A novel fertilization and weed control system based on transgenic plants able to metabolize phosphite

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Poor soil fertility and aggressive weeds pose major constraints to meeting the increasing demand for global food production. Starting with the green revolution in the 1960s, higher yields have been accompanied by a steady increase in the use of fertilizers and herbicides. Phosphorus (P) is a nutrient that limits crop yield in over 60 percent of the world's arable land. To increase plant productivity in soils with low P availability, several million tons of P fertilizer is applied every year to agricultural soils. However, by some estimates, world resources of inexpensive P may be depleted by 2080. Low Pi availability in the soil is mainly due to its high reactivity with soil components and rapid conversion by soil bacteria into organic forms that are not readily available for plant uptake. Due to both of these factors, as little as 20–30% of the Pi that is applied as fertilizer is actually used by cultivated plants. The inefficient utilization of Pi present in fertilizer is further aggravated by the competition of weeds with crops for soil resources. Because Pi cannot be substituted in plant nutrition, relatively little attention has been given to the use of other chemical forms of phosphorus to formulate effective and potentially less environmentally hazardous fertilizers. Phosphite, a reduced form of phosphorus, was proposed as a promising alternative fertilizer after the Second World War, owing to its distinct chemical and biochemical properties compared with orthophosphate, including higher solubility, lower reactivity with soil components and the inability of most microorganisms to use it as a phosphorus source. However, plants cannot metabolize phosphite, limiting its use as a fertilizer.

In this presentation I will report on the development of a novel fertilization and weed control system by engineering plants to metabolize phosphite. This was achieved by expressing a phosphite oxido/reductase that converts phosphite into Pi, in transgenic plants. When grown in soil that contains native microflora and fertilized with phosphite, engineered plants expressing the phosphite oxidoreductase achieve maximum productivity with 30 to 50% less P than that required to reach the same productivity using Pi as fertilizer. Since non-engineered plants are unable to use phosphite as a P source, when fertilized with phosphite the engineered plants easily outcompete weeds reducing or eliminating the need for herbicides to achieve maximum yield. In contrast to Pi that when released from contaminated rivers into the ocean promotes toxic algal blooms that kill aquatic organisms, phosphite should not cause these severe ecological problems since it cannot be used as a nutrient by algae. Thus these metabolically engineered plants allow the design of a dual fertilization and weed control system with both potentially important economical and ecological benefits.