Weedy science – the Arabidopsis research boom

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Figure 1: The thale cress, *Arabidopsis thaliana* – Photo by A. Salguero Quiles en Getafe (GFDL)

You may not be familiar with it, but there's a plant (Fig. 1) more heavily researched than wheat, barley, rice, potatoes and maize combined. It is a tiny weed called *Arabidopsis thaliana*, and it causes no economic damage in any major crop. That's right - its economic significance is virtually zero. And yet, more people are currently conducting research on this plant than on any food crop. In the years 2004 to 2008 the number of scientists working on Arabidopsis was roughly four times as large as the number of scientists working on wheat[1]. In times when the term "food crisis" is swiftly moving up the agenda the world over, this is, to put it mildly, rather astonishing.

So what is the reason for the weed's curious career? The answer is simple. Arabidopsis has become the toy plant of molecular biology and plant physiology. Researchers use it as a model species to understand cellular, physiological and molecular mechanisms in detail, and it serves as a reference point against which other plant species can be compared. In fact, so excited have biologists become about Arabidopsis that the number of scientific publications about this flimsy flower has increased more than tenfold during the last two decades, and is now well above a staggering 100 per week[2] – resulting in 5500 to 6000 Arabidopsis research publications per year (Fig. 2).

This development is particularly striking when these numbers are compared with the publication output for staple food plants. For the last 20 years, the numbers of scientific papers on wheat, barley, potatoes and maize have all stagnated at a level well below 1500 publications per year, with rice being the only staple food plant that shows (slightly) growing attention by scientists (Fig. 2). Since 1996, all these major food crops have received less research interest than our tiny, inconsequential weed plant.

Questioning these contrasting developments could be dismissed as mere envy, if research on Arabidopsis was completely unconnected and unrelated to agricultural research. However, research on this small weed species directly competes against crop research for resources. There is of course competition for money from biological research funds and there is also competition for people. Scientists are often judged not only by how many publications they have produced but also by how many times their publications are cited by other papers. Following just this criterion, it would be more "reasonable" for a scientist to study Arabidopsis than to study wheat, because there are more colleagues around who will cite an Arabidopsis publication. Also, as it currently stands, Arabidopsis simply offers a gateway to larger networks, i.e. more job opportunities for biologists than research on crop plant biology.

The standard reply to this critique would be that only the focus on one plant species can generate the comprehensive knowledge that is needed to understand how plants work in general. Arabidopsis is a model plant, so knowledge gained in this species may then easily be transferred to other species – such as crop plants. Indeed, fundamental research is necessary and justified, as long as it is kept in a reasonable balance with applied research and as long this type of knowledge transfer within science actually happens. Undoubtedly, many findings from Arabidopsis research have improved the understanding of crop genetics and physiology.

However, the promise to deliver in the area of food plants by studying model species, has so far come to only relatively limited fruition. If the exciting advances in Arabidopsis research were indeed easily and readily transferred to crop plants, would we not expect a noticeable increase in the research output for these food plants as well, stimulated by new knowledge gathered in the "model" species?

A look at Figure 2 shows that this has, at least in the last 15 years, not been the case. A closer look at Arabidopsis papers confirms that their direct impact on crops research has been relatively marginal. For example, in the years 2004 to 2008 Arabidopsis publications were cited by a total of 26,555 papers. Of these, 62.5% were again papers on Arabidopsis, but only 1.4% were papers on barley, and only 0.2% were on rye. Arabidopsis research, it seems, is mainly just generating more Arabidopsis research. Second, Arabidopsis is not even an ideal model plant, because in many respects it is a quite untypical plant species (e.g. regarding its relatively low number of chromosomes[3]).

Belonging to the crucifer family, it is only very distantly related to cereals. Of course, understanding the molecular and physiological intricacies of Arabidopsis does not help in many questions of designing and optimizing cropping systems. Although Arabidopsis research has helped to solve some major physiological and molecular conundrums in crop species, how much will that facilitate the design of intelligent rotations, the optimization of seed rates and sowing dates, or the improvement of mechanical weed control?

Although it is clear that fundamental research on model plant species is essential to understand plants in general, it appears that current Arabidopsis science is at risk of becoming mostly self-referential.

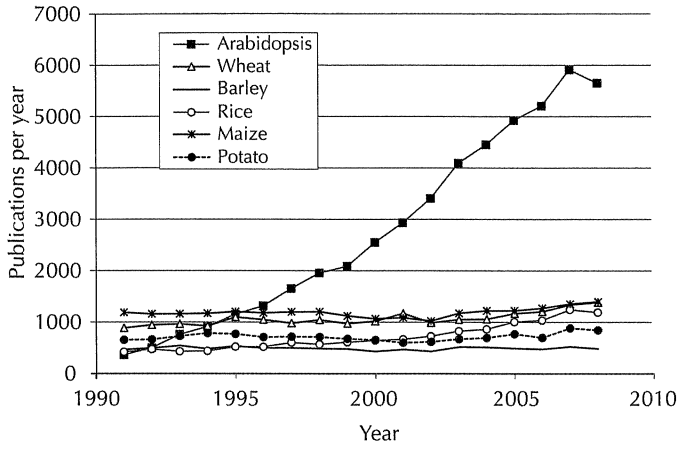

Figure 2: Number of scientific publications per year for Arabidopsis and selected crop plants

This is of particular concern if scientists defend their research on this model species with arguments of applicability to food plants.

In the last few years, the aim "to feed nine billion people by the year 2050" has been taken up almost universally as an explicit target for food production and is being repeated over and over again. Even allowing for some media hype, we might need to acknowledge that the sense of urgency regarding the future of food production is based on real developments. In that case, should we not expect that agricultural research is being boosted, that public research funds are increased to find the best and most resource-efficient ways of producing healthy food, and that scientists, even if they are only following the funds, increasingly turn their efforts towards solving this "food crisis"?

In fact agricultural research is stagnating, if not positively crumbling, while at the same time immense research efforts are being put into an ever-more meticulous understanding of an insignificant crucifer. If we are to have any hope that agricultural productivity can be maintained and increased sustainably in the future, research priorities in biology need an urgent review. While fundamental research into plant biology is essential and should not be dismissed in general, it is crucial that its applicability in designing sustainable food production systems is questioned and monitored. Importantly, future crops research should not just concentrate on a few species of staple crops, thereby neglecting the vast diversity of usable crop plants. In the end, the massive work on the tiny thale cress may play a role for understanding the diverse species suitable for human consumption, but we expect that it will be rather limited. We may be able to eat many plant species, but Arabidopsis is not among them.

Notes and References
(1) According to a search on ISI Web of Science, the largest database of scientific publications.
(2) Again based on a search on ISI Web of Science; the searched publications comprise only peer reviewed papers, i.e. conference proceedings and abstracts are not included in the numbers.
(3) LYSAK MA ET AL. 2006. Proc. Nat. Acad. Scie. 103: 5224. doi: 10.1073/pnas.0510791103.

Using non-organic plant material and animals in organic production – a Swiss solution

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Amongst the countries of the world, Switzerland has the reputation of being one of the toughest regulators of organic production. In practice though, how true is that image?

Swiss organic farmers are strictly controlled with regard to conversion of the whole farm in contrast to only partial conversion from conventional to organic farming in many other countries and they are also very regulated with regard to the use of plant material and animals from non-organic production systems.

However, even Swiss organic farmers have had to acknowledge that it is very often difficult to obtain such material from organic production and there is therefore a need for some exemptions - which again have to be controlled very closely.

Bio Suisse creates solution

With typical Swiss discipline a creative, pragmatic solution has been developed. The Swiss umbrella organization for organic producers "Bio Suisse" has created a procedure for such exemptions from organic standards, in which all the producer organizations in Switzerland are very much involved.

They have also decided that the use of non-organic plant materials and animals should not be "a cheap way out" for organic producers.

The system is based on a levy, put on the plant and animals from non-organic production to bring the price up to the comparable level of such materials from organic production systems. This means that there is no financial incentive for organic producers to use non-organic material.

Funding future fixes

The income from the levy is then used to reduce the price for organically produced seed and for funding support to increase the production of organic plant materials and animals. This delivers fair regulation of the exemptions today but also builds hope for a truly organic-sourced production system for the near future.

The whole system is very transparent and all producers know why there is an exemption, for how long this exemption will last and what is happening with the money from the levy.