few, but those that do exist seem to be among the most outstanding courses offered. For example, I was among the four founders of what is called Bio-X at Stanford University that supports, organizes and facilitates interdisciplinary research in the biosciences that includes faculties from the School of Medicine, the School of Engineering, and the School of Humanities and Sciences. The idea for this programme came from the faculty; the ability to implement the same and make it a reality could only have happened with the support of the university administration.

In my own department at Stanford University I serve as one of the members of an undergraduate curriculum committee. We receive input from teaching staff, students, other faculty members, and from the university administration. We also worry about whether any change can have a life beyond one particular faculty member who may want to offer the course. We also face the problem that many faculty feel that they 'own' certain courses, a practice that often causes the course to become stale with the particular faculty teaching the course in the same way for too many years in a row. I must add that university intervention is sometimes fully needed. For example, it was only with the promise of various benefits to the department did mine agree to offer some biological chemistry track to major in this discipline. Yet, the success of this new track is not simply because of some university administrator, in this case the Dean of the School of Humanities and Sciences, asking for this programme, but by a number of faculty deciding it was in the interest of the department and the students to have such a programme. Many faculty initially opposed this new way to major in chemistry. If the plan had not been thoroughly discussed, it certainly would have failed and at best would have had only a short life. Presently, it is a positive way we attract students to major in chemistry.

Freedom is the ability to set your schedule, to decide on the work you do, and to make decisions. Responsibility is being held accountable for your actions. To have exclusively either one or the other is a recipe for disaster. Freedom and responsibility go together. At the same time, as more autonomy is granted I believe more accountability is also required. This accountability can be achieved in many different ways, for example, periodic outside reviews by panels of experts. An intriguing question is whether national academies can be encouraged to play an important role in upholding standards and certifying successes. It is the true challenge to university administrators to effect the right balance between prescribed and overprescribed. This challenge of how to make autonomy succeed is not exclusively the provenance of university administrators. All stakeholders need to voice their concerns and aspirations.

1. http://indianexpress.com/article/opinion/columns/the-anatomy-of-autonomy-ugc-hrd-ministry-prakash-javadekar-5116607/
2. https://scroll.in/article/873128/granting-autonomy-to-universities-now-is-like-giving-power-to-khap-panchayats-says-jnu-professor
3. http://www.currentscience.ac.in/Volumes/102/01/0009.pdf
4. https://onlinelibrary.wiley.com/doi/abs/10.1002/anie.201201011

Richard N. Zare is in the Department of Chemistry, Stanford University, Stanford, California 94305, USA.
e-mail: zare@stanford.edu

Is export-oriented and currency dynamics-based Indian soybean revolution environment-friendly?

Siddhartha Paul Tiwari and S. P. Tiwari

Export orientation, market liberalization and currency dynamics have significantly promoted agricultural and industrial growth in export commodities. Rapid spread of soybean in South America and India is a glaring example of this. The saga of Indian soy revolution has been told[1] and ramifications of the Indian soybean industry have been documented[2,3]. Soybean expansion in South America has been associated with environmental loss. The Indian soy revolution needs to be viewed from this angle.

Emergence of the South American soybean industry has been associated with the rise in global prices for protein meals in the 1970s (ref. 4). This was also the period of phenomenal growth in Indian soybean area and export of soymeal. A favourable exchange rate as well provided for related developments and expansion of soybean[5]. The profit from export was an incentive in itself for making soybean production and the industry boom in India and South America. India normally exported soymeal plus other soybean products valued at around US$ 2.5 billion annually till 2013–14. After 2013–14, the exports declined due to instability in production, stiff global competition and currency dynamics. Domestic use of a substantial amount of soymeal and almost the entire soy oil produced (~1.7 million tonnes per year) is also appreciable.

Soybean spread and deforestation in South America

Soybean spurt in South America was held responsible for neotropical deforestation[6–8]. Brazilian cerrado, the Atlantic Forest and the Amazon in particular were affected. In Mato Grosso, Brazil, soybean displaced pastures further north into the forested areas, causing indirect deforestation. In South Brazil, soybean production has been accounted for severe shrinkage of the Atlantic Forest. In Argentina, soybean spread was associated with the loss of 2.7 million ha of forest between 1972 and 2011, the major loss occurring after 2002.

Soybean spread in India

Increase in soybean area started in early 1970s and was confined mainly to central India. The period from 1973 to 1981 has been analysed[9]. Determinants of this rapid growth were the availability of fallow land[10], assured market by solvent extraction plants, double cropping, viz. the then ruling indigenous black-seeded soybean variety 'Kalitur' followed by wheat, intercropping, and minor replacement of sorghum and cotton. Soybean presently covers about 12 million ha with a production of about 14 million tonnes.

Indian soybean spread is unlike that in South America, as it has not resulted in the loss of pastures and forests. Soybean mainly occupied fallow land and only slightly replaced sorghum and other low-return crops. Being a biological nitrogen-fixing crop, it did not put pressure on the demand for nitrogenous fertilizers. Soybean thus spread without obliterating any sequestration reserve, unlike what happened in some other countries.

The myth of beneficial effects of CO_2 on soybean in the backdrop of climate change

Studies show that rising CO_2 may have collateral improvement in the photosynthesis–transpiration ratio, and the resultant water-use efficiency could offset some of the negative effects of global warming in a C_3 plant like soybean. This does not seem to be practically tenable. First, a wide range of yield effects with both positive and negative figures was reported[11]. Secondly, lower than predicted yield increases from higher CO_2 were observed and the beneficial response was offset by high temperatures[12–14]. Further, rainfed soybean in India is liable to be more climatically challenged than other better-managed crops.

Non-GM, organic and sustainability-certified soybean

Despite a large worldwide area under genetically modified (GM) soybean (92 million ha, ~78% of total soybean area), future demand for non-GM soybean will continue in regions like the European Union. This could be advantageous for India, where no GM soybean is yet grown. A system of segregation, identity preservation and certification can allow both GM and non-GM crops to coexist. There is a growing global demand for organic, sustainably produced and fair-trade products. Certified organic and sustainable soybean has carved a small but specific niche in India, saved yet from greenwashing, which could act as promoter for environment-friendly farming.

1. Tiwari, S. P. *et al.*, *The Saga of Success – The Advent and Renaissance of Soybean: A Landmark in Indian Agriculture*, NRCS, ICAR Publ., 1999, pp. 1–54.
2. Chand, R., Agro-industries characterization and appraisal: soybeans in India. Working Document of the FAO-AGSF, 2007.
3. Tiwari Siddhartha Paul, *Soybean Res.*, 2017, **15**(1), 1–17.
4. Warnken, P. F., *The Development and Growth of the Soybean Industry in Brazil*, Iowa State University Press, Ames, USA, 1999, pp. 1–168.
5. Richards, P. D. *et al.*, *Global Environ. Change*, 2012, **22**(2), 454–462.
6. Fearnside, P. M., *Environ. Conserv.*, 2001, **28**(1), 23–38.
7. Barona, E. *et al.*, *Environ. Res. Lett.*, 2010, **5**, 1–9.
8. Gasparri, N. I. *et al.*, *Global Environ. Change*, 2013, **23**(6), 1605–1614.
9. Bisaliah, S., CGPRT, Paper No. 5, UN/ESCAP CGPRT Centre, Bogor, Indonesia, 1986, pp. 1–77.
10. Williams, S. W. *et al.*, Potential production of soybean in north central India, INTSOY Ser. 5, University of Illinois, Urbana, USA, 1974.
11. Adams, R. M. *et al.*, *Climate Res.*, 1998, **11**, 19–30.
12. Long, S. P. *et al.*, *Science*, 2006, **312**, 1918–1921.
13. Morgan, P. B. *et al.*, *Global Change Biol.*, 2005, **11**, 1856–1865.
14. Mall, R. K. *et al.*, *Agric. For. Meteorol.*, 2004, **121**, 113–125.

Siddhartha Paul Tiwari is with Google Asia Pacific Pte. Ltd, Singapore 117371; and S. P. Tiwari is in RAC, ICAR-Indian Institute of Soybean Research, Indore 452 001, India.*
**e-mail: sptiwari999@gmail.com*