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Phosphorus in Agriculture: Need for Efficient Use and Re-Use

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Due to the global climate change and rapid increase in world population, there is a need for efficient agriculture and food production. Yet, intensive modern agriculture has created a strong demand for fertilizers, and in the future, there may be an acute limitation in the availability of these resources, especially for phosphorus (P).

Phosphorus (P) is the 11th most abundant element of the earth's crust. Phosphorus (P) is an essential element for all living organisms. The world's main source of P is phosphate (Pi) rock. It is a non-renewable resource. There is neither any alternative to P nor a synthetic way of creating it. P is involved in various basic biological functions, for instance as a structural element in nucleic acids, or as an essential component of the energy carrier, phospholipids, and of numerous metabolic intermediates [1].

Plants require large amounts of P for growth and development, and acquire it from the soil mainly in its ionic form (phosphate, Pi). Being one of the most immobile nutrients in soils, Pi is poorly available for plants [2,3], and consequently severely affects thier productivity. Therefore, to compensate Pi limitation in soil and to ensure maximum crop yield, an excessive use of Pi fertilizers is a current agricultural practice. Neverteless,crops take up only 15–30% of the applied Pi fertilizer within the year of its application [4]. As stated by [5]. we have to "Feed the crop not the soil ». In addition, using high levels of Pi fertilizers is costly and associated with environmental degradation such as pollution and eutrophication of surface and ground waters. It is important to note that even small P additions to lakes and streams can have a big impact on water quality. The amount of P causing water quality problems is very small compared to the amount of P required for crops or the amounts contained in manure and P fertilizers.

Using high levels of Pi fertilizers is non-sustainable.The global P reserves are becoming increasingly scarce [6,7] and consequently a potential Pi crisis looms for agriculture in the 21st century [6,2] Some predictions indeed suggest that the current Pi reserves will be nearly exhausted within a few decades [7]. In 2009, the US Geological Survey estimated the total mineable Pi rock reserves at 15-16 billion tons. The severity of the situation is appearing clearly when considering that >1% of these reserves were extracted that same year to produce fertilizers [8]. At the same time, reduced Pi availability led to a rapid increase in market price. During the 2008 food crisis, fertiliser prices soared and the commodity price of Pi rock increased by 800% over a period of 18 months [2]. Recent European Union's report clearly demonstrates the vulnerability of the European food system to future P scarcity (Sustainable Use of Phosphorus: ENV.B.1/ETU/2009/0025). Thus reducing Pi flows through the agriecosystems by having crops displaying a better Pi use efficiency is an imperative goal. It is thus clear that research on Pi nutrition in plants is of primary practical interest and should lead to changes in agricultural practices that would be both economically and environmentally beneficial.

Collectively, the aforementionned issues constitute compelling socio-economic and environmental reasons for advancing our knowledge on the P nutrition in plants. Although, our understanding of adaptive mechanisms regulating Pi homeostasis in plants has been significantly progressed the last years, the discovered genes and pathways are not operating in all stress conditions known to alter the Pi homeostasis [9-11]. This indicate the existence of additional unknown genes regulating the Pi nutrition in plants that remains to be cloned. Developping this knowledge will be a basis for the improvement of Pi use efficiency by plants, reducing plant dependency on Pi-fertilizers while maintaining an optimum yield, and will offer optimistic view on the capacity of the world to sustain additional billion people in the next decades.

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