research grants, they rarely get NET-qualified candidates.

Think of the plight of the faculty who are constrained to take these students sometimes as non-stipendiary research scholars, for the sake of career-development schemes. The project investigators agree that they take only 'technicians' and are aware that ultimately it is the investigator who has to write the student's thesis. Such doctorates add to the agony of educated unemployed, aggravating the social disorganization; their brains virtually become the devil's workshop. The self-financing institutions come to their rescue. They easily 'start' courses such as gene technology and genetic engineering taught by these doctorates. Such doctorates who are already in teaching and research institutes add to the woes of the student community. It is like one blind person leading other blind persons. Most of the enrolled students for such programmes are rich and just want a degree. A. Gnanam, Chairman of NAAC, once said that, 'the expenditure incurred on producing an undergraduate is appallingly low when compared to that of a professional degree holder. Unfortunately these people ultimately turn out to become the major part of the service sector and reflect the deteriorating quality here too'.

CHELLAM BALASUNDARAM*
P. MARIAPPAN

Department of Animal Science,
Bharathidasan University,
Tiruchirapalli 620 024, India
**For correspondence.*
e-mail: bal213@rediffmail.com

Rationally cautious: GM crops

S. K. Ghosh (*Curr. Sci.*, 2001, **81**, 655–660) advocates the use of transgenics in commercial agriculture. The issue of gene pollution, however, did not get its due attention. Especially in the context of herbicide and insect pest-tolerant transgenics, there is a potent danger of the transgene passing on to the weedy relatives of the crop in question, through natural outcrossing. Such a possibility in case of wheat and its wild relative, viz. jointed goatgrass (*Aegilops cylindrica*) has already been reported[1]. Additionally, insect pest-resistant transgenics can lead to evolution of a resistant gene in the pest species or can accelerate the faster multiplication of pest strains carrying such genes. Possibility of such a hazard has already been proved correct in case of transgenics utilizing *Bt* gene[2,3].

The potent danger of the transgene getting passed on to weedy relatives can, however, be overcome by placing the desired gene in a plastid. Chloroplast transformation[4] has come a long way from the time it was conceptualized initially. This technology offers unique advantages in plant biotechnology, including high-level foreign protein expression, absence of epigenetic effects, and gene containment due to the lack of transgene transmission through pollen, thus ruling out the possibility of any transgene getting passed on to the wild and weedy relatives from the cultivated transgenic. Recently, Ruf *et al.*[5] have described a plastid transformation system for tomato. In the report on the generation of fertile transplastomic plants in a food crop with an edible fruit, Ruf *et al.* have shown that chromoplasts in the tomato fruit express the transgene to 50% of the expression levels in leaf chloroplasts. Given the generally very high foreign protein accumulation rates that can be achieved in transgenic chloroplasts (> 40% of the total soluble protein), this system paves the way to efficient production of edible vaccines, pharmaceuticals, and antibodies in tomato. The viable option thus is to place transgenes offering resistance to insect pests and herbicides in plastids; however, the more perfected systems of nuclear transformation may continue to be used for transferring genes for enhanced productivity or those that confer tolerance to abiotic stresses, which ultimately will enhance productivity levels.

1. Mallory Smith, C. A., Snyder, J., Hansen, J. L., Wang, Z. and Zemetra, R. S., Proceedings of a Symposium held at Keele, UK, 12–14 April 1999, p. 165.
2. Gahan, L. J., Gould, F. and Heckel, D. G., *Science*, 2001, **293**, 857–860.
3. Griffits, J. S., Whitacre, J. L., Stevans, D. E. and Aroian, R. V., *Science*, 2001, **293**, 860–864.
4. Pal Maliga, *Trends Biotechnol*, 1993, **11**, 101–106.
5. Ruf, S., Hermann, M., Berger, I. J., Carrer, H. and Bock, R., *Nature Biotechnol.*, 2001, **19**, 870–875.

RAJIV K. SHARMA

Division of Genetics,
Indian Agricultural Research Institute,
New Delhi 110 012, India
e-mail: rajivsharma@rediffmail.com

Why should bee-keeping be utilized as an input in agriculture?

A majority of people in India are vegetarian and depend on agriculture for their food, nourishment and clothes. Though the country has attained self-reliance in food-grains production, there is a shortage of edible oil, fruits, vegetables, condiments, spices, etc. The average yield of the crops providing these commodities in the country is much below the expected one. The simple reason is the failure of these crops due to inadequate pollination.

All the crop plants are angiosperms, i.e. they bear flowers. For setting-up of seed/fruit, the flower must be pollinated, i.e. pollen must be transferred from the anther (male part) to the stigma (female part). If the flower utilizes its own pollen for seed set, this is called self-pollination (autogamy), and if the pollen comes from other flower(s), it is called cross-pollination (xenogamy)[1,2]. Most of the crops providing the above commodities need cross-pollination of their flowers due to the presence of strong reproductive barriers. These include self-incompatibility, differential maturity of the reproductive organs and unisexuality[1,2]. Under these barriers, a flower is not able to utilize its own pollen.

Self-incompatibility is witnessed when pollen of a flower is genetically incapable of setting seeds in the same flower or even in a flower of the genetically same ramet/genet (self-pollination is useless)[1,2], e.g. in case of many oilseed crops like rapeseed toria (*Brassica campestris* L. var. toria), sarson (*Brassica campestris* L. var. sarson), rocket cress (*Eruca sativa* Mill.), sunflower (*Helianthus annuus* L.), clove oil (*Syzygium aromaticum* Merr & L.M. Perry), and two cultivars of olive oil (*Olea europaea* L.). Vegetable crops like cauliflower (*Brassica oleracea* L. var. botrytis), turnip (*Brassica rapa* L.), radish (*Raphanus sativus* L.); fruit crops like apple (*Malus sylvestris* Mill.), almond (*Prunus amygdalus* Batsch), plum (*Prunus domestica* L.), pear (*Pyrus communis* L.), carambola (*Averrhoa carambola* L.), almost all kinds of berries, sweet cherry (*Prunus avium* L.) and sour cherry (*Prunus cerasus* L.), passion fruit (*Possiflora* spp.), some cultivars of citrus (*Citrus* spp.) and grape (*Vitis vinifera* L.), and many cultivars of apricot (*Prunus armenica* L.) are self-incompatible. Guava (*Psidium guajava* L.) is partially incompatible. Likewise, some cultivars of tea (*Camellia sinercis* L. O'Kuntze) and coffee (*Coffea* spp.), medicinal plants like white sapote (*Casimiroa edulis* Llan and Lex), salad chicory (*Cichorium intybus* L.) and forage crops like berseem (*Trifolium alexandrinum* L.), white clover (*Trifolium repens* L.) and red clover (*Trifolium pratense* L.) are also self-incompatible. Under differential maturity of reproductive organs, there can be two situations. When the anthers mature before the receptivity of the stigma this is called protandry[1,2]. Here, if pollination occurs due to self-pollen, the latter will go waste as it cannot germinate. This pollen can be useful only for the other flower(s) that have a receptive stigma. Some cultivars of sunflower, fruit crops like jujube (*Zizyphas jujuba* Mill. and *Z. mauritiana* Lamk.); vegetable crops like onion (*Allium cepa* L.), carrot (*Daucus carota* L.), celery and celeriac (*Apium graveolens* L.) and parsnip (*Pastinaca sativa* L.); spice/condiment crops like fennel (*Foeniculum vulgare* Mill.), coriander (*Coriandrum sativum* L.), cumin (*Cuminum cyminum* L.), lavender (*Lavandula* spp.), etc. are examples of protandry[3,4]. On the contrary, if the stigma becomes receptive much before the liberation of self-pollen (protogyny)[1,2], the pollen it needs can come only from the other flower(s). This is because the stigma dries up/becomes non-receptive much before the self-pollen is liberated. Examples of protogyny are the spice crops like black pepper (*Piper nigrum* L.) and fruits like pawpaw (*Asimina triloba* (L.) Dunal) and cherimoya (*Annona cherimola* Mill.)[3,4]. In some crops, contrary to the above, the plant bears flowers of one sex only, i.e. male and female plants are separate – the male plant bears male flowers and the female plant bears female flowers, e.g. in papaya (*Carcia papaya* L.), date palm (*Phoenix dactylifera* L.) and Chinese gooseberry (*Actinidia chinensis* Planch.). Or the male and female flowers are borne on the same plant, e.g. in all the cucurbits, asparagus (*Asparagus officinalis* L.), coconut (*Cocos nucifera* L.), oil palm (*Elaeis guineensis* Jacq), etc. These are the cases of unisexuality.

Under all of the above situations, pollen of the same flower (self-pollen) cannot be utilized for pollination and seed/fruit set, and pollen from other flower(s) must be brought for this purpose (cross-pollination is a prerequisite). Besides these crops, there are others which are benefitted from cross-pollination in the enhancement of their seed/fruit production[1,3,4]. Bees, due to their morphological (as they bear branched hairs to collect pollen) and nutritional (they feed on pollen and nectar) adaptations, can accomplish this task most efficiently[3]. Among bees, honey bees are the best suited crop-pollinators (except in some cases where specialist pollinators are needed)[1,3,4], due to their high floral constancy (an individual bee makes repeated visits to the same floral source till it is exhausted; this behaviour makes the bee a faithful visitor)[3]. Two species of honey bees, viz. Asian hive bee (*Apis cerana* F.) and European honey bee (*Apis mellifera* L.) are utilized for pollination of crops due to two main reasons: (1) these honey bees can be kept and managed in artificial wooden boxes (the hives), that can easily be transported from one place to the other; and (2) their population can easily be manipulated depending upon the pollination requirements of the given crop area[3].

Inadequate pollination leads to low seed set and mishappen fruits in several cross-pollinated crops. Significant increase in seed/fruit yield has been reported in cross-pollinated crops by honey bees than those devoid of bee-pollination[3–5]. Therefore, honey bees play a significant role in seed/fruit production. However, bee-keeping as an input in agriculture has not yet been recognized by the farmers and seed growers, especially in developing countries, primarily due to their ignorance about the role of honey bees in pollination of crops. The major problem lies with the agri-scientists and agri-biotechnologists, who are not willing to share the credit of their high-yielding varieties with other inputs. It is now well-established that despite the use of high-yielding varieties good crop management practices, including agronomical recommendations, use of irrigation, fertilizers and pesticides, the yield of cross-pollinated crops remains very low if there are no pollinators. This is because, the seed production in these crops is pollinator-limited, i.e. due to the inadequate number of honey bee pollinators, the pollination level in these crops remains inadequate. In self-incompatible and unisexual flowers/crops, the effect is much severe. Here, if the flowers are not cross-pollinated, there will be no seed/fruit set. Therefore, to achieve the desired level of seed/fruit yield in these cross-pollinated crops, bee-keeping has to be recognized as an essential input in agriculture.

In India, the National Commission on Agriculture (1976) recognized the role of honey bees in crop-seed production and recommended the utilization of honey bees for pollination of crops. At present, there is a standard requirement of over 150 million honey bee colonies in the country for the pollination of entomophilous crops and, in addition, they can produce over 2.25 million metric tons of honey. In 1982, there were 0.6 million honey bee colonies in the country[6]. Later Indian hive bee (*Apis cerana indica*) was badly affected by the Thai Sac Brood Virus (TSBV) disease[7]. This has caused a great loss to the bee-keeping industry in the country, as majority of the colonies of the Indian honey bee were lost by the start of the 1990s. The Indian Council of Agricultural Research, honouring the recommendations of the National Commission on Agriculture (1976), sanctioned an 'All India Coordinated Project on Honey bee Research and Training' in the early 80s. This project was implemented at many centres across the country. Though some work was carried out under this project, the overall achievement of the project remained highly unsatisfactory. The project failed to provide a right direction to honey bee research in the country. No specialized laboratories for honey bee breeding, management, nutrition, pathology, toxicology, pollination, etc. could be developed, even in a time span of over 20 years. The country, therefore, badly failed even to make its presence felt on the world honey production scene, as has been done by countries like China – the major honey exporting country in the world. At present, the estimated number of honey bee colonies in the country remains even less than 0.5 million against a fixed target of 6 million, and a potential of 150 million colonies[6]. There is a long way to go to achieve the required target and potential. In the absence of the required number of honey bee colonies, much of the floral resources in the country are going waste, in addition to losing the benefits of cross-pollination of crops. Therefore, there is an urgent need to recognize bee-keeping as an input in agriculture. For this, honey bee research in the country should be given top priority and specialized honey bee research centres should be established across the country. This will help in raising the number of honey bee colonies in the country so that, like other inputs, bee-keeping in agriculture is also well utilized.

1. Sihag, R. C., *Pollination Biology: Basic and Applied Principles*, Rajendra Scientific Publishers, Hisar, 1997, p. 215.
2. Faegri, K. and van der Pijl, L., *The Principles of Pollination Ecology*, Pergamon Press, Oxford, 1979, p. 244.
3. Free, J. B., *Insect Pollination of Crops*, Academic Press, London, 1993, p. 684.
4. McGregor, S. E., *Insect Pollination of Cultivated Crop Plants*, Agric. Handbook No. 496, USDA, Washington, 1976, p. 411.
5. Sihag, R. C., *J. Apic. Res.*, 1986, **21**, 121–126.
6. Anon, *Indian Bee J.*, 1982, **44**, 17–19.
7. Kshirsagar, K. K., Saxena, U. C. and Chauhan, R. M., *Indian Bee J.*, 1982, **44**, 8–9.

R. C. SIHAG

Department of Zoology and Aquaculture,
CCS Haryana Agricultural University,
Hisar 125 004, India
e-mail: sihagrc@hau.nic.in

The need for a National Institute of Seismology

Nirupa Sen[1] had recently elaborated the DST plans for earthquake management and research. A coordinated Himalayan Seismicity Programme has been started and funded by DST since 1982. After the Latur earthquake of 1993, peninsular India was also included in the DST programme. However, there is one limitation; all the DST plans and programmes in seismology are funded as projects and not on a permanent basis. The major player in executing the plans of the DST is India Meteorological Department (IMD), which is responsible for running and maintenance of seismological observatories in India on a permanent basis. A national seismological network has been planned by IMD for monitoring microseismicity and preparing microzonation maps of earthquake-prone areas. Unfortunately, like any other government department, IMD is also plagued by inefficiency and bureaucratic hurdles. Our own seismic observatory at Amritsar is also included in the national network, but nothing concrete has happened during the last two years.

The frequency of occurrence of earthquakes has increased at an alarming rate during the last decade. Five major earthquakes of magnitude 6.0 or more on the Richter scale have occurred in Uttarkashi (1991), Latur (1993), Jabalpur (1997), Chamoli (1999) and Bhuj (2001). According to Roger Bilham[2], the Himalayan belt will experience five to eight major quakes during the present century to release the accumulated stress at the boundary of the Indo-Tibetan collision zone. The proposal of IMD to set up an Earthquake Evaluation Research Centre (EERC) is welcome, but considering the present scenario of enhanced seismic activity in India, it will be most appropriate to set up a National Institute of Seismology and Disaster Management[3] on a turnkey basis. This institute should have experts from earth sciences, structural engineers, town planners, architects and social scientists, headed by a seismologist. It should employ international experts on disaster management on its faculty. It is true that earthquake prediction may not be possible in the near future but monitoring of seismic activity, evaluation of seismic data, preparation of seismic zonation maps of earthquake-prone areas, training of manpower, involvement of NGOs and creation of awareness among the public about natural disasters and their mitigation should be on the agenda of the national institute.

1. Nirupa Sen, *Curr. Sci.*, 2001, **80**, 1095–1097.
2. Bilham, R., International Conference on Natural Hazards: Mitigation and Management, Abstracts Volume, Guru Nanak Dev University, Amritsar, 12–15 March 2001, p. 1.
3. Reddy, P. R., *Curr. Sci.*, 2001, **80**, 1090–1091.

H. S. VIRK

Department of Physics,
Guru Nanak Dev University,
Amritsar 143 005, India
e-mail: virkhs@yahoo.com