metal tolerance does not necessarily increase metal accumulation in shoots in transgenic plants, as a recent study by the same group [21] illustrates. When transformed with a bacterial efflux pump, transgenic plants accumulated significantly less metal even though metal tolerance and consequently biomass was significantly increased.

Real breakthroughs on the way to engineering the ideal phytoremediator will therefore require a thorough understanding of metal uptake and translocation processes in higher plants on a molecular basis, particularly in natural metal hyperaccumulators. Until then, trial and error is the only tool available to advance research and understanding.

Acknowledgements
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Indian publishing: enduring the boom

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There has been a boom in the publication of Indian plant science research in recent years, defying national trends in other sciences and outperforming the international trends in plant science publications. This boom augurs well for India considering the importance of agriculture to her economy and the crucial need for science-based solutions to break the yield barriers. However, sustaining it requires tackling the problems of funding, infrastructure, manpower and other policy issues.

Indian plant scientists are increasingly making their presence felt in the international arena through their publications in recent years, and are following in the footsteps of agricultural researchers who have led the 'green revolution' in India over the past four decades. The current status and emerging future trends in Indian plant biology have been documented recently [1]. Here, I analyse the Indian publishing trends in international terms and address the issues of sustainability.

Analysis of plant science publications in the Web of Knowledge – Science Citation Index (SCI) Expanded database reveals an impressive 70% growth in the number of plant science papers by Indian authors, surpassing the world trend (Figure 1). The Indian contribution to international journals indexed in the SCI has increased rapidly since the mid-1990s and crossed the 1000 mark in 2002 even

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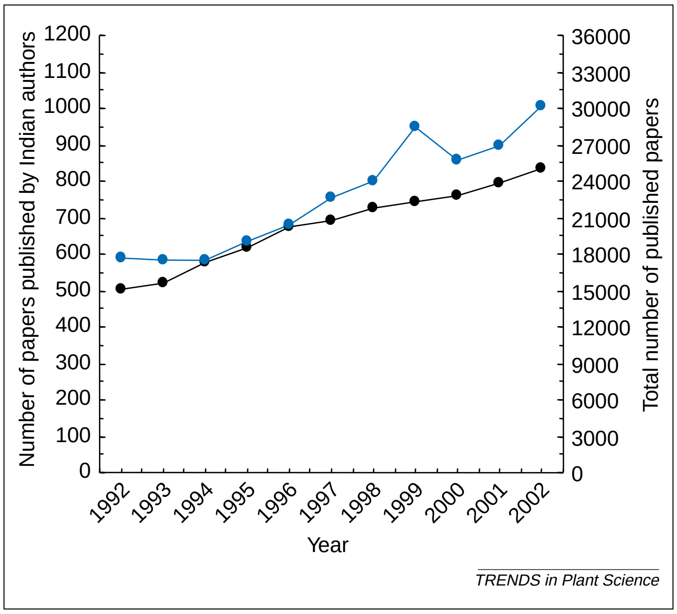

Figure 1. Plant science publishing trends: the number of plant science publications by Indian authors (blue) compared with the total number of world plant science publications (black). Data from an online search of the Science Citation Index (SCI) Expanded database.

though there are fewer plant journals (particularly Indian journals) in the SCI database compared with specialist databases such as AGRIS. A list of journals covered by the SCI each year was not available for detailed scrutiny.

A comparison of the plant science publications from India, the USA, the UK and Australia (countries that publish all their research in English) indicates that in 2002, these four countries accounted for nearly half of the plant science literature published in English (Figure 2). 4% of the world plant science literature is from India and 4% from Australia. This might appear miniscule compared to the plant science publications form the USA (29%), or even the UK (9%).

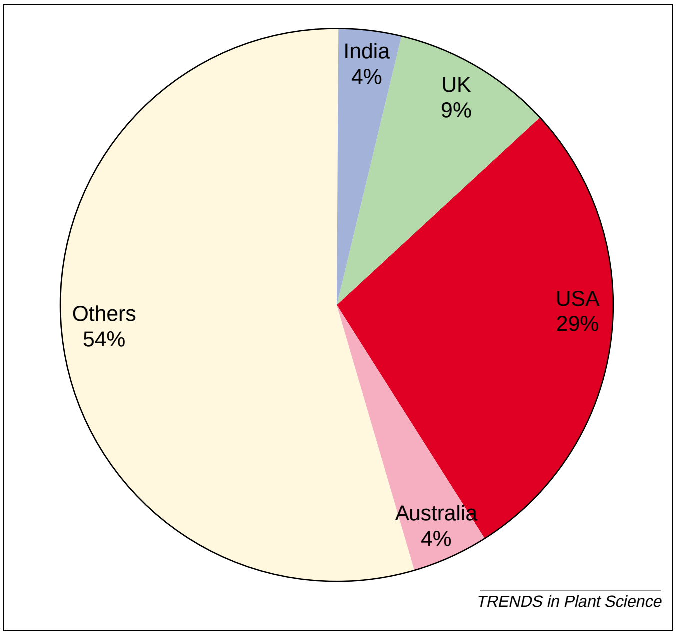

Figure 2. World plant science publications (in English) in 2002. The percentage of plant science publications from India (blue), UK (green), USA (red), Australia (pink) and the rest of the world (pale yellow) have been obtained for the year 2002 from an online search of the Science Citation Index (SCI) Expanded database.

However, a more detailed analysis of publication trends in plant science between 1992 and 2002 revealed the opposite trend (Figure 3). India showed the greatest increase in the number of publications (70%) over this period, well above the world aggregate figures, followed by the UK (51%), Australia (46%) and the USA (25%). Therefore, even though the USA and the UK publish more than India in terms of the number of plant science research papers (7.3-fold and 2.3-fold higher, respectively), their growth trends over the years indicate a possible reversal of publications in the long term. India is the only country (among those examined) that has surpassed the world aggregate growth in plant science publications, whereas the number of publications from the USA was less than half of the world aggregate growth in the past decade.

The consistency of this trend is shown in a plot of the year-wise change in the percent share of world plant science research papers by India, the USA, the UK and Australia over the past decade (Figure 4a). India has steadily increased her share, whereas the proportion of UK publications has remained the same and the proportion of Australian and US publications has declined, putting Australia on a par with India. These trends are even more interesting when measured in terms of the change in the proportion of plant science publications from each country as a percent share of the overall scientific output from that country in all sciences (Figure 4b). Plant science currently constitutes ~5.4% of the Indian scientific publications, which is close to that of Australia (5.6%) and 1.6 times higher than that of the UK and the USA, reflecting the relative size and role of plant research in the scientific establishments of these countries. By contrast, in 1992, Australian plant scientists had a bigger share in their national scientific output than all the other countries examined. The annual percent share of plant science papers in the total scientific output of the USA remained more or less static at around 3% during the 1990s. The absolute number of US plant science publications, as well as for all sciences combined, stagnated in the later half of

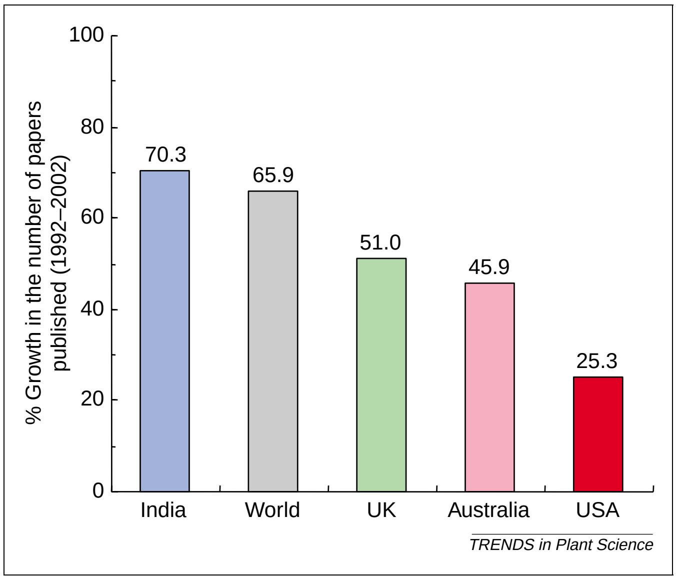

Figure 3. The percent growth in plant science papers published between 1992 and 2002. The number of plant science publications from India (blue), the UK (green), the USA (red), Australia (pink) and the world as a whole (grey), have been obtained for the years 1992 and 2002 from an online search of the Science Citation Index (SCI) Expanded database.

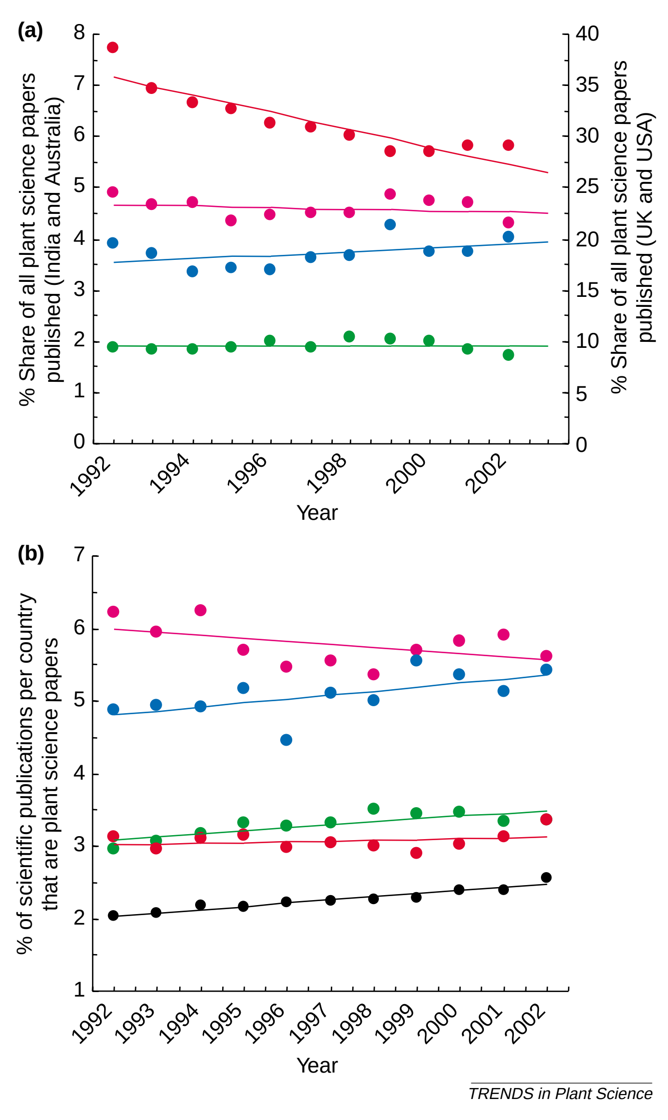

Figure 4. **(a)** Change in the share of world plant science publications from India (blue), UK (green), USA (red), Australia (pink) and the world as a whole (black) between 1992 and 2002. **(b)** Change in the proportion of plant science publications compared with the total number of scientific publications by each country between 1992 and 2002. Data in (a) and (b) were obtained from an online search of the Science Citation Index (SCI) Expanded database.

the past decade (data not shown), perhaps because of a shift of focus from publications to technologies and patents. By contrast, plant scientists in India and the UK have steadily enhanced their percent share of papers, superseding the growth in other areas of science (Figure 4b). Analysis of some of the prominent plant science journals included in the SCI Expanded database reveals that the following journals showed the greatest growth in the number of plant science contributions by Indian authors: *Plant Cell*, *Tissue* and *Organ Culture* (4.0-fold), *Plant Molecular Biology* (3.0-fold), *Crop Science* (3.0-fold), *Plant Cell Reports* (2.6-fold) and *Plant Science* (2.2-fold).

Thus, publications by Indian plant science scientists have increased impressively in absolute as well as relative terms during the past decade. The upward trend in publications by Indian authors in the late 1990s is particularly significant considering the decrease in India's share of the world scientific output during the 1980s and early 1990s [2].

This growth reflects the returns on the various inputs and investments made in the expansion of modern plant science during earlier decades in India. Currently, India spends ~15% of its total R&D expenditure on plant and agricultural research and development. This amounts to only 0.1% of India's gross national product (GNP) or 0.5% of the agricultural gross domestic product (GDP) as compared to 3.0% of the agricultural GDP in some developed countries. Yet, the overall economic returns on investments in the past four decades have been as high as 60–80%, according to different estimates. It is important to emphasize the economic value of R&D because government support for R&D has stagnated in real terms under the ongoing programme of economic liberalization and globalization. Agriculture currently accounts for 28% of the Indian GDP and 15% of exports and these figures are likely to increase in the future provided that the Cancun deadlock is broken. Therefore, greater public support for research in plant science and agriculture makes economic sense for India because it helps to sustain the current growth trends and consolidate the gains made in agricultural productivity. Because of the poor intramural funding in recent years, modern plant science research infrastructure is lacking in the majority of universities, including many agricultural universities. Inflexibility in the education, recruitment and funding policies of the Indian Council of Agricultural Research (ICAR) have also confined the agricultural universities and institutes to the fringes of interdisciplinary convergence that fuelled the growth of mainstream life sciences and biotechnology elsewhere in the country. If this situation is not remedied, modern plant science in India will be limited to only a few elite centres, with the vast majority of departments impoverished.

On the human resources front, ~3000 Masters students and hundreds of PhD students graduate every year in agriculture, and an even larger number of students graduate from plant science departments of other universities and affiliated institutes. Enrolment in modern biology courses, particularly in biotechnology or agriculture-related courses, has increased by ~10% over the past decade. However, there are concerns over the retention of high-quality manpower for plant science research and teaching within the country because most PhD graduates, particularly male PhD graduates, from the elite plant science departments, institutes or centres eventually leave the country for careers in the West, particularly the USA. Hopes of their returning to take up plant science careers in India are diminishing because the majority of them change their research field to pursue biomedical research or join private companies because of the declining opportunities for plant research abroad, particularly in the USA. Corporate R&D in multinational companies offers a more attractive option for male PhD graduates who do remain in India than R&D in the universities and institutes. Female PhD graduates tend to remain in India for familial reasons, which could explain why the number of women scientists pursuing R&D in plant science and agriculture in India has nearly tripled over the past two decades. The scientific community tends to look down upon those who opt to stay within the country regardless of their competence, further justifying emigration. This has led to a rather peculiar situation: India produces one of the largest pools of trained manpower in plant sciences in the world and yet the number of scientific positions that remain unfilled or downgraded in Indian universities and institutes, ostensibly for lack of suitable candidates (i.e. from abroad) is increasing. Indian policy makers and employers are yet to wake up to these challenges that could threaten the sustainability of the current growth trends in plant science research. These are ominous portents for what otherwise seems to be a bright future for plant science in India.

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Erratum

Erratum: Knowing when to grow: signals regulating bud dormancy

***Trends in Plant Science* 8 (2003), 534**

In the review article by David P. Horvath, James V. Anderson, Wun S. Chao and Michael E. Foley in the November issue of *Trends in Plant Science* [Horvath, D.P. *et al*. (2003) Knowing when to grow: signals regulating bud dormancy. *Trends Plant Sci*. 8, 534–540], the arrow in the top right of Figure 2 should have had only one arrowhead.

We apologize to the authors and our readers for this error. Figure 2 is printed correctly below. doi of original article: 10.1016/j.tplants.2003.09.013.

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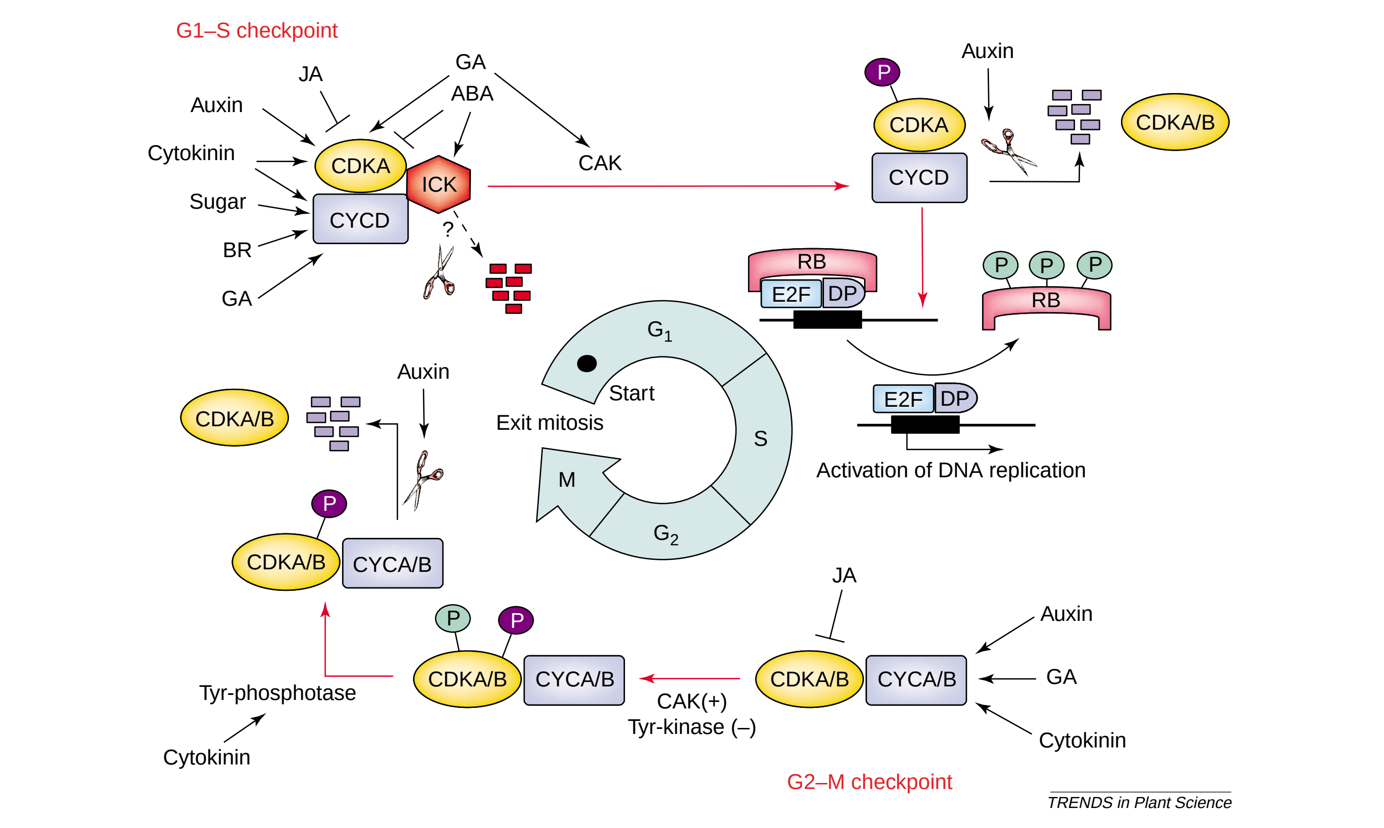

Figure 2. Model for G1–S and G2–M transitions in plants based on combined models by Gutierrez, Anderson *et al.* and Stals and Inzé [7,60,61], and on recent results obtained from plants and animals. Activation of G1 progression involves the expression of D-type cyclins (CYCD) and their catalytic subunit, cyclin-dependent kinase (CDKA), dissociation of CDK inhibitory protein (ICK1) from CDKA–CYCD complex, and phosphorylation of the Thr160 residue (P highlighted in purple) of CDKA. *CYCD* and *CDKA* are upregulated by various growth regulators including auxin, cytokinin, brassinosteroids (BR), sugar and gibberellic acid (GA). *ICK1* is induced by abscisic acid (ABA). Phosphorylation of CDKA is the activity of CDK-activating kinase (CAK), which is induced by GA [14]. Active CDKA–CYCD complex hyperphosphorylates retinoblastoma protein (RB), which inhibits its binding to transcription factors (E2F) and the docking protein (DP), thus initiating chromatin remodeling, transcription activation, DNA replication and S-phase transition. The SCF (SKP1–Cullin–F-box-protein) complex mediates ubiquitination and proteolysis (scissors) of ICK1 [62] and CYCD that is necessary to trigger the G1–S-phase transition in yeast (and possibly plants, denoted by '?'). Initiation of the G2–M-phase transition requires induction of the A- and B-type cyclins (*CYCA/B*) and the activity of A- and B-type CDKs (CDKA/B). The plant hormones auxin, cytokinin and GA have all been implicated in *CYCA/B* and *CDKA/B* expression and/or stability. At G2, the Thr160 (P highlighted in purple) of CDKs is positively phosphorylated (+) by CAK, and the Thr14 or Tyr15 (P highlighted in green) of CDKs are negatively phosphorylated (−) by a tyrosine kinase in the CDKA/B–CYCA/B complex. A cytokinin-regulated tyrosine phosphatase (*CDC25*) removes the inhibitory phosphate and allows the G2–M-phase transition to occur. Commitment to mitosis requires ubiquitin-dependent proteolysis of B-type cyclins. The anaphase-promoting complex (APC) regulates ubiquitination and proteolysis of CYCA/B. Auxin appears to be involved in the degradation of cyclins. Jasmonic acid (JA) inhibits CDK activity in both the G1–S-phase and the G2–M-phase transitions.