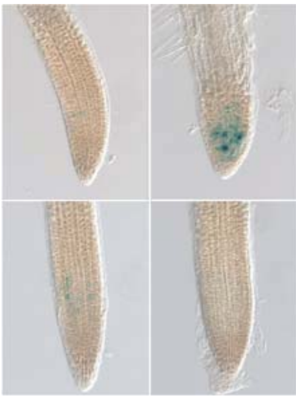
Toxicity-Resistant Crops

Researchers have engineered aluminum-tolerant crops.

By Mason Inman

Thursday, October 02, 2008

Much of the world's cropland contains aluminum that stunts crops. But a new study has found a way to make plants grow tall in spite of the metal's toxic effects. The discovery, by plant biologists at the University of California, Riverside, suggests that genetic engineering could boost yields from fields that today are not ideal for growing crops.



Aluminum foiled: When aluminum in soils gets activated by acidic conditions, it damages plants' DNA. In response, normal root cells stop in the middle of dividing (top row). But in plants with a mutation that makes them blind to the DNA damage, root cells keep dividing, bypassing aluminum's stunting effects (bottom row).
Credit: Megan Rounds and Paul Larsen, Current Biology publication date: Oct 2, 2008 (online) and October 14, 2008 (print)

Aluminum is common in soils--it's a major component of clay--but only in acidic soils does the metal form an ion that can dissolve into liquids and that's toxic to plants. Acidic soils make up as much as half the world's croplands, however, and aluminum toxicity is the main factor holding back crop growth in nearly 20 percent of the world's arable soils, including large areas of the United States east of the Mississippi River and northwestern Europe.

"The problem is, we have all these crop plants--wheat and corn and barley and so on--that didn't evolve or get developed on aluminum-toxic soils," study leader and professor of biochemistry Paul Larsen says. "They don't have natural resistance or tolerance to aluminum." Plant breeders are working on developing strains that can cope better with toxic aluminum, but they have only been able to make incremental improvements, Larsen says.

Story continues below

In a study in *Current Biology*, Larsen and his colleague Megan Rounds have uncovered a simple mutation to a single gene that makes plants thrive in spite of levels of aluminum that would normally be toxic. Larsen and Rounds found the gene, called AtATR, by combing through mutants of *Arabidopsis*, a member of the mustard family that's commonly used in plant-genetics studies. The gene is related to a family of proteins known to help with finding and responding to DNA damage in nearly all multicellular organisms.

Toxic aluminum ions are known to damage DNA, and the new study suggests that plants respond by shutting down growth of cells in the tips of their roots when they accumulate too much DNA damage. Plants may have evolved this response to help them, over generations, cope with aluminum's toxic effects, Larsen speculates. But in the short run, it means that the plants are less healthy and are stunted and more vulnerable to stressors such as droughts.

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Questions on edibility
It would seem reasonable to question the edibility of crops with high levels of aluminum. Is there an increased risk of dna damage in people or livestock. It might seem that if used with bio fuel crops, this new technology would make otherwise poor crop land productive.

Could an alternative be to change the acidity of the soils to make them more alkaline, or is this solution too costly.

Could the mutated gene "AtATR" be used to encourage other mutations in plants for scientific study with mutation rates modulated with soil acidity levels, possibly even during the plants life cycle. Each generation, select for desired characteristics.

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shomas
10/02/2008
Posts:44
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Re: Questions on edibility
I worked on this project and the possibilities are rather exciting. We hadn't considered its utility for biofuel crop production, but that's certainly an interesting application!

As to the levels of aluminum in the crops, it depends on whether the crops themselves are bioaccumulators. Most aren't, as Al bioaccumulators are also Al-tolerant plants. Tea is one such accumulator, and people have been consuming it for thousands of years.

Aluminum-rich soils can be treated with ground limestone to raise the pH and allow for crop growth, but this is expensive, labor intensive, and short-lived as Al-rich soils are often sandy and ions tend to leach out over time (hence the acidic pH).

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soil ph conditioning crop.
Is it possible and would it be of any benefit to engineer a plant for conditioning a soils PH, making it more alkaline, and used every other year on soils other wise normally too acidic.

shomas
10/04/2008

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- **Re: Questions on edibility**

  Foods genetically modified in a way that allows "more genetic damage" as stated in the article, may not be accepted by the general population as
  quickly as modified plants for bio fuel might be.

  I looked at http://en.wikipedia.org/wiki/Soil_pH and it says "Many nutrient cations such as zinc (Zn^{2+}), aluminum (Al^{3+}), iron (Fe^{2+}), copper (Cu^{2+}), cobalt (Co^{2+}), and manganese (Mn^{2+}) are soluble and available for uptake by plants below pH 5.0", and at http://en.wikipedia.org/wiki/Acidosis "Blood pH values compatible with life in mammals are limited to a pH range between 6.8 and 7.8. Changes in the pH of arterial blood (and therefore the extracellular fluid) outside this range result in irreversible cell damage".

  From that can I assume, Because humans have a ph of 7.35 to 7.45, they wouldn't normally have to worry about aluminum ions damaging their dna?

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  shomas
  10/02/2008
  Posts:44
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- **Okay, props to the editor...**

  ...for the "aluminum foiled" caption.

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  Monsterboy
  10/02/2008
  Posts:90
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pandoras box

For someone, who, after having done all the major work that he needed to do in philosophy and metaphysics by the age of fourteen, and quite literally played the Sorcerers Apprentice for his fifteenth year, I know firsthand just how foolhardy and dangerous that the search for real esoteric knowledge can be. Although our recent attempts at genetic manipulation would seem to be an almost biological necessity in the face of fighting pandemic diseases and promoting hybrid plants, it is also, at least to my way of thinking, just a modern form of alchemy. Ancient texts on the subject, some of which are still in existence today, reveal that inexhautible and equally foolhardy desire to quite literally turn dross into gold. If todays scientific community published a modern online compendium of each experiment which has been undertaken so far to achieve that very same effect, I'm sure that it would be an interesting study in how human nature never quite changes regardless of its present circumstances.

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phoenix
10/02/2008
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Any reason for concern here?

It would seem that disabling a pathway which evolved to detect genetic damage (and respond by shutting down further replication using that damaged 'blueprint') might present some risk of unleashing tumorous growth, depending on the range of possible genetic damage involved... At least we supposedly aren't talking about anything which might affect changes to germplasm, i.e. allowing the alumina-content of the substrate to somehow have an impact on the SEEDS produced later by the plant.

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flared0ne
10/02/2008
Posts:80
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- **Re: Any reason for concern here?**

  The article proposed this "To avoid DNA damage accumulating over generations of growing on aluminum-rich soils, farmers could obtain seeds from mutant plants grown on aluminum-free soil."

  On a side note, could it be possible to genetically engineer the plant to sense ph, When ph drop too low cells make an alkaline keeping the plants ph at a level to prevent dna damage?

  shomas
  10/04/2008
  Posts:44
  Avg
  Rating:

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