there are many problems entailed in the application of chemical pesticides such as health hazards, environmental effects, adverse effects on non-target organisms, and destruction of natural enemies. Therefore, it is necessary to search for alternative methods to control the flea beetle in an eco-friendly manner. This paper reports on the use of natural agents such as plant- and animal-based products in controlling the flea beetle, *P. nemorum*.

Materials and methods

Experiments were first carried out in the laboratory using test cages and then repeated in the field using those treatments found to be successful in the laboratory. The field trials were carried out in Pokhara Valley, Kaski district, Nepal, from March to June 1999. Testing was performed on adult flea beetles (*P. nemorum*). Insects were collected from the cruciferous plants (especially radish) in the study area. Radish (*Rhaphanus sativus*) was chosen for testing because it can be cultivated easily and it allows effective assessment of flea beetles during the test. Transparent plastic bottles 7.5 cm high by 6 cm in diameter were used as test cages. The mouths of the bottles were covered with muslin to prevent the insects from escaping. Six pesticidal plants and 2 animal products were tested. Selection of the plants and animal products was based on information collected from local farmers; abundance and availability were taken into consideration. The selected plants were *Acorus calamus* (Bojho), *Ageratum conyzoides* (Ganmane ghans), *Azadirachta indica* (Neem), *Duranta repens* (Nil kanda), *Spilanthes acmella (*Marati) and *Urtica dioca* (Stinging nettle). Buffalo urine and cow urine were the selected animal products. The natural resources were collected from the experimental site in Pokhara Valley. Neem azal (Azadirachtin), a commercial neem product provided by Trifolio-m-Gmbh, Germany, was the only formulated compound tested.

For the preparation of an aqueous extract, a fixed amount of chopped plant parts was ground and soaked in water in polythene bags. The soaked materials were allowed to settle in the shade. After 48 hrs, the materials were squeezed and then filtered. The residue was again mixed with water and squeezed and filtered. This process was repeated three times. The filtrate was collected and diluted to make the required solution **(Table 1)**.

Laboratory tests were carried out by spraying radish leaves with the various extracts, urine and neem azal, and placing them inside the experimental cages separately. Ten beetles were

placed in each cage bottle. The mouths of the bottles were covered with muslin cloth for aeration and to prevent insect from escaping. The leaves inside the cage were replaced daily with leaves to which the same treatment had been applied at the beginning of the experiment. The experiment was continued for 168 hrs of spray application.

For the field experiment, three blocks of equal size (4.5 m x 1 m) were prepared. Each block consisted of four plots. A distance of 50cm was maintained between blocks and between plots. Each plot was of size 100 cm by 75 cm. Twenty plants were planted in each plot. Treatments were randomly arranged.

In the laboratory, the treatment was applied using a syringe. The volume of spray solution per leaf was about 3 to 5 ml. In the field, a hand sprayer was used for spraying. The rate of treatment application was controlled by adjusting walking speed. The distance between the nozzles and the plant tips was about 40-50 cm during application. The applied spray volume corresponds to 500 ml/plot. The time of application of test materials was between 3 pm to 4 pm. All the applications were made under natural weather conditions.

For assessment of mortality in the laboratory, three replications were used for each treatment. The effect of treatments on the flea beetle was recorded at 24 hrs, 72 hrs, 120 hrs and 168 hrs of treatment application. The three most effective treatments, as assessed in the laboratory study, were used in the field tests. Five plants in each plot were selected randomly for observation. The number of live flea beetles on these five plants was noted before treatment and 24 hrs after treatment application and then on alternate days for a period of one week.

The mortality coefficient (MC) value was estimated following Abbott (1925):

$$MC = [(T-C)/ (100-C)] 100$$

Where, T= Percentage mortality in control
C= Percentage mortality in treatment

In the laboratory, the percentage mortality of the flea beetle for the various treatments at varying concentrations 24 hrs and 168 hrs after treatment was analyzed by two-way ANOVA. In the field, the number of flea beetles per plant was used to estimate the mortality variance.

TABLE 1. Experimental materials and concentration of preparation used in the study

Experimental material	Concentrations		
	C_1	C_2	C_3
Fresh leaves of *Ageratum conyzoides, Azadirachta indica, Urtica dioca*	1Kg/5l	1Kg/10l	1Kg/20l
Fresh rhizome of *Acorus calamus*	1Kg/5l	1Kg/10l	1Kg/20l
Fresh fruits of *Duranta repens*	1Kg/5l	1Kg/10l	1Kg/20l
Fresh flower heads of *Spilanthes acmella*	1Kg/5l	1Kg/10l	1Kg/20l
Buffalo urine	20%	15%	10%
Cow urine	20%	15%	10%
Neem azal	0.1%	0.01%	

Results

Laboratory experiment

Variation in percentage mortality with time

In all treatments mortality occurred in the flea beetles. The percentage of mortality was higher in various treatments than in control and highest mortality occurred with Neem azal **(Figure 1, 2, 3)**. The mortality value gradually increased from the beginning of the treatment, and after 168 hrs, the values reached 76.7% for *S. acmella*, 73.3% for buffalo urine and 66.7% for cow urine at C_1 concentration. At C_2 concentration, it was 70%, 66.7% and 60% for *S. acmella*, buffalo urine and cow urine respectively. The percentage mortality data when analyzed for treatment effect showed a significant difference ($p<0.05$) between treatment concentrations and among treatments.

TABLE 2. Mortality coefficient of flea beetle by treatment and concentration in laboratory

Treatment	Mortality coefficient of flea beetle					
	24 hrs after treatment			168 hrs after treatment		
	1Kg/5l (C_1)	1Kg/10l (C_2)	1Kg/20l (C_3)	1Kg/5l (C_1)	1Kg/10l (C_2)	1Kg/20l (C_3)
Acorus calamus	12.3	1.8	1.8	41.7	33.3	29.2
Ageratum conyzoides	12.3	1.8	1.8	33.3	25	20.8
Azadirachta indica	8.8	5.3	1.8	45.8	27.5	25
Duranta repens	12.3	5.3	1.8	33.3	29.2	20.8
Spilanthes acmella	19.3	8.8	15.8	70.8	62.5	45.8
Urtica dioca	1.8	5.3	1.8	37.5	29.1	25
Buffalo urine	22.8	19.3	12.3	66.7	58.3	50
Cow urine	19.3	15.8	5.3	58.3	50	45.8
Neem azal	57.9	5.3		79.2	12.5	
Control	5%			20%		

Mortality coefficient of flea beetle

Mortality coefficients of flea beetles for each treatment at 24 hrs and 168 hrs after treatment application were calculated. The mortality coefficient increased with increase in concentration in all cases except in the case of *S. acmella* and *U. dioca* at 24 hrs of treatment application.

Mortality coefficients for all treatments after 168 hrs of treatments application were found to be greater than MC values at 24 hrs of treatment application **(Table 2)**. All concentrations of *S. acmella*, buffalo urine and cow urine showed significant effects. C_1 concentration of *S. acmella*, buffalo urine and cow urine showed MC values of 70.8, 66.7 and 58.3 respectively, which are close to the value for neem azal (79.2).

Field experiment

Percentage reduction in flea beetle population

At 24 hrs of treatment application, the number of flea beetles per plant decreased

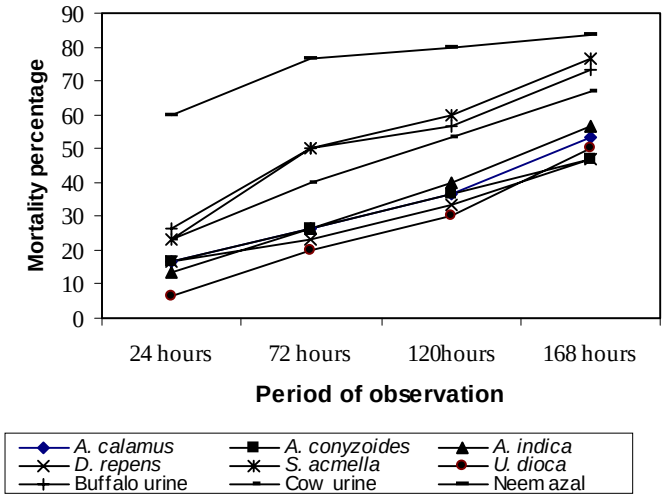


FIGURE 1. Percentage mortality of flea beetle for different treatments with respect to duration of treatment at C_1 concentration (1 kg/5 l) in laboratory

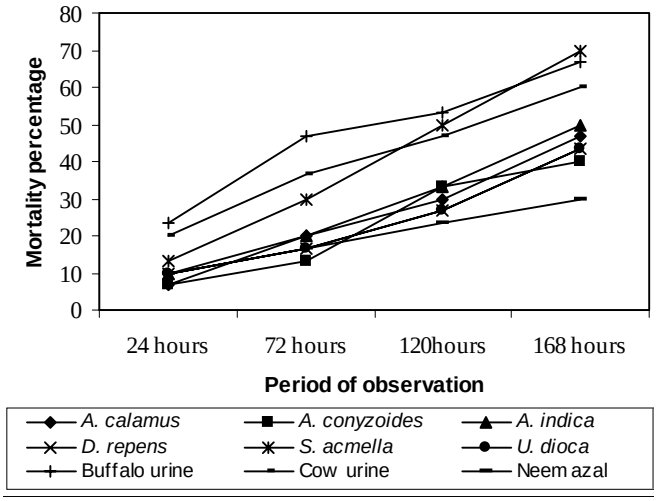


FIGURE 2. Percentage mortality of flea beetle for different treatments with respect to duration of treatment at C_2 concentration (1 kg/10 l) in laboratory

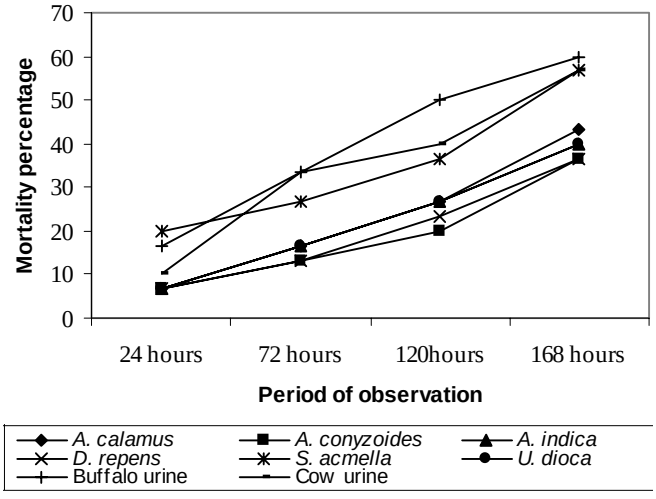


FIGURE 3. Percentage mortality of flea beetle for different treatments with respect to duration of treatment at C_3 concentration (1 kg/20 l) in laboratory

by 76% with cow urine, 74.5% with *S. acmella* and 55.7% with buffalo urine whereas in the control plot the value corresponds to 10.1% **(Figure 4)**. The highest reduction in flea beetle population was recorded in plots treated with cow urine. One week after treatment, there was a significant reduction in flea beetle populations (buffalo urine 75.4%, cow urine 75% and *S. acmella* 70.9%), while in the control plot the number of flea beetle per plant remained more or less stable throughout the study period **(Figure 4)**.

Variation in population per plant with respect to time

In the field, the population of flea beetles was greatly reduced in all treated plots compared to those in control plots. In the control plot, there was a slight fluctuation in the number of live flea beetle per plant. Flea beetle population per plant at the end of experiment was found to be the least on plants treated with cow urine (1.8 insects/plant). Buffalo urine (2.0) and *S. acmella* (2.1) were the second and third most effective treatments. However, in the control plot, there was only a slight change in populations, from an average of 9.2 before treatment to 8.9 one week after treatment **(Figure 5)**. The differences among the treatments were statistically significant

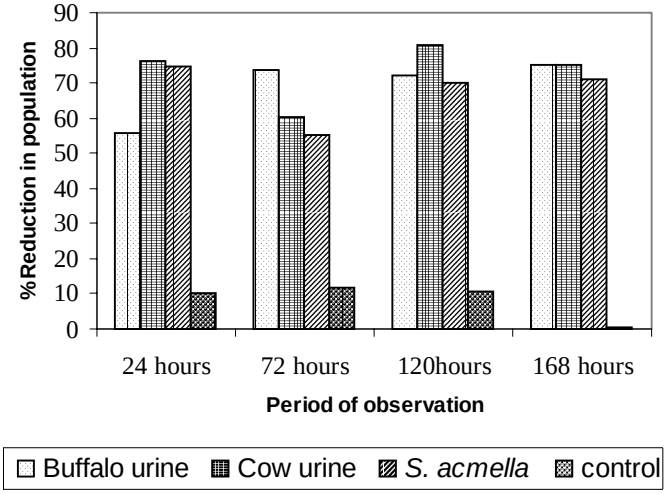


FIGURE 4. Percentage reduction in flea beetle population after treatment at C_1 concentration (1 kg/5 l) in field

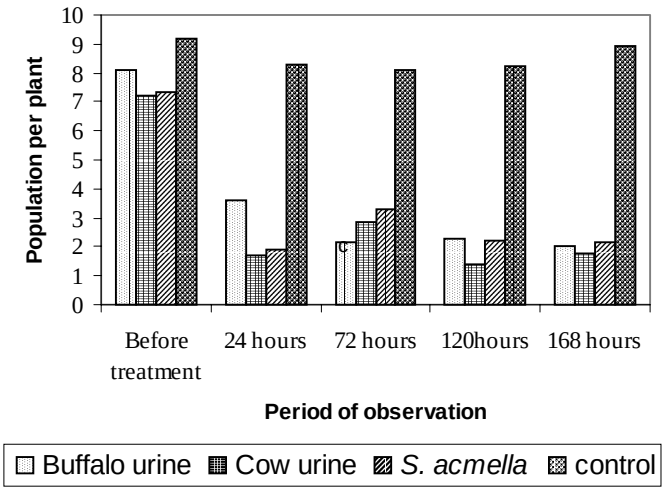


FIGURE 5. Flea beetle population per plant with respect to duration of treatment at C_1 concentration (1 kg/5 l) in field

($p<0.05$). However, treatments were not significant at 1% level at 24 hrs of treatment application. The effect was highly significant ($p<0.01$) after 168 hrs of treatment application.

Discussion

The study shows that all the tested natural resources possess pesticidal properties to some degree or other. *A. calamus, A. indica, S. acmella, U. dioca*, buffalo urine and cow urine are proved effective agents for flea beetle control; the effect of *A. conyzoides* and *D. repens* was not significant.

All tested concentrations of *S. acmella* showed significant results. Kadir et al. (1989) also showed that extracts of *S. acmella* were toxic against adult American cockroach (*Periplaneta americana*). The pesticidal property of *S. acmella* is due to its active component Spilanthol (Kadir et al. 1989). The N-isobutyl amides from flower buds of *S. acmella* were effective against *Aedes aegypti* larvae and *Helicoverpa zea* neonates at 12.5 and 250 µg/ml concentration respectively (Ramsewak et al. 1999).

Regmi and Karna (1998) have shown that *A. calamus* and *A. indica* have pesticidal value. Powdered rootstock of *A. calamus* has been reported effective as an insecticide, repellent and contact poison, and *A. indica* as a plant of multifarious pesticidal values (Regmi and Karna 1998). Joshi and Paneru (1999) described *A. calamus, A. conyzoides, A. indica* and *U. dioca* as plants with potent insecticidal properties and *A. indica* is effective against the flea beetle. Palaniswamy and Wise (1994) reported that neem-based products are effective with high mortality or repellency against the crucifer flea beetle (*P. cruciferae*). The pesticidal property of *A. indica* is due to the active principle, the limnoid azadirachtin. Azadirachtin is the most potent natural insect antifeedant, which suppresses insect feeding at concentration of less than 1 ppm (Ishman et al. 1991).

Cow urine and buffalo urine both showed significant results at all concentrations. Cow urine is traditionally widely used in Nepal for various purposes, including religious, ritual and medical applications, and insect control. According to Vaidya (1993), cow urine is the most effective solution for the control of *Lipaphis erysimi, Myzus persicae* and *Dorylus orientalis*. Budhathoki (1992) reported that diluted cow urine applied on broad leaf mustard significantly reduces powdery mildew. Farmers use cow urine in various concentrations (1:2 to 1:5) as curative plant protection measures against aphids of cowpea and bean and late blight of potato and tomato (Gyawali et al. 1994).

In the laboratory, no tested natural resources showed significant results at 24 hrs of treatment application. However, in the field, there was marked population reduction at 24 hrs of treatment application. It may be due to the repellent effect of different treatments. The effects persist up to one week and there was remarkable population reduction in the field even 168 hrs after treatment application. ■

References

Abbott WS. 1925. A method of computing the effectiveness of insecticides. *J Econ Entomol* **18**: 265-7

Budhathoki K. 1992. *Vegetable farming through indigenous technology.* Lumle (Kaski): Lumle Regional Agricultural Research Centre. Seminar paper no 92/15

Fan KY and IJ Huang. 1991. Occurrence and control of major insect pests on vegetables in Taiwan. *Chin J Entomol Spec Publ Ola* **4**: 1-13

Gyawali S, RB Thapa and P Amatya. 1994. Assessment of indigenous knowledge in plant protection for possible integration into intregated pest management. In: Neupane FP and M Kharel (eds), *IAAS research reports*. Rampur: IAAS. p 107-27

Ishman MB, O Koul, JT Arnason, J Stewart and GS Salloum. 1989. Developing a neem based insecticide for Canada. *Mem Entomol Soc Can* **159**: 39-47

Joshi SL and RB Paneru. 1999. Botanicals against insect pests of agricultural importance in Nepal. Paper presented on "Regional training program in chemistry of natural products and related fields"; 1999 May 18-28; Kathmandu, Nepal. Kathmandu: Central Department of Chemistry, Tribhuvan University

Kadir HA, MB Zakaria, AA Kechil and MS Azirum. 1989. Toxicity and electrophysiological effects of *Spilanthes acmella* Murr. extracts on *Periplaneta americana*. *Pestic Sci* **25**(4): 329-36

Palaniswamy P and I Wise. 1994. Effects of neem based products on number and feeding activity of crucifer flea beetle, *Phyllotreta cruciferae* (Goeze) on canola. *J Agric Entomol* **11**(1): 49-60

Ramsewak RS, AJ Erickson and MG Nair. 1999. Bioactive N-isobutylamides from flower buds of *Spilanthes acmella*. *Phytochemistry* (Oxford) **51**(6): 729-32

Regmi PP and PP Karna. 1988. Weeds and other plants of pesticidal values in Nepal. In: *Proceedings of 1st National Conference on Science and Technology*; 1988 Apr 24-29; Kathmandu, Nepal. Kathmandu: RONAST. p 161-73

Turnoc WJ and SA Turnbill. 1995. The development of resistance to insecticides by cruciferous flea beetle, *Phyllotreta cruciferae. Can Entomol* **126**(6): 1369-75

Vaidya K. 1993. *Agricultural pest management using animal and plant products.* Kathmandu: Tribhuvan University. xi +135 p

Vaidya K. 1995. *Organic pest management* [project report]. Kathmandu: Tribhuvan University. AAA GATE/TU. 300 p

Acknowledgements

We would like to express our sincere gratitude to Tej K Shrestha, Suresh B Karki and Vasanta K Thapa (Central Department of Zoology, TU) for their encouragement, guidance and assistance, especially in providing necessary laboratory facilities. We are thankful to SR Ghimire (Lumle Agriculture Research Centre) for revising this paper, and to Trifolio-m Gmbh, Germany for providing us with Azadirachtin.

Surface modification of polycarbonate (bisphenol A) by low pressure rf plasma

Deepak P Subedi*†, Lenka Zajickova‡, Vilma Bursikova‡ and Jan Janca‡

† *Department of Physics, Kathmandu University, Dhulikhel, Kavre, Nepal*
‡ *Department of Physical Electronics, Masaryk University, Kotlarska 2, 61137, Brno, The Czech Republic*

* *To whom correspondence should be addressed. E-mail: deepaksubedi2001@yahoo.com*

Effects of low pressure radio frequency (rf) plasma treatment on the surface properties of polycarbonate are presented in this paper. Results obtained from the surface energy measurement after different conditions of treatment are compared. After treatment the surface free energy increased from the original value of 35 mJ/m^2 to 63-74 mJ/m^2. X-ray photoelectron spectroscopy measurements showed an increase in oxygen to carbon ratio after the treatment indicating an increase of oxygen-containing functional groups on the polycarbonate surface. A study of the stability of the modified surface property has been made on the basis of surface free energy. To study the improvement of adhesion between the polycarbonate and thin coatings, organosilicon thin films were deposited on the untreated and plasma treated polycarbonate. The adhesion of film to substrate was quantitatively analysed by 'cross-hatch peel test'.

Key words: Polycarbonate, surface modification, rf plasma, ageing, surface energy

Him J Sci **1**(2): 115-118
URL: www.himjsci.com/issue2/polycarbonate

Received: 27 Apr 2003
Accepted after revision: 25 June 2003

Introduction

Polymers have been applied successfully in fields such as adhesion, biomaterials, protective coatings, friction and wear-resistant composites, microelectronic devices and thin film technology. Polymeric materials have been able to replace traditional engineering materials like metals and glass because of their high strength to weight ratio, resistance to corrosion, possibility of recycling and their relatively low cost. However, the low surface energy of polymers and resulting poor adhesion of additional coatings have also created numerous important technical challenges which have to be overcome by manufacturers (Michael et al. 1999). Polycarbonates (PCs) are synthetic polymers with a very wide field of applications due to their excellent breakage resistance, good transparency, low inflammability and good workability.

In recent years, polycarbonate has become a very attractive business article. The world production of PC increases every year by 8-10% and nowadays it is more than 1.35 million tonnes/year (Mapleston 1999). The most important types are the PCs based on bisphenol A (business labels Diflon®, Macrolon®, Lexan®, and so on). PCs can be used for plastic vessels and machine parts; optical grades can be used for compact discs (CDs, CD-ROMs and DVDs), optical fibres, etc. But the low hardness, low scratch resistance and degradation by UV radiation require modification of surface properties by means of additional coating.

Therefore, in many applications (e.g., in industry, technology, biology and medicine) it is necessary to change or improve some of the surface properties of the polymers without altering the bulk properties. Several techniques have been developed to modify the polymer surfaces for improved adhesion, wettability, printability and other technologically important characteristics. The common methods of surface modification include mechanical or chemical treatment; and exposure to flames, photons, ion beams, and other types of radiation (Pasco and Everest 1978). Mechanical treatment alone has limited effectiveness, and chemical treatments with solvents, oxidants such as chromates and permanganates, strong acids or bases, and sodium-liquid ammonia treatments for fluoropolymers are becoming increasingly unacceptable because of environmental and safety considerations. Furthermore, wet chemical treatments tend to entail inherent problems of uniformity and reproducibility. Among all the methods of modifying polymer surfaces to improve wettability and adhesion, low pressure plasma treatment has proved to be one of the most effective, ensuring uniformity, as well as being non-polluting.

In general, the surface modification techniques can be divided into three categories: (i) cleaning and etching by removal of material from the surface; (ii) surface reactions producing functional groups and cross linking (these entail little or no removal or addition of material); and (iii) deposition of thin films on the surface (Yasuda et al. 1990, d'Agostino et al. 1990). An important objective of any such treatment is to remove loosely bonded surface contamination, thus providing intimate contact between interacting materials on the molecular scale.

This paper discusses the surface modification of PCs utilising a low pressure rf glow discharge produced in argon, oxygen and ammonia gases. However, detailed study of the modified surface has been undertaken after argon and oxygen plasma treatment only. The modified surface has been characterised by measuring the contact angles and calculating the surface free energy. The changes in chemical composition have been studied by X-ray photoelectron spectroscopy. The results of adhesion test are also presented.

Materials and methods

Plasma treatment and film deposition

The major part of the research work consists of plasma treatment and film deposition performed at the plasma chemical laboratory of Masaryk University, Czech Republic. Plasma treatments were carried out in rf capacitively coupled glow discharge. The bisphenol ➔

A PC samples of sizes 50 by 60 mm^2 were cleaned in isopropyl alcohol and dried before inserting into the reactor. The samples were placed on the powered bottom electrode, which was capacitively coupled to the rf generator PG 501 working at the frequency of 13.56 MHz. The effect of treatment time and rf power on the wettability of PC was investigated. The rf power was varied from 100 to 400 W, and the DC negative self bias voltage varied from -10 to -270 V depending on the rf power and the pressure inside the reactor. The gas flow was controlled by electronic massflow controller. All the treatments were carried out in flow regime. The reactor chamber was pumped by a diffusion pump backed by a rotary pump.

The SiO_2 films were deposited from the hexamethyldisiloxane/oxygen (HMDSO/O_2) feeds 4 hours after the treatment in argon discharge (Q_{Ar} =5.7 sccm, p =1.5 Pa, P =100 W, U_{bias} = -35 V, t =5 min). The gases were fed into the reactor through the showerhead electrode to ensure uniform deposition. The distance between the electrodes was 55 mm. For film deposition, 4 sccm of HMDSO was diluted with two different oxygen flow rates, namely 45 sccm and 10 sccm. The rf powers were 100 and 400 W respectively.

TABLE 1. Surface free energy and its polar and dispersion components of water and glycerine used to determine the surface energy of PC

Liquid	Total surface energy (mJ/m^2)	Polar component (mJ/m^2)	Dispersion component (mJ/m^2)
Water	72.8	51	21.8
Glycerine	63.4	29.7	33.6

Source: Correia et al. 1997

TABLE 2. Atomic concentration of carbon, oxygen and nitrogen measured by XPS for untreated and plasma treated polycarbonate. Plasma treatments were performed for 5 min at a pressure of 1.5 Pa and gas flow rate 5.7 sccm

Gas	Power(W)	Atomic concentration (%)			
		C	O	Si	N
Untreated	-	84.3	15.7	0	0
Ar	100	76.4	20.3	0.4	2.2
O_2	100	74.0	24	0.4	1.7

TABLE 3. Results of adhesion measurements of silica films deposited on PC after an argon plasma treatment carried out at different rf powers and treatment times

Gas	Power (W)	Treatment time (min)	Film thickness (nm)	Adhesion (%)
Untreated	-	-	490	10
Ar	100	5	459	90
Ar	400	5	545	96
Ar	100	10	472	94
Ar	400	10	523	99

Surface characterisation

Over the years a large number of techniques have been developed to probe the different aspects of the physics and chemistry of surfaces; however, only a few have found wide application in basic surface science and applied surface analysis. Among these methods, X-ray photoelectron spectroscopy (XPS) and Fourier transform infrared spectroscopy are used to study the surface chemical composition. Similarly, scanning electron microscopy (SEM) and atomic force microscopy (AFM) are used to investigate the surface morphology of the material at the atomic scale. These methods require relatively expensive equipments, skilled technicians and quite sophisticated techniques to interpret the data. A good understanding of the surface properties of a solid may be obtained relatively inexpensively from the measurement of the surface free energy. Therefore contact angle measurement has been used in the study of surface free energy, wettability and adhesion of low surface energy materials. The surface free energy of a solid is an important parameter, playing a vital role in the phenomena that occur at solid-liquid and solid-gas interfaces. Hence, knowledge of this parameter is useful in studies of adsorption and wettability processes which play important role in many industrial applications of the material (Zimon 1974, Leja 1982). Measurement of contact angle of liquid with the solid surface permits a rapid and qualitative evaluation of surface free energy of polymers. In the present paper, analysis of the surface free energy of PCs has been made on the basis of dispersive and non-dispersive components. Surface free energy (γ_s) and its polar (γ_s^p) and dispersion (γ_s^d) components of the sample were determined from two sets of contact angles (water and glycerine) according to Owens-Wendt-Kaelble equation (Owens and Wendt 1969).

$$\gamma_l(1+\cos\theta) = 2[\gamma_l^d \gamma_s^d]^{\frac{1}{2}} + 2[\gamma_l^p \gamma_s^p]^{\frac{1}{2}}$$

where, γ_l , γ_l^p and γ_l^d are the total surface free energy, the polar component and the dispersion component of the surface free energy of the liquid, respectively. The values of the surface free energies of the test liquids obtained from the literature are given in **Table 1**.

The changes in the chemical composition of the samples after the plasma treatments were analysed by XPS measurements. The measurements were carried out on an ultra-high-vacuum (lower than 10^{-8} mm Hg) surface analytical system equipped with Omicron EA 125 hemispherical analyser working in multi-channel detection regime. The analyser was operated in the retarding field mode using pass energy of 20 eV. MgKα was used for excitation. The electron take-off angle was 90° and the analysed area 6 mm in diameter. Standard fitting procedure was used to determine the core level-peak position and spectral intensities. The charging was evaluated and corrected after the fitting of the C1s signal from the position of C-H peak, which is characterised by binding energy of 284.6 ± 0.2 eV.

The improvement made by the argon plasma treatment in the adhesive property of PC to thin coating of silica was studied using the cross-hatch peel test method. SiO_2 films of about half mm thickness were deposited by plasma enhanced chemical vapour deposition (PECVD) on the untreated and plasma treated PC. The deposited films were cut into 384 2.5 by 2.5 mm^2; adhesive tape (3M No. 369) was then applied to the film and pulled swiftly. The numbers of the squares adhering to the PC was counted and the ratio of the adhering film area to the total area of the film under the applied tape was determined. The percentage adhesion of the films after different conditions of argon plasma pre-treatment was determined.

Results and discussion

Surface free energy measurement

The values of surface free energy and its components before and after the treatment in argon, oxygen and ammonia plasmas are compared in **Figure 1**. The surface energy corresponds to the contact angles measured within 10 min of the plasma treatment. It shows that all three types of treatment can produce significant increase in the surface free energy. The treatment carried out in argon and oxygen plasma resulted a higher value of total surface energy compared to ammonia plasma. Argon plasma treatment produces purely physical surface modification; no new functional groups are incorporated on the polymer surface. The direct and radiative energy transfer processes cause the surface modification in all types of inert gas plasma treatments. The direct energy transfer corresponds to the ion bombardment of the surface, which is particularly important in the case of the PC specimens placed on the dc- biased capacitively-coupled rf electrode. Another important factor for the modification mechanism is the UV (VUV) radiation emitted by the plasma (Chan et al. 1996). The exposure of the sample to the argon discharge is sufficient to break chemical bonds (C-C, C-H), leaving free radicals at or near the surface. These radicals can react only with other surface radicals or by chain-transfer reactions. If the polymer chain is flexible, or if the radicals can migrate along it, then recombination, unsaturation, branching, or cross-linking can occur. Moreover, the plasma removes low molecular weight species or converts them to high molecular weight species by crosslinking reactions. In summation, the argon plasma treatment causes the crosslinking of the PC surface as well as the sputtering of the material.

Unlike argon plasma, the oxygen plasma produces a variety of new functional groups including C-O, C=O, O-C=O, C-O-O, that increase polymer wettability. In general, two processes may occur simultaneously during the oxygen plasma treatment: (i) etching of the polymer surface through the reactions of atomic oxygen with the surface carbon atoms, yielding volatile products, and (ii) the formation of oxygen functional groups at the polymer surface through reactions between the active species from the plasma and the surface atoms. Hence, for oxygen plasma, the reactive oxygen atoms play an important role in the surface modification of the sample.

The mechanism of surface modification in the case of ammonia plasma treatment is somewhat similar to that of oxygen plasma. Ammonia plasma treatment incorporates hydrophilic functional groups such as amine (N-H), imine (N=C), nitrile (N≡C) and amide (N-C=O) on the surface of PC. Moreover, the additional oxygen functional groups can be incorporated after the ammonia plasma treatment because free radicals created on the surface react with oxygen when the surface is exposed to the atmosphere (Hudis 1974).

For untreated PC the values of polar and dispersion components of surface free energies are almost the same. But there is a substantial increase in the polar component after all treatments, whereas no any remarkable change in the dispersion component was observed. The ratio of polar component to the total surface free energy is also regarded as the polarity of the material. An important information obtained from the surface energy measurement is that the polar component increases, corresponding to the formation of covalent bonds. The formation of covalent bonds plays an important role in adhesion at the interface.

XPS Analysis

Further information about the changes induced by argon and oxygen plasma treatment was obtained from the XPS measurements. The atomic compositions of the PC surface before and after the treatment are compared (**Table 2**). The treatments produced a decrease in the carbon concentration on the PC surface. On the other hand the oxygen content increased and a small amount of silicon and nitrogen appeared. The impurity of the silicon is caused by the fact that the reactor was also used for the deposition of silicon oxides. Although, before the PC treatment experiments the reactor was cleaned mechanically as well as in argon and oxygen discharges there was probably still some residual silica that appeared on the PC surface. The nitrogen impurity found on the sample after the treatment could be the nitrogen incorporated during the plasma treatment as a result of some nitrogen traces in the feed gas as well as after the exposure of the treated surface to the atmosphere.

Adhesion measurement

The percentage adhesivity of the SiO_2 films deposited on PC with and without pre-treatment is presented in **Table 3**. A significant improvement in the relative adhesivity of the film to substrate is achieved by argon plasma treatment made before deposition of the film. A five-minute argon plasma treatment was sufficient to increase the relative adhesivity from 10% to as high as 96%. The argon plasma pre-treatments were made with two different rf

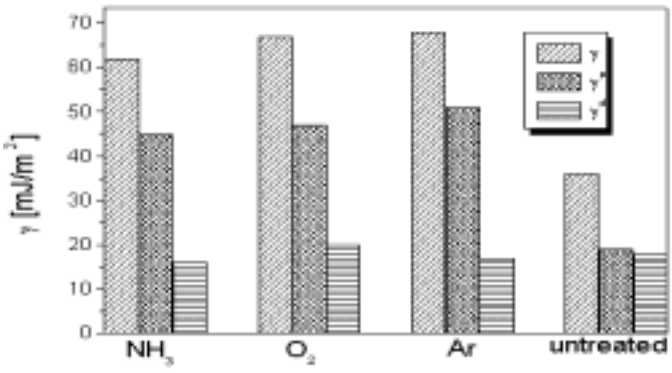


FIGURE1. Comparison of surface free energy and its components before and after the treatment in Ar, NH_3 and O_2 discharges. The domain represents the types of the sample. The treatment conditions were P = 100W, Q = 52 sccm, p= 36.5 Pa, and exposure time t = 10 min. The bias voltages U_{bias} were -20, -25, -30 V for ammonia, oxygen and argon discharges respectively.

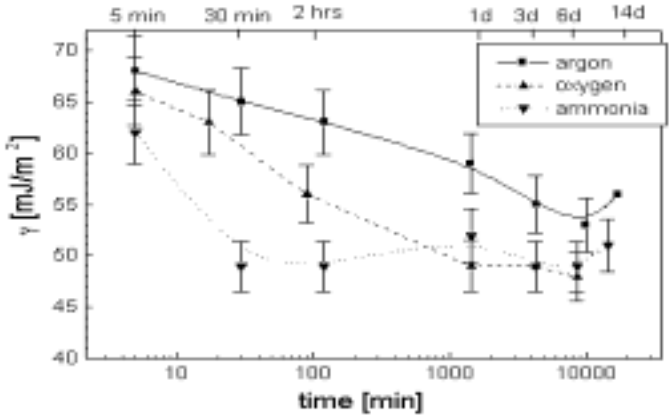


FIGURE 2. Ageing of surface free energy of PC after treatment in Ar, NH_3 and O_2 plasmas. The treatment conditions were P =100 W, U_{bias} = -25 V, Q = 52 sccm, p = 36.5 Pa. and treatment time t = 10 min. The bars in the graph correspond to standard deviation.

powers and treatment time in order to observe the influence of these parameters on the adhesivity. However, the difference in the results for the treatments at different rf powers and with different treatment times was within the limit of experimental error.

The adhesion or bondability between polymer surfaces and other materials deposited onto them can often be related to wettability as determined from the contact angle measurements. Plasma treatment can improve adhesion to polymers via surface cleaning, cross-linking, or formation of chemical bonds. The increased adhesivity produced by argon plasma treatment is well supported by our contact angle measurements. From these we observed that argon plasma treatment under the conditions as used before the film deposition produces significant increase in wettability of PC, which can be correlated with the increased adhesivity. A previous study of the adhesivity of SiO_2 film to PC has reported that a Si-O-C bond must be formed in order to produce the strong adhesivity of the film to the substrate. The unsaturated bonds opened by the treatment in argon plasma can help the formation of such bond and hence increase the adhesion.

A scratch test performed on PC showed that SiO_2 films deposited without pre-treatment were almost completely delaminated from the surface, whereas there was negligible delamination of the film deposited on PC after argon plasma pre-treatment. The characteristics of thin SiO_2 films deposited on PC by PECVD have also been discussed in our previous paper (Zajickova et al. 2001).

We also studied the dependence of the surface free energy of the sample on time after treatment. For that purpose, surface energy of PC was measured for several days after the treatment in Ar, O_2 and NH_3 plasma by storing the samples in a dust-free environment. The results are shown in **Figure 2**. It indicates that the most stable modification of PC surface was produced by argon plasma treatment. On the other hand, ammonia plasma resulted in the least stable modification of the surface.

This effect, commonly known as 'ageing', is important from the point of view of industrial application. It has been reported that ageing is due to (i) thermodynamically driven reorientation of polar species away from the surface to the subsurface, (ii) diffusion of mobile additives from the polymer bulk to the surface, and (iii) the reaction of residual free radicals with the ambient (Spell and Christension 1979). The more stable surface free energy after argon plasma treatment is due to the cross-linking effect. The uses of cross-linking process via inert gas plasma treatments to obtain better surface properties are discussed in detail elsewhere (Michael et al. 1999, Sheu et al. 1992, Vallon et al. 1996). The result clearly indicates the different effects of treatment in inert and reactive plasmas.

Conclusion

The effects of argon, oxygen and ammonia plasma treatments on PC are discussed in the paper. The result of surface energy measurement and its dependence on time after treatment are summarised. All types of treatment resulted an appreciable increase in the wettability of the sample. However, the improved wettability decreased with time. Results of XPS analysis revealed an increase in O/C ratio of the sample after the treatment. The peel tape test showed that a significant improvement in adhesivity of deposited protective film to PC can be achieved by performing a treatment of the sample before the deposition of the film. ■

References

Chan C-M, T-M Ko and H Hiraoka. 1996. Polymer surface modification by plasmas and photons. *Surface Sci Rep* **24**(1-2): 1-54

Correia NT, JJM Ramos, BJV Saramago and JCG Calado. 1997. Estimation of the surface tension of a solid: Application to a liquid crystalline polymer. *J Colloid Interface Sci* **189**(2): 361-9

d'Agostino R, F Cramarossa and F Fracassi. 1990. Plasma polymerization of fluorocarbons. In: d'Agostino R (ed), *Plasma deposition, treatment, and etching of polymers*. New York: Academic Press. p 95-162

Hudis M. 1974. *Techniques and application of plasma chemistry*. New York: Wiley-Interscience. p 113-47

Leja J. 1982. *Surface chemistry of froth flotation*. New York: Plenum Press

Mapleston P. 1999. *Modern plastics international*

Michael RM, L Martinu and JE Klemberg-Sapieha. 1999. In: Mittal KL (ed), *Adhesion promotion techniques: Technological applications*. New York: Marcel Dekker

Owens DK and RC Wendt. 1969. *J Appl Polym Sci* **13**: 1741-7

Pasco IK and JH Everest. 1978. *Optics Laser Technol* **10**: 71

Sheu MS, AS Hoffman and J Feijen. 1992. A glow discharge treatment to immobilise poly (ethylene oxide)/ poly (propylene oxide) surfactants for wettable and non-fauling biomaterials. *J Adhesion Sci Technol* **9**: 995-1009

Spell HL and CP Christension. 1979. *Tappi J* **62**: 77

Vallon S, A Hofrichter, L Guyot, B Drévillon, J E Klemberg-Sapieha, L Martinu et al. 1996. Adhesion mechanisms of silica layers on plasma-treated polymers. Part I. Polycarbonate. *J Adhesion Sci Technol* **10**(12): 1287-313

Yasuda HK, YS Yeh and S Fusselmann. 1990. *Pure Appl Chem* **63**: 1689

Zajickova L, V Bursikova, V Perina, A Mackova, D Subedi, J Janca et al. 2001. Plasma modification of polycarbonates. *Surface Coatings Technol* **142-144**: 449-54

Zimon AD. 1974. *Chem Moscow*

Acknowledgements

We thank Katerina Veltruska, Charles University, Czech Republic, for her kind help with the XPS measurement and analysis, and Pavel Stahel, Masaryk University, for his help with contact angle measurements.

Hydrogeological conditions in the southern part of Dang valley, mid-western Nepal

Birendra Sapkota*

Amrit Campus, Kathmandu, Nepal

** For correspondence, E-mail: birendrasapkota@hotmail.com*

The Dang valley consists of several patches of confined and unconfined aquifer systems. Drilling data reveals that the northern portion of the study area has more permeable surfaces than the southern and central portions. Annual domestic draft and safe yield were calculated to be 7.43 x10^6 m^3/year and 3.16 x 10^7 m^3/year, respectively. The fact that the safe yield is higher than the annual draft indicates the presence of good groundwater potential in the study area.

Key words: terrace, lithology, aquifer, tubewell, yield, draft, piezometric surface, water table

Him J Sci **1**(2): 119-122
URL: www.himjsci.com/issue2/hydrogeology

Received: 27 Apr 2003
Accepted after revision: 15 July 2003

Introduction

Bounded on three sides by the Siwaliks, the Dang valley is approximately 80 km in length and 30 km in width and thus its area is approximately 2400 km^2. The elevation of the valley floor ranges from 550 to 750 m asl. The study area stretches from below the Ghorahi-Tulsipur highway in the north down to the Babai River in the south, from Ghorahi in the east to Tulsipur in the west **(Figure 1)**.

The Dang valley has an undulating terrain sloping towards south. The terrain, consisting mainly of alluvium and outwash deposits from the hill slopes, comprises six terraces- the highest terrace, higher terrace, middle terrace, lower first terrace, lower second terrace and lower third terrace (Yamanaka and Yagi 1984). These are fill-top terraces composed of consolidated detritus. The valley is filled in the central part with fluviolacustrine sediments. Ancient river terraces are more prominent in the northern part of the valley than in the south. The fluvial terraces include soils of diverse types in different regions. Red soil is observed in the northern area, brown in the middle and black in the south and eastern parts of the valley.

The Babai River is one of the major rivers in the Dang valley, flowing east to west and passing through the southern end of the valley. Other perennial streams, such as the Sisne and the Katwa, originate in the lesser Himalaya and join the Babai River on the south, creating alluvial fan plains, sand and gravel bars, depositional basins and other depositional landforms. The erosional activity of the rivers has indented the river terrace of the valley by 8 to 15 m and has created badland topography in the northern part.

Climate in the Dang valley is tropical to sub-tropical, characterized by monsoon rainfalls from June to September, which on average account for 85% of the total annual rainfall (Uprety and Karanjac 1989).

Study area

The subsurface lithology obtained from borehole logs of deep tubewells (DTWs) and shallow tubewells (STWs) consists primarily of sand, gravel, silt and clay, mixed in differing proportions. The comparative study of these wells shows that the northern part of the valley has more sand and gravel. Towards the south and especially along the Babai River, clay and silt are dominant. Intermixing of gravel and fines is dominant in the middle part of the study area.

Materials and methods

A field survey was undertaken to determine the hydrogeological conditions in the study area, and the preliminary data was collected at the Groundwater Resource Development Board (GWRDB), Kathmandu and Groundwater Field Office, Lamahi.

Various types of wells (dugwells, deep tubewells and shallow tubewells) selected for present study were located in a location map **(Figure 1)**. The study was conducted in June 1999 (during the monsoon) and February 2000 (post-monsoon). The depth of water from the ground surface in the dugwells both in monsoon and post monsoon was noted. Geological information regarding the dugwell section of the fluvial terrace was correlated with the nearest columnar section but data from shallow tube-wells and deep tubewells was obtained from borehole logs.

Transmissivity was calculated using figures for well discharge obtained from secondary data. Water table measurements taken from dugwells of study area were useful in determining the direction of groundwater flow.

Safe yield of the groundwater reservoir was calculated for the entire aquifer system based on the piezometric surface fluctuation. This was relevant since the clay zones occur as isolated patches in most of the areas, with laterally interconnected deep and shallow aquifers. Thus, safe yield can be calculated on the basis of the following formula:

Safe yield = area of aquifer × storage coefficient × mean piezometric surface fluctuation (cf. Driscoll 1987)

Typical storage coefficient for confined aquifers ranges from 10^{-5} to 10^{-3} (Driscoll 1987). The above parameters showed the potential of groundwater in the valley and the possibility of future well development for irrigation and drinking water purpose.

Results and discussion

Aquifer setting

The general pattern of aquifers, as revealed from the lithological logs, is irregular and discontinuous with lenses or layers of sediment admixture at different levels. Unconfined aquifers are observed in Dhikpur and Dangigaun. Confined ones are commonly observed at Bangain, Dhikpur and in many other places. The presence of confined aquifers may be due to the shifting of the river course within the valley.

As far as shallow tubewells in the study area are concerned, the best granular zone is found in the well of Ammapur (DG/STW-7), which has a total of 14.6 m thick permeable material (sand and gravel) out of the total well depth of 20.1 m **(Table 1)**.

As for deep tubewells, the thickness of permeable materials varies from 18.5 m in TG-2 (Bangain) to 84.7 m in DG/DTW-5 (Dhikpur). The thickest clay zone, 49.3 m appears in NISP/INV/DTW-3 (Khausapur) **(Table 2)**. Most lithologs of the wells reveal the permeable material to be greater than 40%, indicating good presence of aquifers in the valley **(Table 1** and **2)**.

Piezometric surface

The piezometric surface in deep tubewells as recorded by GWRDB ranges from 5.1 m in DG/DTW-27 (Dangigaun) to 37.5 m in DG/DTW-21 (Lalpur), and in shallow tubewells ranges from 0.7 m in NISP/STW-7 (Ammapur) to 5.0 m in DG/STW-6 (Dundre) **(Table 4)**. The general pattern observed in the area is an increase in depth to piezometric surface towards the northern part of the valley.

Water table

The greater fluctuation of water level, as revealed by the dugwell inventory data, takes place in central and northern parts of the valley **(Table 3)**. The depth to water level in dugwells is found to be less toward the south and near the banks of river. This may be due to high transmissivity in wells toward the north, resulting in rapid recharge of storage during the monsoon season and quick release of water to the south during post-monsoon (Uprety and Karanjac 1989).

Yield

The maximum yield is greater in the central and southern part of the area, in places such as Dundre (DG/STW-6) and Dangigaun (DG/DTW-27) **(Table 4)**. This suggests that the southern and central parts of the study area would offer better venues in which to develop tubewells for irrigation purposes.

Transmissivity

Transmissivity in the deep tubewells of Dangigaun (DG/DTW-27) and Ammapur (DG/STW-7) is greater than in other wells of the valley. Hydraulic conductivity, calculated as the ratio of transmissivity to cumulative aquifer thickness, is also greater in these wells. Even wells adjacent to each other, for example NISP/STW-7 and DG/STW-7 may vary in transmissivity. The discontinuous

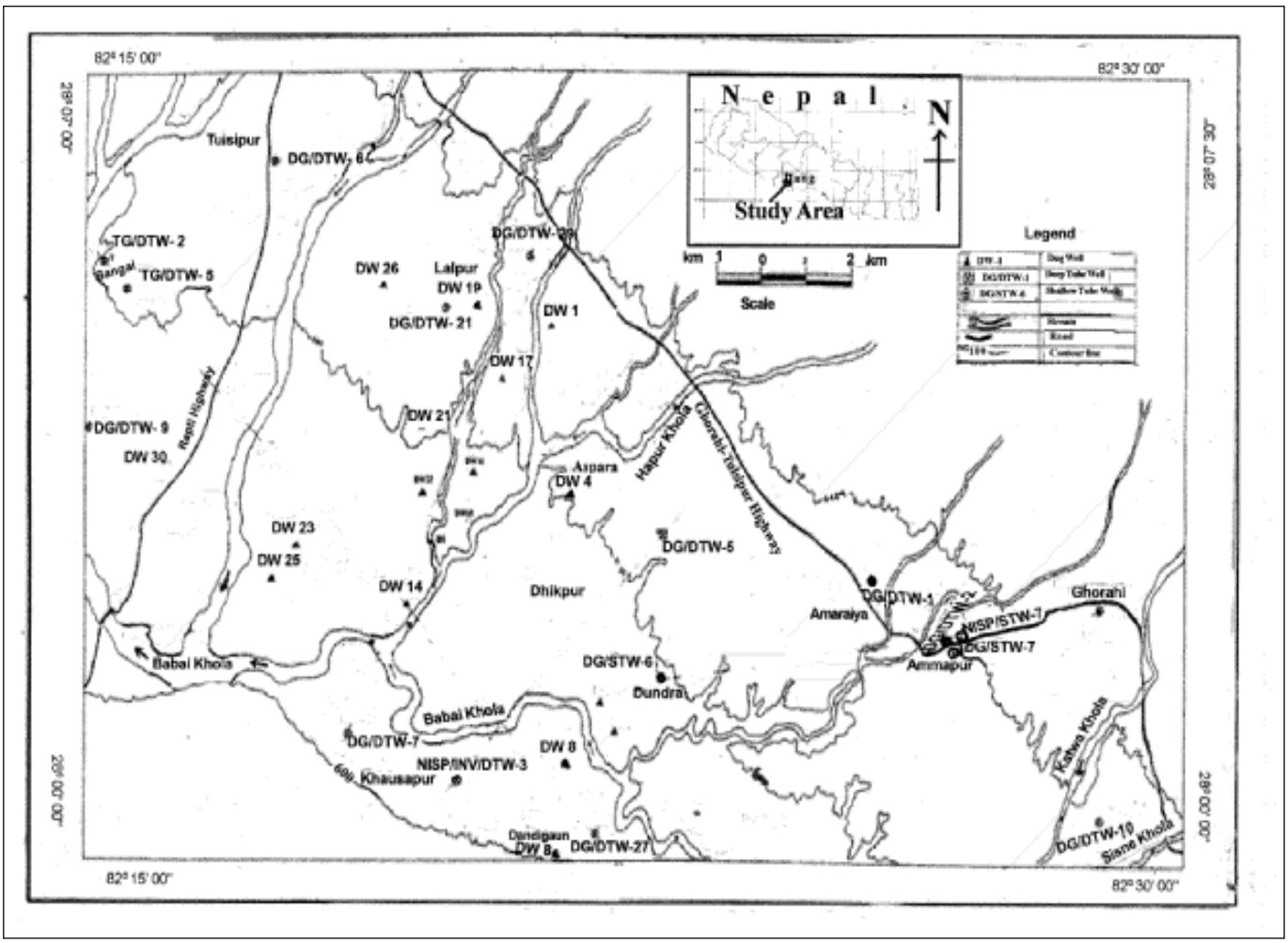


FIGURE 1. Location map of the study area

TABLE 1. Thickness of permeable, semi-permeable and impermeable layers in STWs

Well No.	Location	Depth of well drilled* (m)	Thickness of (m)			% of permeable materials
			Permeable layer	Impermeable layer	Semi permeable layer	
DG/STW-6	Dundre	37.5	18.3	9.4	9.7	48.8
Saibahani	Ghorahi	29.0	15.5	8.0	5.6	53.4
NISP/INV/STW-7	Ammapur	36.0	13.0	22.0	1.0	36.1
DG/STW-7	Ammapur	20.1	14.6	4.6	0.9	72.8

**GWRDB (1996)*

TABLE 2. Thickness of permeable, semi-permeable and impermeable layers in DTWs

Well No.	Depth of well drilled* (m)	Thickness of (m)			% of permeable materials
		Perme-able layer	Imperme-able layer	Semi-permeable layer	
DG/DTW-2	68.9	41.4	11.9	15.6	60.1
NISP/INV/DTW-3	106.1	45.5	49.3	11.2	42.6
DG/DTW-27	111.2	58.2	41.0	12.0	52.3
TG-5	107.0	49.0	6.5	52.0	45.8
TG-2	105.0	18.5	7.0	79.5	17.6
DG/DTW-29	113.5	63.5	29.5	20.5	55.9
DG/DTW-5	140.2	84.7	43.9	11.6	60.4
DG/DTW-7	111.2	76.0	18.0	17.2	67.7
DG/DTW-9	80.2	38.7	27.1	14.3	48.3
DG/DTW-6	70.1	54.9	-	15.2	78.2
DG/DTW-1	149.3	64.6	-	71.3	43.3
DG/DTW-21	74.4	49.9	18.9	5.6	67.1

**GWRDB (1996)*

TABLE 3. Dugwell inventory preparation data of study area

Well No.	Location	Well depth (m bgl)	Post monsoon water level depth (m asl)	Monsoon water level depth (m asl)	Water level fluctuation (m)
DW 1	Mangari	16.0	612.7	513.2	0.5
DW 4	Aspara	6.0	592.4	596.0	3.6
DW 8	Dhikpur	6.0	585.3	587.8	2.5
DW 9	Dangigaun	10.0	583.4	587.5	3.5
DW 10	Duruwa	10.0	581.0	584.0	3.0
DW 14	Duruwa	9.0	582.7	586.9	4.2
DW 15	Manoharpur	10.0	582.6	584.8	2.2
DW 17	Bankatta	8.0	610.7	613.9	3.2
DW 19	Lalpur	8.0	619.5	621.9	2.4
DW 21	Bhituria	13.0	593.6	594.2	0.6
DW 23	Malawar	7.0	581.6	584.5	2.9
DW 25	Karanga	9.0	569.4	573.9	5.5
DW 26	Sajnewar	8.0	607.6	608.5	0.9
DW 30	Hemnagar	7.0	581.8	584.9	2.7

Source: GWRDB (1996); m bgl: meters below ground level, m asl: meters above sea level

clay layers present in the aquifer differ in percentage of the permeable material. Thus, wells with more cumulative thickness of the aquifer tapped zone give more transmissivity.

Groundwater recharge

In the study area, the aquifers are mainly recharged by rainwater infiltration. In addition, parallel streams flowing across the valley assist in recharging the valley. Since the northern fringe of the valley consists of coarse materials (gravels and boulders), major recharge occurs in this zone.

Safe yield

The storage co-efficient is much lower in confined aquifers because they are not drained during pumping. Any water released from storage is obtained primarily by compression of the aquifer and expansion of the water when pumped. Thus, assuming the higher value for the aquifer in the study area, which is 10^{-3} (Driscoll 1987),

Safe yield = area of aquifer × storage coefficient × mean piezometric surface fluctuation

$$= \sim 24 \times 10^{8}\ m^2 \times 10^{-3} \times 13.2\ m/\text{year}^*$$

$$= \sim 3.16 \times 10^{7}\ m^3/\text{year}$$

*mean piezometric surface fluctuation = 13.2 m/ year (Piya 1993)

Groundwater draft

In the valley groundwater is extracted through dugwells, deep tubewells and shallow tubewells. The requirement for drinking and domestic use per person per day as per WHO (1984) standard is 45 l (0.045 m^3). The estimated population of Dang valley in 1995 was 411149 (CBS 1996). Therefore the total amount of groundwater draft by that population is 411,149 × 45 l/day = 18,501,705 l/day.

For livestock, total draft of groundwater as estimated by WHO (1984) is 1/10 of population demand. This is equal to 1,850,171 l/day. Total groundwater draft for domestic purposes comes to be 20351876 l/day, or 7.43 x 10^{6} m^3 / year. This is about 48.7% of the groundwater storage.

Thus, the annual draft for domestic use is less than safe yield, or in other words, the recharge rate is much higher than the draft. Therefore, with proper planning and management, extensive well development can be carried out in the valley in the future. However, irrigation of maximum land surface can ➔

TABLE 4. Hydrogeological characteristics of deep and shallow aquifers

Well No.	Water level (m asl)	Depth of well (m)	Total cumulative thickness of aquifer (m)	Piezometric surface (m bgl)	Discharge/ maximum yield (m^2/day)	Transmissivity (m^2/day)	Hydraulic conductivity (m/day)
DG/DTW-6	632.0	70.1	9.18	15.8	1483.5	3394.0	369.7
TG-5	608.0	107.0	30.0	21.0	691.2	632.5	21.1
DG/DTW-9	633.0	113.5	37.2	6.0	-	-	-
DG/DTW-21	618.0	74.4	16.5	37.5	-	-	-
DG/DTW-7	580.0	111.2	21.4	-	630.0	-	-
DG/DTW-3	583.0	106.1	-	11.0	-	-	-
DG/STW-7	638.0	20.1	7.1	3.2	950.4	3477.5	-
DG/DTW-5	610.0	140.0	22.0	9.2	167.1	101.9	4.6
NISP/STW-7	636.0	36.0	6.1	0.7	661.8	712.5	117.3
DG/STW-6	580.0	37.5	6.1	5.0	1987.2	-	-
DG/DTW-27	586.0	111.2	33.9	5.1	2592.0	3953.0	116.4
DG/DTW-1	619.0	149.4	11.0	15.2	194.4	14.2	1.3
DG/DTW-2	641.0	68.9	11.1	23.7	-	-	-
Saibahini	666.0	29.0	-	-	0.1	-	-
TG-2	604.0	105.0	30.4	28.9	1036.2	2709.3	89.1

Source: GWRDB (1996); m asl : meters above sea level; m bgl: meters below ground level

be achieved through combined use of both the surface water and groundwater. ■

References

CBS. 1996. *Statistical pocket book*. Kathmandu: Central Bureau of Stastics, HMGN. 301 p

Driscoll FG. 1987. *Groundwater and wells*, 2nd ed. St. Paul (Minnesota): Johnson Filtration System Inc. 5512. 1089 p

GWRDB. 1996. *A compilation of tube-well inventory data of Dang valley, mid-western Nepal*. Kathmandu: Groundwater Resource Development Board. 52 p

Piya B. 1993. *Hydrogeological studies in parts of Dang valley, western Nepal* [thesis]. Kathmandu: Central Department of Geology, Tribhuvan University. 120 p

Uprety SR and J Karanjac. 1989. Shallow well drilling, testing and monitoring in 1987/88: Basic documentation and preliminary interpretation, Dang valley. Technical report no 8. Kathmandu: UNDP and HMGN. 19+ 38 p

WHO. 1984. *Guidelines for drinking water quality*, Vol 1. Geneva: World Health Organization

Yamanaka H and H Yagi. 1984. Geomorphological development of the Dang dun. *J Nep Geol Soc* **4**: 151-9

Acknowledgements

I am grateful to Megh R Dhital, Central Department of Geology, TU, for supervising this study, and to Madhav Belbase, GWRDB, Lamahi, for providing materials and allowing the field observation of the running tube wells.

Silica gel chromatographic study of phenolic compounds in some cultivated cucurbits

Suresh N Baitha* and Vijoy S Pandey

Botany Department, Mahanth Sheo Shankar Giri College, Baba Sahab Bhim Rao Ambedkar Bihar University, Muzaffarpur, Areraj 845411, India

** To whom correspondence should be addressed. E-mail: snbaitha2000@yahoo.co.in*

Phenolic compounds in the leaves of cultivated cucurbits viz. *Trichosanthes dioica* Roxb., *Lagenaria siceraria* (Molina) Standl., *Luffa cylindrica* (L.) Roem., and *Luffa acutangula* (L.) Roxb. were carried out through silica gel chromatographic separation to ascertain their relative phylogenetic position. On phytochemical analysis, paired affinity, group affinity and isolation value supported the inclusion of these species in the same tribe Cucurbiteae on the basis of earlier cytotaxonomic studies. The two species of *Luffa* showed the closest phytochemical affinity and occupied as intermediate position between *Lagenaria* and *Trichosanthes*. *Luffa* was distantly related to other two genera having paired affinity values of less than 50%.

Key words: Silica gel chromatography, separation of phenolic compounds, cultivated cucurbits

Him J Sci **1**(2): 123-125
URL: www.himjsci.com/issue2/cucurbits

Received: 21 Nov 2002
Accepted after revision: 20 June 2003

Introduction

The secondary metabolites such as alkaloids, terpenes and phenolics including flavonoids can be employed to study phylogenetic affinitiy in many plant genera. The thin layer chromatography was employed successfully for the separation of phenolic compounds in a number of genera like *Secale* (Frost 1966, Dedio et al. 1969), *Aegilops* (Kaltsikes and Dedio 1970), *Hordeum* and *Triticum* (Frost and Holm 1973), Cucumerineae (Das et al. 1974) etc. for substantiating earlier conclusions drawn on the status of their taxa on the basis of cytogenetic evidence. Among the earlier reports of chemosystematics in the Cucurbitaceae, Enslin and Rehm (1958) used the distribution of cucurbitacins as an index in the taxonomy of the Cucurbitaceae. On the basis of distribution of phenolics, Das et al. (1974) concluded that *Citrullus vulgaris* had closer relationship with *Lagenaria* than *Citrullus vulgaris* var *fistulosus* and suggested the possible evolution of *Citrullus vulgaris* from *Lagenaria* or vice-versa. They also showed the close relationship between *Lagenaria* and *Luffa*.

The present investigation on the distribution of phenolics was carried out in four morphologically related species of cucurbits to examine their relative phyletic distance as evidenced from their biochemical picture.

Materials and methods

Four species of cucurbits viz. *Trichosanthes dioica* Roxb., *Lagenaria siceraria* (Molina) Standl., *Luffa cylindrica* (L.) Roxb. and *Luffa acutangula* (L.) Roxb. were studied in the present investigation. The leaves from the apical portion of all the species of same age were collected for biochemical assay. The leaves were first washed thoroughly in running tap water and dried at 40°C in an oven for 24 hrs. The leaves were crushed and kept in a 50% solution of pertoleum ether (BP 40-60° C) and aqueous methanol for 24 hrs in order to get phenolic extracts. Each extract, on evaporation under vacuum pump, yields a sticky residue.

A chromatographic plate was prepared with silica gel. 0.1 ml aqueous methanolic extract was applied at the starting point of the plate. It was then dipped in the solvent TCA (toluene-chloroform-acetone) and allowed to develop chromatogram. The chromatogram was first treated with ammonia vapour, then with iodine vapour and finally with 1% lead acetate as recommended by Block et al. (1953) to distinguish the spots. Ammonia vapour gave distinct colour under visible and UV light in case of some phenolic spots. The spots of other phenolic compounds became apparent after treatment with iodine vapour and lead acetate. The visible spots were traced on a transparent paper. The RF (relative distance) of each spot was used as a basis for comparison and specification of various phenolic compounds obtained. On the basis of colour and position, spots assumed to be indentical in two or more species were assigned the same number. The chromatographic results were subjected to numerical taxonomic treatment as an aid to establish phenolic relationship in the different species of the family Cucurbitaceae.

Analysis of phytochemical data

The method adopted by Ellison et al. (1962) was followed to make the suitable comparisons in the form of qualitative relationships. Species were compared on the basis of their biochemical affinityies.

Values of paired affinity (PA), group affinity (GA) and isolation value (IV) were calculated as follows:

$$PA = \frac{\text{Spots common in species A and B}}{\text{Total spots in A and B}} \times 100$$

$$GA = \text{Total PA value} + 100$$

$$IV = \frac{\text{Number of unique spots in a species}}{\text{Total number of spots in all species}} \times 100$$

Results

The total number of spots obtained in all the species was 20, out of which eight were found in *T. dioica,* nine in *L. siceraria,* eight in *L.* ➧

cylindrica and nine in *L. acutangula* **(Figure 1)**. From the observation of the composite chromatogram it was distinct that *L. cylindrica* and *L. acutangula* had six spots in common. A relative distribution of all the spots has been shown in **Table 1**.

The PA value calculated on the basis of presence and absence of the phenolics is shown in **Table 2**. The highest PA value 70.68% was observed between *L. cylindrica* and *L. acutangula*. The lowest PA value (25%) was found between *L. cylindrica* and *L. siceraria*. The PA value between *T. dioica* and *L. siceraria* was 35.29%. These values showed that two species of *Luffa* were closely related but showed a distant relationship with both *T. dioica* and *L. siceraria*. Above observations showed the intermediate position of *Luffa* species between *L. siceraria* and *T. dioica*.

Group affinity values also showed the close relationship between *L. cylindrica* (230.57) and *L. acutangula* (230.31). The *Luffa* species were also related to *L. siceraria* (215.02) on one hand and *T. dioica* (195.58) on the other **(Table 3)**.

The isolation value was found to be 20% each in *T. dioica* and *L. siceraria* while for *L. cylindrica* and *L. acutangula* it was just half i.e. 10% **(Table 3)**.

Discussion

Although phenolics are considered to be metabolically inert, they are present in the cell wall of plants in considerable amounts and are stable and characteristic end products (Bate-Smith 1958). In the present investigation a number of phenolic compounds were spotted but they were not identified qualitatively. Chromatographic spots are regarded as excellent markers and are much more important than the chromosome numbers in taxonomy of plants (Grant 1968).

In the present study spot no 4 was present in all the species and appeared to be the characteristic spot for all the 4 species. Spot no 20 was found in three species viz. *L. siceraria, L. cylindrica* and *L. acutangula*. Its absence in *T. dioica* indicated that in comparison to *T. dioica, L. siceraria* was closer to the *Luffa* spp.

Higher PA value was considered as an indication of close affinity between different species. PA value of 50% and above was considered as a marker of close relationship. In this regard, the two species of *Luffa* (with PA value of 70.58%) were most closely related and appeared distantly related with *Lagenaria* and *Trichosanthes* conforming the conclusions drawn from cytotaxonomy.

The PA value was supported by the GA value, on the basis of which it could be said that *T. dioica* was distantly related to the other species; *L. cylandrica* and *L. acutangula* were very close and showed some closeness to *Lagenaria siceraria*.

According to Ayyangar (1967), on the basis of a number of criteria like chromosome number, chromosome morphology, meiotic behaviour, secondary association, satellites, nucleoli, chiasma statistics, developmental morphology, amino acid assay, geographical distribution pattern

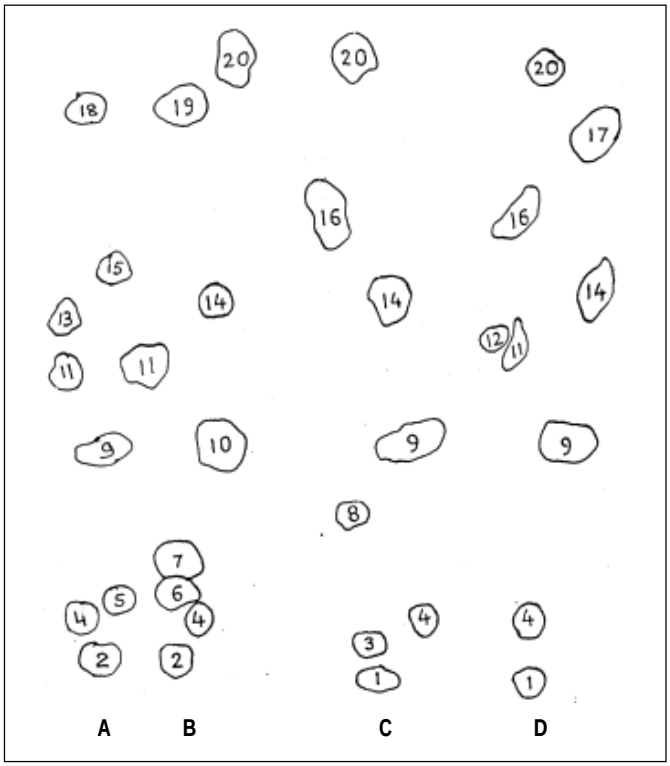


FIGURE 1. A composite chromatogram showing distribution of phenolic compound in
A - *Trichosanthes dioica* B - *Lagenaria siceraria*
C - *Luffa cylindrica* D - *Luffa acutangula*

TABLE 1. Thin layer chromatographic separation of phenolics in four cucurbits revealing colour of spots, their RF values and concentration

SN	Colour	RF values T/C/A	*Tricosanthes dioica*	*Lagenaria ciceraria*	*Luffa cylindrica*	*Luffa acutangula*
1	Bl (c)	0.032	-	-	++	++
2	Ye (c)	0.054	+	+	-	-
3	Ye (c)	0.075	-	-	+	-
4	Bl (c)	0.108	+++	+	++	++
5	Vi (b)	0.118	++	-	-	-
6	Gr (c)	0.140	-	+	-	-
7	Or (a)	0.182	-	+	-	-
8	Bl (c)	0.254	-	-	+	-
9	Vi (b)	0.351	+	-	+	+
10	Or (a)	0.356	-	+	-	-
11	Ye (c)	0.464	++	+	-	+
12	Ye (c)	0.491	-	-	-	+
13	Bl (c)	0.497	+	-	-	-
14	Ye (c)	0.545	-	++	+++	++
15	Or (c)	0.556	+	-	-	-
16	Or (a)	0.659	-	-	+	+
17	Vi (b)	0.767	-	-	-	+
18	Ye (c)	0.778	+	-	-	-
19	Or (a)	0.806	-	+	-	-
20	Vi (b)	0.875	-	+	++	++

Colour of the spots: *Bl: Blue, Or: Orange, Gr: Green, Vi: Violet, Ye: Yellow*
Reagents used: *a: ammonia, b: iodine, c: 1% lead acetate*
Concentration of the spots: *+++ more intense, ++ less intense, + trace, - absent*

in conjuction with conventional morphological characters a system is proposed in which *Trichosanthes*, *Luffa* and *Lagenaria* were placed in the same tribe Cucurbiteae and were closely related, with *Luffa* occupying intermediate position between *Trichosanthes* on one hand and *Lagenaria* on the other. The distribution of phenolic compounds as reveled in the present study also supports the classification and phylogeny suggested by Ayyangar (1967).

It has been mentioned by Griesbach (1972) that the presence and concentration of given substance depend on the physiological growth condition of a plant and on its stage of the development. It was found that the same chromatographic patterns of the flavonoids from the leaves of one and the same plant varied with age and environment (Harborne1967, Armstrong 1968, Parks et al. 1972). Therefore, the most suitable leaves for the study of phenolic compounds were considered the apical leaves obtained from the plants of same age. ■

TABLE 2. Paired affinity value (PA) of different species

	Tricosanthes dioica	*Lagenaria siceraria*	*Luffa cylindrica*
Lagenaria siceraria	35.29%		
Luffa cylindrica	25%	35.29%	
Luffa acutangula	35.29%	44.44%	70. 58%

TABLE 3. Group affinity, number of unique spots and isolation value of phenolic compounds in cucurbits

Species	**GA**	**No of unique spots**	**Isolation value (%)**
Tricosanthes dioica	195.58	4	20
Lagenaria siceraria	215.02	4	20
Luffa cylindrica	230.57	2	10
Luffa acutangula	250.31	2	10

References

Armstrong SM. 1968. Effect of potassium, magnesium and nitrogen deficiencies on the chlorogenic acid in tobacco [abstract]. *Diss Abstr*. Abstract no 2311B. p 29

Ayyangar KR. 1967. Taxonomy of Cucurbitaceae. *Bull Natl Inst Sci Ind* **34**: 380-96

Bate-Smith EC. 1958. Plant phenolics as taxonomic guide. *Proc Linn Soc Lond* **169**(3): 198-210

Block RJ, EL Durram and G Zoreig. 1958. *A manual of paper chromatography and paper electrophoresis*, 2nd ed. New York: Academic press. 710 p

Das HC, GS Randawa and M Kaur. 1974. Phylogenetic studies in Cucumerinae by leaf phenolics. *The Nucleus* **XVII**(II): 103-8

Dedio W, PS Kaltsikes and EN Larter. 1969. A thin layer chromatographic study of the phenols in *Triticale* and its parents. *Can J Bot* **47**: 1589

Ellison WL, RE Alston and BL Turner. 1962. Methods of presentation of crude biochemical data for systematic purposes with particular reference to the genus *Bahia* (Compositae). *Am J Bot* **49**: 599-604

Enslin PR and S Rehm. 1958. The distribution and biogenesis of the cucurbitacins in relation to taxonomy of the Cucurbitaceae. *Proc Linn Soc Lond* **169**(3): 230-8

Frost S and G Holm. 1973. Thin layer chromatographic studies of phenolic compounds in twenty varieties of barley. *Hereditas* **74**(2): 304

Frost S. 1966. Variation of phenolic compounds in different inbred lines of rye. *Hereditas* **55**: 68-72

Grant WF. 1968. Botanical editors and biochemical systematics. *Chem Taxon* **17**: 159-60

Griesbach H. 1972. Comparative biosynthetic pathways in higher plants. *Chem Taxon Newslett* **186**

Harborne JB. 1967. *Comparative biochemistry of the flavenoids*. New York: Academic Press. 383 p

Kaltsikes PJ and W Dedio. 1970. A thin layer chromatographic study of the phenolics of the genus *Aegilops* I: Numerical taxonomy of the diploid species. *Can J Bot* **43**(10): 1775-80

Parks CR, SS Sandhu and KR Montogometry. 1972. Floral pigmentation studies in the genus *Gossypium* IV: Effects of different growing environments on flavonoid pigmentation. *Am J Bot* **58**: 158-64

Quercus semecarpifolia Sm. in the Himalayan region: Ecology, exploitation and threats

Bharat B Shrestha*

Central Department of Botany, Tribhuvan University, Kathmandu, Nepal

***** *For correspondence, E-mail: bhabashre@yahoo.com*

Oaks (*Quercus* spp.) are among the dominant vascular plants of the Himalayas, ranging from the subtropical to the sub-alpine zones. They play an important role in maintaining ecosystem stability. Oaks in the Himalayan region are intimately linked with subsistence hill agriculture as they protect soil fertility, watershed and local biodiversity. They also supply fodder, leaf litter, firewood and timber. *Q. semecarpifolia* is a high altitude oak, ranging up to the timberline in the Himalayan region and forming the climax community on the southern aspect; it is considered to be one of the oldest plants of the region. It is also one of the most over-exploited species and fails to regenerate adequately either in disturbed or undisturbed natural habitat. Since plantation has not been successful, it is important to manage natural forest more effectively. This can be done by implementing sustainable methods of lopping the trees for fodder, removing an adequate number of old and dying trees to make the canopy more open, and controlling the population of cattle and wild animals that damage seedlings through browsing and trampling.

Key words: Himalayan region, oak, *Q. semecarpifolia*, khasru, regeneration of *Quercus*

Him J Sci **1**(2): 126-128
URL: www.himjsci.com/issue2/quercus

Received: 24 Apr 2003
Accepted after revision: 20 June 2003

Oaks in general

Oak (*Quercus*), a genus under the family Fagaceae, is a large group of hardwood trees with about 600 species. Oaks are found in the northern temperate zone, subtropical and tropical Asia, and the Andes of South America. Oaks dominate many forest landscapes and are intimately linked with a large number of other organisms, ranging from fungi to ferns, birds to bears, and wasps to ants. Human beings have always had a strong connection with oak. Throughout history the oak has been a symbol of permanence, strength, and courage (Keator and Bazel 1998).

Himalayan oaks are evergreen, mostly gregarious, medium- to large-sized tree, distributed at elevations of 800 to 3800 m asl throughout the Himalayan region. There are more than 35 species reported from this region (Negi and Naithani 1995), most of which are abundant in temperate forest. Eight species occur in Nepal (DPR 1997): *Q. floribunda* Lindl., *Q. glauca* Thunb., *Q. lamellosa* Sm., *Q. lanata* Sm., *Q. leuchotrichophora* A. Camus, *Q. mespilifolioides* A. Camus, *Q. oxyodon* Miq. and *Q. semecarpifolia* Sm.

The economical and ecological values of oak are generally higher than those of other species associated with oak. It is closely linked with hill agriculture as an important source of fodder for animals, litter for making compost, fire wood and timber. Oaks dominate the canopy in many temperate forests of the Himalayan region. In comparison to other forests such as pine, oak forests are characterized by higher species diversity, stratification, litter production and soil fertility. The bark of mature trees supports a luxurious growth of non-vascular as well as vascular epiphytes. Many oaks are keystone species without which the complex web of the ecosystem would soon unravel. Oaks also promote the recharge of mountain springs (Valdia 1998).

Unfortunately, the regenerative capability of this important forest element is poor not only in the Himalayan region but also in North America (Lorimer et al. 1994) and Europe (Andersson 1991). Some reasons that have been suggested to explain the poor regeneration of oak forest are erratic seed production, defoliation, acorn herbivory, browsing damage to seedlings, forest fire, extensive lopping, accumulation of thick litter with slow decomposition rate, infestation by stem parasites such as mistletoe, and leaf damage by insect pests. These factors, concatenated, interfere with the natural regeneration of oak forest.

Biology of *Q. semecarpifolia*

Distribution

Q. semecarpifolia (local name khasru) is an element of central Himalayan vegetation, which has occurred in this region for millions of years. Steppe formed after the final uplift of the Himalayas was invaded by this species and oak became the dominant element of then sub-alpine and alpine forest (Singh and Singh 1992). At present it is a dominant species in the Himalayas, from southwest China to Afghanistan, at elevations of 2100 to 3800 m asl. It occurs in moist temperate and sub-alpine regions with heavy snowfall and moderate rainfall, and is absent from the dry regions of the inner Himalayas (Negi and Naithani 1995).

Community structure

Khasru is a gregarious species forming pure forest stands. Its forest is one of the oldest vegetation types of the Himalayan region and a climax community, especially on the southern aspect (Negi and Naithani 1995). Disturbances such as lopping, felling, grazing and fire in most cases result in the development of mixed conifer-oak forest, which represents a seral stage of secondary succession. Major species associated with Khasru in mixed forests are *Q. floribunda, Q. lanata, Q. leucotrichophora, Abies pindrew, Rhododendron*

arboreum, *Picea smithiana*, *Cotoneaster acuminata*, *Viburnum mullaha*, *Betula utilis*, etc.

Morphology

In natural forest, khasru grows up to 35 m; the lower two-thirds are clear bole without branches. Coppicing results in luxuriant growth. Tree trunks and branches are usually densely covered with epiphytic plants, including ferns and orchids. The leaves are coriaceous, elliptical to oblong, with sub-cordate to rounded base, and veins forked near the margin; they are glossy green above, generally with rust coloured hairs beneath, but old leaves are almost hairless. The leaves of saplings and coppice shoots have spines on the margin but those of older branches of trees have smooth margins. Male spikes are pendulous and occur in fascicles. Involucral scales are free and imbricate, and the acorns are globular, developing in clusters of three. Seeds are among the largest in the oak family, weighing 5.0 to 6.5 gm (Jackson 1994).

Phenology

New shoots appear in May and June and leaf fall begins during the same period, but most of the new leaves attain full size before the completion of leaf fall. Sometimes, however, leaf fall is completed before the new shoot emerges, and the tree stands leafless for a brief period. Male and female spikes appear at the same time as new shoots, and pollination takes place in June. The period between the pollination and the ripening of the acorn is about thirteen months. The ripening of the acorn takes place from July to August, and germination takes place immediately after the fruit falls. Phenology, however varies with altitude, aspect and micro-climate. Foliar phenology of Khasru in central Nepal (Shivapuri National Park) is different from the pattern mentioned above. Shrestha and Lekhak (2002) reported completely leafless trees during early September.

Seed germination

Mature seeds fall during the rainy season and are viable for a very short period, while stored seeds cannot germinate. More than 95% of fresh seeds can germinate. Some seeds start germination even before they fall on the ground, i.e. partial vivipary (Negi and Naithani 1995). Germination is hypogeous, and a long tube is formed by the cotyledonary petiole which pushes the radicle (tap root) through the thick layer of litter deep into the soil. The plumule lies safely at the base of the petiolar tube. Seedlings are normally leafless in the first year with buds on the axil of the scale leaf, which enables them to withstand autumn drought and winter cold. Food stored in the large seed is sufficient to allow the early growth of the seedling before green leaves are produced. However, under favorable conditions new leaves are produced in the first season. The growth of the tap root is rapid which ensures early establishment in soil with thick litter cover. Dying back of the seedling is common but does not occur under favorable conditions (Negi and Naithani 1995).

Use and level of exploitation

The economic and ecological benefits of khasru oak are substantial. Khasru foliage is a staple dry season fodder from February to April when other green fodder is not available. The leaves are also suitable for feeding the caterpillars of the silk moth *Antheraea perrnyl*. Litter collected from the forest floor is used for making compost. The bark yields tannins. The wood is fine, strong, durable and attractive, and can be easily shaped, making it useful for furniture and agricultural implements. Large branches and trunk wood are in high demand as firewood; the wood is also readily processed into charcoal of superior quality. The acorn is a favored food of many wild animals including bears, monkeys, squirrels and birds. Unfortunately, it has become one of the most over-exploited tree species of the Himalayan region.

The primary reason for the over-exploitation of khasru oak is the demand for dry season fodder, but large branches with foliage are lopped for firewood as well. In privately owned forests, trees are lopped for fodder once every two years, and sometimes even less often (Mathema 1991). In public forests, however, heavy and indiscriminate lopping continues throughout the year (Shrestha and Paudel 1996). Trees are reduced to naked poles. Flower and seed production are impeded to the point that the forest cannot regenerate itself. Leaf production is slashed to the point that the fodder supply is inadequate. And, to maintain the soil fertility of mountain farmland, more and more litter is collected, which prevents seedling establishment and upsets the nutrient balance of the forest.

The ecological benefits of any forest community cannot be expressed in monetary terms. As a dominant tree species of temperate and sub-alpine forest, khasru provides food for a wide range of fauna. The closed canopy allows the growth of shade-loving ground vegetation. Vascular and non-vascular epiphytic plants grow luxuriantly on the trunks and branches of mature trees. The abundant litter production helps to maintain soil fertility. The distribution of many plant and animal species depends on micro-climatic conditions maintained by khasru. In a climax community it is a keystone species, playing a critical role in environmental balance at both the local and also the regional level.

Due to over-exploitation and an inherently slow growth rate, khasru oak forest is degrading and shrinking in Nepal and the adjoining Himalayan region (for e.g., Mathema 1991, Singh and Singh 1992, Shrestha and Paudel 1996, Metz 1997). Degradation of khasru oak forest reduces the supply of dry season fodder, manure, higher quality firewood and durable timber. Reduced supply of fodder forces the farmers to abandon the practice of animal keeping and ultimately reduces the crop production in the region (Shrestha and Paudel 1996), which has already faced the problem of food security. This will present the farmers with two alternatives: either to abandon cultivation and migrate or to adopt agricultural method based on chemical fertilizer (Mathema 1991). However, hill and mountain agriculture based on chemical fertilizer cannot economically be profitable. The ecological cost of oak forest degradation is perhaps more important and damage is irreversible. The intensity of soil erosion and landslide is increasing and mountain spring recharge is decreasing. Many dependants, including epiphytic plants, ground vegetation and animal may be locally extinct.

Regeneration

Natural regeneration of khasru oak is poor both in disturbed and undisturbed forests. It is failing to regenerate under its own canopy. Lack of regeneration is sometimes attributed to the effect of climate change (Upreti et al. 1984), however there is no long-term data on population dynamics to support this. Healthy and regenerating forests owe their vitality to a continuing sequence of young, mature and old individuals of dominant species. In many undisturbed and little disturbed khasru oak forests, unfortunately, there are large old trees and seedling, but saplings and recruits are absent (Metz 1997); this indicates large-scale death of saplings and small trees before they reach the canopy. Annual, heavy and indiscriminate lopping precludes flowering and seed production for regeneration. Loss of photosynthetic surface as a consequence of repeated lopping not only leads to early senescence but also impairs the ability to coppice (Singh and Singh 1992). A comparative study has shown that trees lopped every year and at the interval of two years did not produce seeds, while trees lopped at the interval of three years or more do produce seeds (Shrestha and Paudel 1996). Litter collection, overgrazing and forest fire indiscriminately damage the seedling and sapling recruits.

Seed germination depends strongly on the quality and ➧

thickness of litter and quality of light. Litter is an important general factor determining the spatial variation in seedling recruitment. Thick litter generally reduces the rates of germination and of seedling establishment. However, herbaceous cover, rather than litter, has an even more adverse effect on seedling emergence, survival and growth (Tripathi and Khan 1990, Dzwonko and Gawronski 2002). Kharsru has an unusual mode of germination, with rapid elongation of a cotyledonary petiolar tube pushing the radicle deep into the soil penetrating the thick layer of litter. Dense growth of weeds such as *Pteracanthus alatus* (Wallich ex Nees) Bremek and *P. urticifolius* (Kuntze) Bremek inhibit the survival of seedlings and saplings; their removal has resulted in the establishment of many khasru oak seedlings at previously unproductive sites (Negi and Naithani 1995). On the other hand, there is no clear relationship between seedling survival and soil variables, indicating that above-ground factors are more important for seedling survival (Vetaas 2000). Khasru is a light demander; seedlings and saplings respond positively to high intensity solar radiation. As a result, saplings form a thicket along the edges of khasru oak forest, but in the interior of dense forest no young plants beyond seedling stage are found (Negi and Naithani 1995).

The problem of inadequate natural regeneration of khasru oak has long been reported (e.g., Singh and Singh 1992, Negi and Naithani 1995, Metz 1997 and Vetaas 2000). Some management attempts, including artificial plantation, have been undertaken in order to induce natural regeneration. The direct sowing of seeds and planting nursery-raised seedlings are both practiced, however the former is widely preferred. Direct sowing has been successfully adopted in various parts of India (Negi and Naithani 1995). Survival of nursery-raised seedlings in plantation is very low, less than 4% in Solukhumbu, Nepal (Stewart 1984). Due to lack of detailed information on seedling establishment and growth behavior of khasru, the problems of poor survival of planted seedlings have remained unsolved (Jackson 1994, Shrestha and Paudel 1996). Metz (1997) hypothesized that khasru is not able to reproduce in individual tree fall gaps, but needs more severe disturbance. Management practices in natural forest, involving thinning of old trees, so as to open the canopy and allow more light to reach the ground, have produced promising results in India (Negi and Naithani 1995, and references therein). However, even the community forestry programmes in Nepal have not developed any management strategies that might induce natural regeneration of khasru and other oaks (Shrestha and Paudel 1996). In some districts of western Nepal (Parbat and Myagdi), facilitated by Lumle Agricultural Research Center (Kaski), local people have adopted sustainable lopping practices. The accessible forest was divided into several blocks and a few blocks were opened each year for fodder lopping on a three-year rotational cycle. Protection of a few mother trees without lopping was recommended (Shrestha and Paudel 1996) to ensure seed production and natural regeneration. These management practices can increase the total fodder production and ensure regeneration.

Khasru in Shivapuri National Park (SNP)

The temperate forest of Shivapuri National Park (1366 to 2732 m asl), lying on the northern hills of Kathmandu valley, is a major source of water supply to the capital. It is dominated by *Q. lanata* at lower elevations and *Q. semecarpifolia* (khasru oak) at higher elevations. Regeneration of khasru is very poor in comparison to *Q. lanata*. A preliminary study showed that khasru forest had only old dying trees and seedlings but no individuals between these two size classes (Shrestha and Lekhak 2002), a clear indication of inadequate regeneration. The forest is mature, with above-ground biomass and basal area cover of 462.14 t/ha and 0.73% respectively at 2600 m (Subedi and Shakya 1988), which is remarkably high for this altitude (Singh and Singh 1992). Khasru density was 217 trees/ha, although it is the most exploited among the oak trees (Siluwal et al. 2001). The forest has been protected for nearly three decades (since 1975) but khasru oak fails to regenerate under its own canopy; mitigation or removal of human induced pressure alone is not sufficient to ensure regeneration of khasru oak forest in Shivapuri National Park. The regeneration is continuous in the nearly undisturbed forest of khasru in Langtang National Park, central Nepal (Vetaas 2000) but such a situation was not observed in SNP (Shrestha and Lekhak 2002) indicating that absolute conservation does not ensure continuous regeneration of this species. The forest shows prominent signs of decline. Abnormal growth and branching (i.e., clusters of thin, profusely branched and slender branches with shorter internodes), increased defoliation and dying back of leader and branch tips, which are frequently observed in the forest, are sure signs of decline (Larcher 1995). ■

References

Andersson C. 1991. Distribution of seedlings and saplings of *Quercus robur* in a grazed deciduous forest. *J Veg Sci* **2**: 279-82

DPR.1997. *Flora of Nepal: Fagaceae*, Vol 1, Part 20. Kathmandu: Department of Plant Resources, Ministry of Forest and Soil Conservation, HMGN. 12 p

Dzwonko Z and S Gawronski. 2002. Influence of litter and weather on seedling recruitment in a mixed oak pine woodland. *Ann Bot* **90**: 245-51

Jackson JK. 1994. *Manual of afforestation in Nepal*, Vol 1and 2. Kathmandu: Forest Research and Survey Center, Ministry of Forest and Soil Conservation, HMGN. 741 p

Keator G and S Bazel. 1998. *The life of an oak: An intimate portrait*. Heyday Books and California Oak Foundation, USA. 256 p

Larcher W. 1995. *Physiological plant ecology*, 3rd ed. Berlin: Springer-Verlag. 448 p

Lorimer CG, W Chapman and WD Labmert. 1994. Tall understory vegetation as a factor in the poor development of oak seedlings beneath mature stand. *J Ecol* **82**: 227-37

Mathema P. 1991. Focus on oak forest. *Banko Janakari* **3**(1): 13-6

Metz JJ. 1997. Vegetation dynamics of several little disturbed temperate forest in east central Nepal. *Mount Res Dev* **17**(4): 333-51

Negi SS and HB Naithani.1995. *Oaks of India, Nepal and Bhutan*. Dehradun: International Book Distributors

Shrestha BB and HD Lekhak. 2002. Vanishing oak: Shivapuri National Park. *The Sunday Post* **10**(294): 5

Shrestha RK and KC Paudel. 1996. Oak forest under threat: An urgent concern for the mountain environment. In: Jha PK, GPS Ghimire, SB Karmacharya, SR Baral and P Lacoul (eds), *Environment and biodiversity: In the context of South Asia*. Kathmandu: ECOS. p 114-9

Siluwal HR, HD Lekhak and PK Jha. 2001. Ecological study of *Quercus* species in the surrounding hills of Kathmandu valley, Nepal. In: Jha PK, GPS Ghimire, SB Karmacharya, SR Baral and P Lacoul (eds), *Environment and biodiversity: In the context of South Asia*. Kathmandu: ECOS. p181-9

Singh JS and SP Singh. 1992. *Forest of Himalaya*. Nainital: Gyanodaya Prakashan. 257 p

Stewart J. 1984. *Community forestry development in Solukhumbu district 1979-1984* [Miscellaneous document no 22]. Kathmandu: Community forestry development project

Subedi MN and PR Shakya. 1988. Above-ground bio-mass and productivity studies of *Quercus semecarpifolia* Sm. forest at Phulchoki in Lalitpur district. In: *Proceedings of the First National Conference on Science and Technology*. Kathmandu: RONAST. p 381-5

Tripathi RS and ML Khan. 1990. Effects of seed weight and micro-site characteristics on seed germination and seedling fitness in two species of *Quercus* in a subtropical wet hill forest. *OIKOS* **57**: 289-96

Upreti N, JC Tiwari and SP Singh. 1985. The oak forest of Kumaun Himalaya (India): Composition, diversity and regeneration. *Mount Res Dev* **5**(2): 163-74

Valdia KS. 1998. *Dynamic Himalaya*. Haidarabad: University Press Ltd. 178 p

Vetaas OR. 2000. The effects of environmental factors on regeneration of *Quercus semecarpifolia* Sm. in central Himalaya, Nepal. *Plant Ecol* **146:** 137-44

Invasive alien plants and *Eupatorium*: Biodiversity and livelihood

Ripu M Kunwar*

Society for Economic and Environmental Development (SEED), Kathmandu, Nepal

* *For correspondence, E-mail: ripu@wlink.com.np*

Invasive alien species colonize aggressively, threatening native biodiversity. The success of invasive alien plants is due to their opportunistic exploitation of anthropogenic disturbances, the absence of natural enemies, and, frequently, their allelopathic competitive strategies. Invasive species can have a significant impact on development, affecting sustainability of livelihood, food security and essential ecosystem services and dynamics. *Eupatorium adenophorum* Spreng. and *E. odoratum* L. (forest killer, local name banmara) are unpalatable and highly competitive. They have taken hold in scattered sites throughout eastern and central Nepal, currently, they are also rapidly spreading westward. Efforts are being made to control established invasive species, but a better understanding of why species become invasive offers the possibility of taking pre-emptive measures.

Key words: Invasive alien plant species, *Eupatorium*, biological control, livelihood

Him J Sci **1**(2): 129-133
URL: www.himjsci.com/issue2/alienspecies

Received: 6 Apr 2003
Accepted after revision: 27 July 2003

Introduction

All of the threats to Nepal's biodiversity are due to the activities of human beings: habitat destruction and over-exploitation are accompanied by introduction of exotic species leading to habitat change and soil degradation (Chaudhary 1998). The wide range of habitats and environmental conditions makes Nepal especially vulnerable to the establishment of invasive species of foreign origin. Potential invasive alien species from most areas of the world may find suitable habitat somewhere in Nepal. In recent years invasive species have gained considerable notoriety as major threats to native species and ecosystem.

Introduction of plants from one place to another may be natural or planned. Accidental and intentional introduction by gardeners, traders and foresters have contributed to the large number of exotic plants in Nepal. Nepal has a long history of introduction of non-native species, especially species proven to be productive elsewhere and offering potential economic benefits to the country. *Tamarindus indica* (tamarind), originally from Africa, is believed to have been first introduced into Turkey in 126 B.C.-220 A.D. (Yan et al. 2001), spreading gradually toward China along the 'Silk Road'; by now it has been thoroughly naturalized in Nepal. In the 19th century, the British were major contributors, bringing economically important plants from almost every continent (Islam 1991). Some of the alien tree species, such as *Tectona grandis* (teak) and *Albizia* spp. (siris), were introduced for their timber potential or for watershed protection. Some now-common fruit trees, including *Litchi chinensis* (litchi), *Ananas comosus* (pineapple), and *Cocos nucifera* (coconut), were also introduced, as were most of the pulses and oil yielding plants (Das 1982). Similarly, vegetables such as *Cucurbita* spp. (cucurbits), *Raphnus sativus* (radish), *Solanum tuberosum* (potato) and *Daucus carota* (carrot), came from other countries and have been welcomed by Nepalese farmers. Likewise, *Eupatorium odoratum, E. adenophorum, Lantana camara* and *Eichhornia crassipes* were first introduced as ornamental plants and they are now well established and dominant in forest, farmland, wetland and wasteland.

In the 20th century, the country's economic development including growth in trade and transportation systems multiplied the avenues of introduction and spread of invasive species. Newcomers such as *Leucaena leucocephala* (ipil ipil), *Eucalyptus camaldulensis* (masala), *Acacia auriculoformis* (watal), *Cassia occidentalis* (chakor) and *Samania saman*, are becoming plantation favorites. In the hills and even in the Terai, fields are sown with the woody legume species *L. leucocephala* in order to rehabilitate soils left bare by intensive deforestation. In recent decades, however, there has been a growing awareness of the significant impact of such transformations of indigenous ecosystems.

Biological invasion worldwide threatens biodiversity, ecosystem dynamics, resource availability, national economy and human health (Ricciardi et al. 2000). It is a pervasive and costly environmental problem (Larson et al. 2001). Over the past half century it has become the focus of intense management and research activities worldwide (Kennedy et al. 2002). The Convention on Biological Diversity (CBD), to which Nepal and 177 other countries are party, calls on governments to prevent the introduction, control or eradication of those alien species that threaten ecosystems, habitats or species (Article 8). However, approaches taken to combat this phenomenon and even the data on which they should be based are clearly inadequate to deal with the onslaught of invasive species in Nepal. Participatory biodiversity conservation programme and an inventory of alien species are being run by International Union for Nature Conservation Nepal (IUCN/Nepal). However, accurate predictions of community susceptibility to invasion remain elusive. No story of the ecosystem of Nepal will be complete or comprehensive without taking into account the role played by the well-established *Eupatorium* species (local name banmara, or "forest killer"). This study is an attempt to ➧

BOX 1. Recommended terminology in plant invasion ecology

Native plants	Plant species or subspecies or lower taxa, occurring within their natural range (past or present) and dispersal potential (i.e. within the range they occupy naturally or could occupy without direct or indirect introduction by humans)
Alien plants	Plant taxa in a given area whose presence there is due to intentional or accidental introduction as a result of human activity (Syn.: exotic plants, non-native, non-indigenous plants)
Casual alien plants	Alien plants that may flourish and even reproduce occasionally in an area, but which do not form self-replacing populations and which rely on repeated introduction for their persistence
Naturalized plants	Alien plants that reproduce consistently (casual alien plants) and sustain populations over many life cycles without direct intervention by humans. They often recruit offspring freely, usually close to adult plants, and do not necessarily invade natural or human-made ecosystems
Invasive plants	Naturalized plants that produce reproductive offspring, often in very large numbers, at considerable distances from parent plants (approximate scales: > 100 m; < 50 years for taxa spreading by seeds and other propagules; >6 m/3 years for taxa spreading by roots, rhizomes, stolons, or creeping stems), and thus have the potential to spread over a considerable area
Invasive alien plants	Plants become established in natural or seminatural ecosystems or habitats and are agents of change, threatening native biological diversity
Weeds	Plants (not necessarily alien) that grow in sites where they are not wanted and which usually have detectable economic or environmental effects. Environmental weeds are alien plant taxa that invade natural vegetation, usually adversely affecting native biodiversity

Sources: De Candolle (1855), Humphries et al. (1991), Randall (1997), Richardson (1998), IUCN/SSC (2000), Richardson et al. (2000)

review available information on invasive species and to recommend solutions.

Invasive species

The term 'invasive species' denotes plants and animals that: (i) have been introduced into ecosystems where they are not native by either intentional or unintentional human activity, (ii) have established self-reproducing populations, and (iii) have caused significant changes in pre-existing natural or artificial ecosystems (Richardson 1998) **(Box 1)**.

Eupatorium species have a remarkable range of altitudinal distribution (800 to 2000 m asl) in Nepal (Sharma and KC 1977), which overlaps with human settlements (Shrestha 1989). It has been sporadically spreading and now it is reported from 305 to 2500 m in abandoned slopes after slash and burn cultivation (Joshi 1983), fallow lands and disturbed forests with severe human interference. It is represented by six species in Nepal (Press et al. 2000) viz. *E. acuminatum, E. adenophorum, E. cannabinum, E. capillifolium, E. chinense* and *E. odoratum* out of which two (*E. adenophorum* and *E. odoratum*) are highly undesirable (Singh 1979). *E. odoratum* and *E. adenophorum* are aggressively colonizing abandoned slopes in the tropical to lower temperate zones, respectively (NBLP 2001). *E. adenophorum* was introduced in India after 1498 (Biswas 1934) and it is likely that it was introduced into Nepal from India through eastern border (Banerji 1958) probably before 1950. It is now widespread in eastern and central part of Nepal.

Mode of invasion

Biological invasion is a natural process. Nevertheless, the growing human population and improved worldwide transport have led to a skyrocketing incidence and scale of invasions by non-indigenous species (Ewel et al. 1999). Their introduction relies on mutualism in their new habitats to overcome barriers to establishment and naturalization (Richardson et al. 2000). Parasitism is significantly reduced in organisms in the introduced range, a fact that supports the 'enemy release hypothesis' (ERH) - the idea that species are more likely to become invasive when they are released from control by their natural enemies (Torchin et al. 2003). The biotic resistance hypothesis (BRH) argues that diverse communities are highly competitive and readily resist invasion because interactions with native species, including natural enemies, limit invaders' impacts (Darwin 1859, Maron and Vila 2001). As a result, deep forest, which is less diverse than the forest margin, is vulnerable to ecological invasion (Pimm 1984). Distribution of invasive plants directly correlates with human disturbances, which can be easily seen in forest fringe areas. In general, increasing the frequency, intensity, spatial patterns, or scale of disturbances will likely lead to faster replacement of native species by exotic species (Yan et al. 2001). Massive invasion and spread is also typically allelopathic (Rai and Tripathi 1982, Chettri 1986).

Intentional introduction has been performed by various institutions for economic development, recreation uses, ecosystem betterment, highway beautification and creation of wildlife habitat. It may also take place due to import without quarantine of biological inputs, seeds and saplings, implements and fertilizers from foreign countries. Plants introduced for commercial and ecological purposes include *Eucalyptus* species, *Grevillea robusta* and *Leucaena leucocephala*. Some of the most invasive and widespread unintentional introductions include the *Amaranthus* spp. (amaranth), *Solidago* spp. (gold enrod), *Eupatorium* spp. (crofton weed), *Lantana camara*, and *Cestrum* spp. **(Table 1)**.

Impacts: boon or bane?

Introductions of non-native species can be both boon and bane to society. The relative magnitudes of costs and benefits vary both in space and over time. Although an introduction may meet a desired objective in one area, at one time, or for some sectors, unwanted and unplanned effects may also occur.

Socio-economic impacts

Humans depend heavily on non-native species for food, shelter, medicine, ecosystem services, aesthetic enjoyment and cultural identity. Intentionally introduced plants have priority over native species with respect to household economy and national economy. Only nine crops (wheat, maize, rice, potato, barley, cassava, soybean, sugarcane, and oats) which are cultivated far beyond their natural range yield over 70% of the world's food (Sattaur 1989). Similarly, 85% of our industrial forestry plantations are established with species of just three genera (*Eucalyptus, Pinus* and *Tectona*), which are

TABLE 1. Some alien species, which have detrimental impacts on ecosystems

Scientific Name	Origin	Impact on the ecosystem
Ageratum conyzoides (Asteraceae)	Mexico	Weed frequently encountered on cultivated land and wasteland
Amaranthus spp. (Asteraceae)	N. America	Invasive, widely distributed weeds
Cassia occidentalis (Fabaceae)	Trop. America	Common weed of hilly areas; prevents the regeneration of native species
Cestrum diurnum (Solanaceae)	Trop. America	Weed of roadside and wasteland
Chenopodium ambrosioides (Chenopodiaceae)	Trop. America	Weed of roadside
Convolvulus arvensis (Convolvulaceae)	Europe	Common weed of wasteland and fallow land
Conyza spp. (Asteraceae)	N. America	Common weed of farmlands and wastelands
Eichhornia crassipes (Pontederiaceae)	S. America	Probably the world's most widespread and serious invasive aquatic weed
Eucalyptus camaldulensis (Myrtaceae)	Australia	Controversy over water recharge and discharge
Eupatorium adenophorum (Asteraceae)	West Indies	Common weed of waste land; suppressed the regeneration of other species
Eupatorium odoratum (Asteraceae)	Jamaica and Mexico	Common weed of waste land; suppressed the regeneration of other species
Grevillea robusta (Proteaceae)	Australia	Agricultural landscape and roadside invasion
Ipomoea carnea (Convolvulaceae)	America	Common weed in aquatic and marshy habitat
Lantana camara (Verbenaceae)	Trop. America	Common weed of wastelands
Leucaena leucocephala (Fabaceae)	Trop. America	Suppress the regeneration of other species
Ludwigia adscendendens (Onagraceae)	C. America	Common weed of all habitats
Mimosa pudica (Fabaceae)	S. America	Common weed of cultivated and wasteland
Opuntia stricta (Cactaceae)	Caribbean Coastal area	Widespread weed in hot and dry areas
Plantago spp. (Plantaginaceae)	N. America	Common in grassland and along roadside
Solidago sp. (Asteraceae)	N. America	Common in suburbs, along roadside

Sources: De Bach (1964), Das (1982), Islam (1991), Richardson (1998), Hossain and Pasha (2001)

also cultivated as exotics (Evans 1992). Thus, although native species fulfill some human requirements, non-native species play an integral role in the economies and culture of most countries.

Despite the many benefits provided by alien species, deliberate and accidental introduction of these species poses a threat to native biodiversity and rural livelihoods. The impact may be devastating, and may entail reduction of carrying capacity of ecosystem (Banerji 1958), alterations in structure and function of natural ecosystem, human health hazards (Ricciardi et al. 2000), crop failure, species extinction, and reduced water yield from watersheds (Harrington and Wingfield 1998). The distribution and composition of biodiversity and local forest resources is affected directly by the invasive species due to change in host pathogen relationship and species competition. The invaders thereby affect the availability of forest resources, both timber and non-timber forest products. This may cause a change in the local people's utilization patterns of forest resources.

Invasion of *Eupatorium* is an enormous problem. Transitional zones and swamp forest are being invaded by dense monospecific stands of *Eupatorium*, which have little understorey except for *Eupatorium* seedlings. Although the species of *Eupatorium* have pesticidal properties (Chettri 1986) which have been applied in a few areas of Nepal, no commercially viable application has been found. Neither cattle nor goats eat this plant, and areas traditionally used for grazing can no longer be used for this purpose, forcing villagers to walk farther in search of grazing pasturage. The increased time spent on this activity translates into a substantial economic loss. The alternative, trying to control the weed, also involves a burden of labour and financial investment.

Eupatorium spp. growing in fallow land prevents soil erosion. They are used as green manure during spring, when the plant is heavily laden with leaves. Dried *Eupatorium* may be burnt to yield potash rich fertilizer. In some parts of the country, it has been used for cattle bedding material (Shrestha 1989). *Eupatorium* leaves when boiled and taken, cure severe stomachache and the apical leaves when made into paste and slaked with lime and applied on the cuts, stops bleeding (Joseph and Kharkongor 1981). Local people apply the fresh juice of *Eupatorium* leaves to stop bleeding from cuts and wounds (NBLP 2001).

Ecological impact

The dominance of *Eupatorium* species has occurred in transitional zones with adequate moisture (Kunwar 2000) and disturbance regimes, which can be easily seen in disturbed forest sites (Baniya and Bhattarai 1984). This plant inhibits growth and may even kill local plants and domestic animals (Jha and Sah 1985). Although many factors interact to determine the susceptibility of an ecosystem to invasion by *Eupatorium*, habitats may be ranked according to their vulnerability: undisturbed forest < moderately disturbed forest < disturbed forest < shrub land < grassland < dunes < denuded land (Richardson and Higgins 1998). Roads or trails, which usually occur in transition areas, often function as conduits for the dispersal of alien plants (Hobbs and Mooney 1991).

Invasive alien species (*Ageratum conyzoides*, *Eupatorium* spp., *Imperata cylindrica* etc.) grow luxuriantly in sunny exposed wasteland (Kunwar et al. 2001) and encroach fresh landslides or areas with deep gullies and open grasslands. The invasive species spread primarily through wind dispersal and propagate through

vegetative means (Saxena and Ramakrishnan 1984). The once slow, erratic and small-scale transfer of species has shifted to a rapid and large-scale translocation; the rate of invasions in San Francisco Bay, for instance, has accelerated from an average of one new species established every 55 weeks during the period 1851-1960 to one new species every 14 weeks during the period 1961-1995 (Cohen and Carlton 1998). Thus, the invasive effects of these species become compounded because of their growth mode and the reproductive strategy. They can promote fire and alter water and nutrient availability. Moreover, the cattle grazing and trampling has allowed noxious *Eupatorium* spp. to take root (NEPA 1998).

It is argued that the complexity of the interactions between alien plants, the native biota and the environment they invade precludes prediction (Bruke and Grime 1996). Invasive alien species reduce biodiversity, replace economically important native plant species and increase the investment in agriculture and silviculture (Ricciardi et al. 2000), disrupt prevailing vegetation dynamics and alter nutrient cycling (Richardson 1998). The invasion process affects all ecosystems but the impact of particularly aggressive species is especially severe on the structure and function of vulnerable and isolated ecosystems (SCBD 2001). In native forests, invasive alien plants are able to dominate the understorey, to strangle saplings and to suppress native species (Denslow 2002). The problem will likely worsen with time because of climatic changes that promote species migration worldwide.

Invasive plants also have a major impact on catchment hydrology: 30-70% lower water runoff is reported from watershed areas with dense stands of alien species (Geldenhuys 1986). Most impacts are detrimental to the invaded systems and threaten sustained functioning and the provision of important ecosystem services. The reduced stream flow obviously has detrimental impacts on aquatic biota. It can also disrupt stock watering, irrigation, tourism and recreational use of resources and heritages.

Controlling measures

The spread of invasive alien species is creating complex and far-reaching challenges that threaten both the natural biological niches of the earth and the well-being of its citizens. Some aspects of the problem require solutions addressing the specific values, needs, and priorities of local ecosystems, national environment and sustainable development. It is now widely accepted that the control of invasive alien species is not a short-term or single effort. On the contrary, it requires detailed surveillance, monitoring and research into the most suitable long-term control options. Much effort is devoted to controlling them after they are established, but a better understanding of why species become invasive offers the possibility of taking pre-emptive measures (Clay 2003).

A variety of well-known methods can be used as measures to control alien invasive species and their spread. These vary from administrative (national and international cooperation and coordination, database management, legislation regarding quarantine and so on), to mechanical (including digging up root systems, slashing and chopping), to chemical (utilizing acceptable and tested herbicides) and to biological (making use of plant specific insects or pathogens to damage and control aliens). These options are generally incorporated into integrated control programme employing a combination of strategies which together may impede and control the invasive species to some extent.

Suitable strategies are needed to conserve the forest and its biodiversity while ensuring a sustainable resources base for indigenous people. Biological control of *Eupatorium* species using gall fly *Procecidochares utilis* has been carried out throughout world including Nepal. It was successful in Hawaii, USA, and elsewhere (Bess and Haramota 1971); however, this technique has not yet been successful in Nepal. 'Best management practices' should include removal of known invasives, and their use should be discouraged. Known invasive alien plant should be replaced with non-invasive native species or with exotics unlikely to spread into native plant communities. Horticultural material such as seed and green mulch should be inspected for their potential to introduce troublesome species. Nurseries, botanical gardens and government agencies should inform the public of the potential danger of invasive species and should encourage the use of alternative native or exotic species unlikely to contribute future invasive species problem.

Some strategies that urgently require implementation are: (i) alert local people to the importance and impacts of alien species; (ii) accord highest priority to preventative initiatives designed to protect vulnerable ecosystems; (iii) give priority to the eradication of invasive alien species on areas that with highly distinctive ecosystems and threatened and endemic species ; (iv) undertake a systematic compilation of research and educational materials and initiate a database on invasive species; (v) conduct more research; (vi) introduce legislation regarding quarantines; and (vii) strengthen international cooperation, national coordination, and local implementation of policies concerning alien species.

Conclusion

The deliberate introduction of alien invasive species threatens to native species, habitats and ecosystem functions and is economically costly. The major impact of alien invasion follows reduction in forest product availability, which directly affects the rural livelihood because the subsistence of rural livelihood entirely relies on such products. Thus, some aspect of the problem requires solutions addressing the specific needs and priorities of human livelihood, local ecosystems and national environment and sustainable development. Concurrently, it is more essential to understand why these species become invasive. ■

References

Banerji NL. 1958. Invasion of *Eupatorium glandulosum* in east Nepal. *Bulletin of botanical society, University of Saugar* **10**(1 and 2): 14-8

Baniya AMS and MD Bhattarai. 1984. *Distribution of Eupatorium adenophorum in some parts of Phulchoki hills and its soil relation*. Kathmandu: Amrit Campus. 38 p

Bess HA and FH Haramota. 1971. Biological control of Pamakani *Eupatorium adenophorum* in Hawaii by a tephritid gall fly, *P. utilis*. *Proc Hawaii Entomol Soc* **21**(2): 165-78

Biswas K. 1934. Distribution of some of the common harmful exotic weeds established in the country. *Ind For* **60**: 861-5

Bruke MJW and J Grime. 1996. An experimental study of plant community invisibility. *Ecology* **77**: 776-90

Clay K. 2003. Parasites lost. *Nature* **421**: 585-6

Cohen AN and JT Carlton. 1998. Accelerating invasion rate in a highly invaded Estuary. *Science* **279**: 555-8

Chaudhary RP. 1998. *Biodiversity in Nepal: Status and conservation*. Majupuria TC (ed). Bangkok: Tecpress Books. 324 p

Chettri MK. 1986. *Effects of herbicides on Eupatorium adenophorum* [thesis]. Kathmandu: Central Department of Botany, Tribhuvan University. 61 p

Darwin C. 1859. *On the origin of species by means of natural selection*. London: John Murray. 448 p

Das S. 1982. Introduction of exotics in the plantation forestry of B'desh. In: *Proceedings of Second B'desh National Conference on Forestry*; Dhaka. p 85-93

De Bach P. 1964. *Projects on biological control of insect pests and weeds*. London: Chapman and Hall. xxiv p

De Candolle AP. 1855. *Geographic botanique raisonne*, Vol 2. Paris: V Masson

Denslow JS. 2002. Invasive alien woody species in Pacific Island forests. *Unasylva* **209**: 62-3

Evans J. 1992. *Plantation forestry in the tropics*, 2nd ed. Oxford: Clarendon press

Ewel JJ, DJ O'Dowd, J Bergelsen, CC Daehler, CM D'Antonio, LD Gomez et al. 1999. Deliberate introductions of species: Research needs. *Bioscience* **49**: 619-30

Geldenhuys CJ. 1986. Costs and benefits of the Australian Blackwood *Acacia melanoxylon* in South African forestry. In: Macdonald IAW, FJ Kruger and AA Ferrar (eds), *The ecology and management of biological invasions in southern Africa*. Cape Town: Oxford University Press. p 275-84

Press JR, KK Shrestha and DA Sutton. 2000. *Annotated checklist of the flowering plants of Nepal*. London: The Natural History Museum, London and Tribhuvan University, Kathmandu. 430 p

Harrington TC and MJ Wingfield. 1998. Diseases and the ecology of indigenous and exotic pines. In: Richardson DM (ed), *Ecology and biogeography of Pinus*.

Cambridge: Cambridge University Press. p 381-404
Hobbs RJ and HA Mooney. 1991. Effects of rainfall variability on gopher disturbance on serpentine annual grassland dynamics in north California. *Ecology* **72**: 59-68
Hossain MK and MK Pasha. 2001. Alien invasive plants in B'desh and their impacts on the ecosystem. *Alien* **13**: 12-3
Humphries SE, RH Groves and DS Mitchell. 1991. Plant invasions of Australian ecosystems. *Kowari* **2**: 1-134
Islam AKMN. 1991. *Two centuries of plant studies in B'desh and adjacent regions*. Asiatic Society of B'desh. Dhaka
IUCN/SSC. 2000. *Guidelines for the prevention of biological diversity: Loss caused by alien invasive species*. Gland (Switzerland): Species Survival Commission (SSC), International Union for Nature Conservation, Invasive Species Specialist Group
Jha PK and RP Sah. 1985. *Banmara (Eupatorium adenophorum): Nepal's worst weed*. Kathmandu: Man and Biosphere. Bulletin no 5
Joseph J and P Kharkongor. 1981. A preliminary ethnobotanical survey in the Khari and Jaintic hills, Meghalaya. In: Jain SK (ed), *Glimpse of Indian ethnobotany*. New Delhi: Oxford and IBH Publishing Co. p 115-23
Joshi RM. 1983. *Role of soil, light and water in the distribution of Eupatorium adenophorum in Phulchoki hills of Kathmandu* [thesis]. Kathmandu: Central Department of Botany, Tribhuvan University. 52 p
Kennedy TA, N Shahid, MH Katherine, MHK Jokannes, T David and R Peter. 2002. Biodiversity as a barrier to ecological invasion. *Nature* **417**: 636-8
Kunwar RM, VNG Gupta, OR Vetaas and RP Chaudhary. 2001. Vegetation dynamics of herbaceous plants in lower Arun river basin of Makalu Barun buffer zone, east Nepal. In: Watanabe T, S Sicroff, NR Khanal and MP Gautam (eds), *Proceeding of the international symposium on the Himalayan environments: Mountain sciences and ecotourism/biodiversity*; 2000 Nov 24-26; Kathmandu. Kathmandu: Hokkaido University, Tribhuvan University and the United Nations University. p 103-10
Kunwar RM. 2000. *Species diversity of herbaceous flora in lower Arun river basin, Makalu Barun buffer zone, east Nepal* [thesis]. Kathmandu: Central Department of Botany, Tribhuvan University. 45 p
Larson DL, PJ Anderson and W Newton. 2001. Alien invasion in mixed-grass prairie: Effects of vegetation type and anthropogenic disturbance. *Ecol Appl* **11**: 128-41
Maron JL and M Vila. 2001. When do herbivores affect plant invasion? Evidence for the natural enemies and biotic resistance hypothesis. *OIKOS* **95**: 361-73
NBLP. 2001. *Makalu Barun landscape project; Biodiversity component*. Kathmandu: Nepal Biodiversity Landscape Project, DNPWC, HMGN. Report no 1. 87 p
NEPA. 1998. *Biodiversity country report*. Beijing: National Environment Protection Agency
Pimm SL. 1984. The complexity and stability of ecosystem. *Nature* **307**: 321-6
Rai JPN and RS Tripathi. 1982. Allelopathy as a factor contributing to dominance of *Eupatorium*. *Ind J Ecol* **9**: 14-20
Randall JM. 1997. Defining weeds of natural areas. In: Luken JO and JW Thieret (eds), *Assessment and management of plant invasions*. New York: Springer-Verlag. p 18-25
Ricciardi A, WWM Steiner, RN Mack and D Simerloff. 2000. Towards a global information system for invasive species. *Bioscience* **50**(3): 239-44
Richardson DM and SI Higgins. 1998. Pines as invasion in the southern hemisphere. In: Richardson DM (ed), *Ecology and biogeography of Pinus*. Cambridge: Cambridge University Press. p 450-73
Richardson DM, P Pysek, M Rejmanek, MG Barbour, FD Panetta and CJ West. 2000. Naturalization and invasion of alien plants: Concepts and definitions. *Diver Distribution* **6**: 93-107
Richardson DM. 1998. Forestry trees as invasive aliens. *Conserv Biol* **12**: 18-26
Sattaur O. 1989. The shrinking gene pool. *New Sci* **1675**: 37-41
Saxena KG and PS Ramakrishnan. 1984. Growth and patterns of resources allocation in *Eupatorium odoratum* in secondary successional environment following slash and burn agriculture. *Weed Res* **24**: 127-34
SCBD. 2001. *Review of the efficiency and efficacy of existing legal instruments applicable to invasive alien species* [Technical series no 2]. Montreal: Secretariat of the convention on biological diversity, CBD. 42 p
Sharma KC and GK KC. 1977. Reports on studies on the biological controls of *Eupatorium adenophorum* in Nepal. *J Agric* **12**: 135-58
Shrestha TB. 1989. *Development of the Arun river basin, Nepal: Country report on biological diversity*. Kathmandu: ICIMOD. 133 p
Singh RM. 1979. *The autoecology of Eupatorium adenophorum: A noxious weed* [thesis]. Kathmandu: Central Department of Botany, Tribhuvan University. 54 p
Torchin ME, KD Lafferty, AP Dobson, VJ Mckenzie and AM Kuris. 2003. Introduced species and their missing parasites. *Nature* **421**: 628-30
Yan X, L Zhenyu, WP Gregg and L Dianmo. 2001. Invasive species in China: An overview. *Biod Conserv* **10**: 1317-41

Acknowledgements

Thanks are due to Sagendra Tiwari, IUCN and Ram P Chaudhary, Central Department of Botany, Tribhuvan University, for their valuable suggestions, and to Vijaya Kunwar, Society for Economic and Environmental Development (SEED), Nepal for providing necessary supports.

ANNOUNCEMENT

National Seminar on Natural Resource Management

(November 6-7, 2003; Kartik 20-21, 2060; Biratnagar, Nepal)

Organisers

Ecological Society (ECOS)
C/o Central Department of Botany, TU
Kathmandu, Nepal

PG Campus
Tribhuvan University
Biratnagar, Nepal

Nepal Biological Society
C/o Post Graduate campus
Biratnagar, Nepal

Background

In human term, one of the important renewable resources is plant, without that we cannot think of existence of life on this planet. This rich variety of genes, species and biological communities gives us food, wood, fibres, energy, raw materials, industrial chemicals, medicines, and above all free mineral recycling and air purification service. To continue the ecological and economic benefits sustainable use of natural resource is important.

Nepal is rich in natural resources but these resources need special attention and sustainable management. Population growth is another important factor which is linked with various environmental issues including natural resource management. Therefore, organisers of the seminar have resolved to organise a national seminar on 'Natural Resource Management' with the following objectives:

- Discuss research findings and share knowledge for betterment of human population and environment.
- Evaluate the natural resources of Nepal and neighbouring countries.
- Discuss the natural resources management issues and strategies.
- Highlight the intricate relation of natural resources, environment and population.

Topics

Ecology and Environment, Agriculture, Human Population Dynamics, Foresty, Natural Resources Management, Medicine, Biotechnology, Systematics, Biodiversity, Ethnobotany, etc and a special session on Environment and Population.

Programmes: Keynote Address, Invited Lectures, Contributory Papers, Poster Presentation, Exhibition, Excursion

Venue: Post Graduate Campus, Biratnagar, Nepal

Language: The official language of the conference will be English

Call for abstracts and papers

Abstracts should reach the conference secretariat by the last of August 2003. The abstract (not exceeding 200 words) should include title, name of author(s), address and abstract. Abstract can be sent by email. The full text of the paper in duplicate (with diskette) should reach before October 15th 2003. The papers will be peer reviewed for publication in ECOPRINT: An international journal published by ECOS.

Poster presentation: The full text should be arranged in one sheet (size 110 by 80 cm) for poster presentation. Young scientists are encouraged for poster presentation.

Accommodation and food

Participants will be provided a modest accommodation, launch and snacks/tea/coffee during the conference hours.

Registration fee

Nepalese participants: NRs 500 (50% concession to students)
Foreign participants: US $ 20 (IRs 500 for scientists from India)

Patrons

Prof Dr GP Sharma
Vice-chancellor, Tribhunvan University
Prof TB Karki
Vice-chancellor, Purbanchal University

Co-patrons

Prof Dr GPS Ghimire (Dean, Institute of Science and Technology, TU)
Dr SP Koirala (Campus Chief, Post Graduate Campus, Biratnagar)

Advisory board

Prof Dr PK Jha (Head, CDB,TU / Past President, ECOS), Prof Dr B Upadhyay, Dr D Parajuli, Dr Ekalabya Sharma, Mr GB Karki, Dr HD Lekhak, Prof Dr KP Sharma, Prof Dr PN Mishra, Dr RB Thapa, Prof Dr RK Kherwar, Mr RN Sapkota, Prof Dr RP Chaudhary, Prof Dr SD Joshi, Dr SM Amatya, Dr SR Baral, Prof Dr TK Shrestha, Dr UR Sharma

Organising committee

Chairperson: Dr SB Karmacharya (President, ECOS)
Co-chairperson: Dr MR Dhakal (President, NBS)
Secretary: Dr MK Chettri (General Secretary, ECOS)
Joint Secretary: Dr TN Mandal Mr SN Jha, Dr BR Subba
Treasure: Mr Umesh Koirala
Joint Treasure: Ms Babita Labh, Ms Bindu Pokharel
Members: Mr Bhabindra Niraula, Ms Bipana Acharya, Mr Damodar Thapa, Mr Kamal Maden, Mr Kul P Limbu, Mr RP Shah, Mr Rakesh Bhagat, Dr S Bajracharya, Mr SK Jha, Mr SK Rai, Dr SR Joshi, Mr Tilak Gautam, Dr VN Prasad, Mr YN Das

Mailing address

Dr MK Chhetri, Secretary
PO Box 21319, Kathmandu
Ph.: 4332560, 4411637
Email: amritcampus@ntc.net.np

Dr TN Mandal, Joint Secretary
PO Box 137, Biratnagar, Ph.: 00977-21-527968
Email: minrdhakal@rediffmail.com

Contact persons

Dr SB Karmacharya, President (ECOS)
Trichandra Campus, TU, Kathmandu
PO Box 21319, Kathmandu
Ph.: 6613353, 4330829
Email: pkjha@ecos.wlink.com.np

Dr MR Dhakal, President (NBS)
Post Graduate Campus, Biratnagar, Nepal
PO Box 137, Biratnagar
Ph.: 00977-21-531453
Email: minrdhakal@rediffmail.com

Dr Mukesh K Chettri, General Secretary (ECOS), Amrit Campus, TU, Kathmandu
PO Box 21319, Kathmandu
Ph.: 4332560, 4411637
Email: amritcampus@ntc.net.np

Dr TN Mandal, Vice President (NBS)
Post Graduate Campus, Biratnagar, Nepal
Ph.: 00977-21-527968
Email: mandal14@hotmail.com
Email: kamalmaden@yahoo.com

HIMALAYAN JOURNAL OF

sciences

Volume 1 **Issue 2** **July 2003** **ISSN 1727 5210**

Himalayan Journal Online

Full text of all opinion-based papers, summary of all papers, guide to authors and other materials are available online at **www.himjsci.com**

To help the authors of research papers, we have added a section 'How to write a scientific paper' in the website (see p 76). For latest information about the journal, please visit the website.

Contact

The Editor
Himalayan Journal of Sciences
Lalitpur, Nepal
G P O Box No 2838
Tel: 977-1-5525313 O, 977-1-5528090 R
E-mail: editors@himjsci.com

To visit the office

Himalayan Journal of Sciences
ICIMOD, Jawalakhel, Lalitpur, NEPAL
Office hours : 4 pm to 7 pm

Acknowledgements

Many institutions and people have helped us bring out this second issue. We would like to acknowledge the logistic support (office space, computers, furnitures) of International Center for Integrated Mountain Development (ICIMOD); and especially we are thankful to Dr J Gabriel Campbell, Greta Rana and Nira Gurung. We are thankful to Bridges-PRTD and San Miguel Brewery for financial support (NRs 20,000). The faithful assistance of Yogendra R Mainali, Bina Gajurel and Sanjay Gajurel is highly appreciated. We thank Bharat B Shrestha (Central Department of Botany, TU) for help in editing one paper, and Bamadev Deep, Krishna Roka, Bijaya Kunwar, Ram B Pant (Nepal Rastra Bank), Babu R Adhikari, Krishna B Karki and Murali D Tiwari for helping to raise funds through advertisement. To all our reviewers and authors, for your patience and persistence, thank you!

Price

Personal : NRs 100.00
Institutional : NRs 300.00
Outside Nepal : US $ 7.00