companies by early-stage funding, research alliances and licensing contracts. Fresh attitudes to stimulate pioneering and interdisciplinary partnership with expansive and dissimilar exploration itinerary with interfaces between multiple individuals and universities are the future. Reciprocal interchange between divergent groups, exchanges and visits from other research institutions with different interests that encourage easy-going encounters may generate interest clusters dedicated to specific enquiry or methodical tactics.

Residence for workers and transportation have challenges. There should be accommodations to house the people working at the ventures so that they can spend their time in creative work and could visit the laboratory as they wish. The preferred design should involve a bridge connection between the scholars residence, laboratory, library, computation facility, cafeteria and gymnasium. A good cafeteria is an excellent place for tea and interaction and should create a friendly atmosphere. A high-speed internet and digital access to scientific literature is also a must. There should also be a machine shop for repairing and building instruments.

Governments have the supremacy to navigate the course of science through broad funding precedence. The young investigators should be given adequate 5 yrs start funding and seed money to start a laboratory. About 10% of National budget should be reserved for enterpreneurial projects to seed young companies to inspire the beginning scientists who could make a difference with their research in creating job opportunities.

Instead of building new facilities, the money may be well used for starting new graduate programmes where advanced scholars trained in physics, mathematics and statistics are immersed into biology to bring a new revolution. The new mindset is needed to confront the problems of future and time for shift from old strategy to new is now. The go-getters who want to chart sturdy ingenious fancies in discerning new areas and wonders of nature for the public good, should not be restricted but encouraged and cheered.

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Massive phosphorus accumulation in soils: Kerala's continuing conundrum

In general, 16 nutrients are essential for normal plant growth. Of these, plants derive three major nutrients (C, H, O) from air and water, and the remaining from the soil. Nitrogen (N), phosphorus (P) and potassium (K) though required in large amounts, are not adequately available in the soil to support plant growth and hence, are supplied through exogenous sources like fertilizers and manures.

Here we focus on P, a major nutrient required for root formation and growth, synthesis of starch, protein and fat. Also, being a constituent of nucleic acids, it is closely concerned with vital plant growth processes. Like any other nutrient, P availability to crops is largely influenced by soil pH. The ideal soil pH is close to neutral and neutral soils are considered to fall within a range from a slightly acidic pH of 6.5 to slightly alkaline pH of 7.5. It has been determined that most plant nutrients are optimally available to plants within this pH range 6.5–7.5. Also, this range is generally compatible to plant root growth.

While among the major nutrients, N and K appear to be less affected directly by soil pH, the availability of P for plant uptake, however, is directly affected by soil pH. At acidic pH values (< 6.5), phosphate ions react with aluminum (Al) and iron (Fe) to form less soluble compounds which are unavailable to plants. This is a universally proven and accepted fact. Simply put, acid soils possess high P-fixing capacity.

In Kerala, characterized by heavy rainfall and extreme humid conditions, 90% of the geographic area is covered by laterite soils, which are inherently acidic. A recent study by the Kerala State Planning Board[1] involving a comprehensive analysis of soils from all the Panchayats across all districts of the state (Figure 1) shows acidity at a whopping 91% of the samples tested, with 54% of the samples testing for strong to extremely acid reaction ($\text{pH} < 5.5$). Thus P availability should have been seriously hampered in these soils, making it unavailable to crops. Surprisingly, this is not the case. We now have a situation with 61% of the samples (Figure 2) registering high (25–35 kg/ha) to extremely high (100 kg/ha) available P levels[1].

High P levels in these soils are usually due to over-fertilizing (through high analysis complex or straight fertilizers) or adding too much manure. Since crops readily respond to N, growers would have historically applied enough chemical

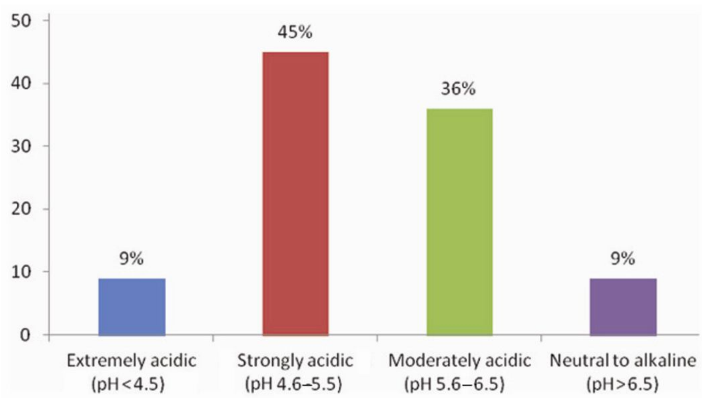

Figure 1. Frequency of soil pH classes across all districts of Kerala (n = 156,801).

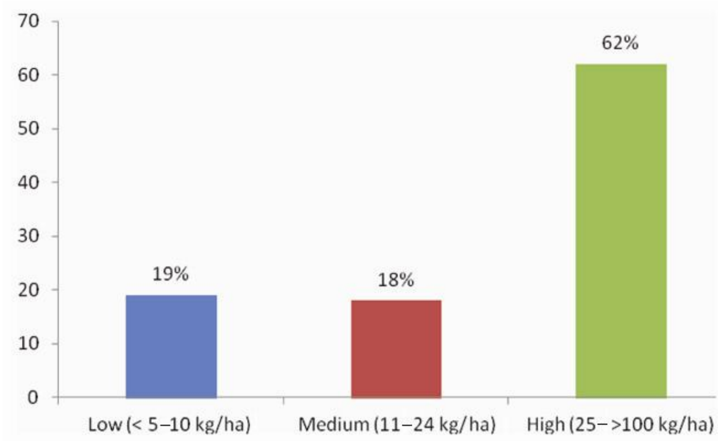

Figure 2. Frequency of soil-available phosphorus classes across all districts of Kerala (n = 150,281).

fertilizers or manures to meet the N needs of crops, unaware that they are applying several times the needed amount of P. Because manure rates are typically based on crop N requirement, concomitant P rates are 2–5-fold greater than crop needs[2]. Therefore, repeated application of manures based on N requirement could have caused P to accumulate in the soil.

High soil P levels would cause a cascading effect, wherein P loads would affect the availability of a nutrient which in turn would affect the cycling of another nutrient, thereby triggering a chain reaction which would predispose the crops to pests, diseases and other physiological disorders resulting in total crop failure. Also, in soils with high P levels, significant amount of soluble P can exist in the run-off water from these sites and can significantly impact water quality in nearby streams and lakes. Studies have shown that the concentration of P in run-off and potential P transport to surface and groundwater increases when P application rates exceed crop requirement[2].

Soils with 300 ppm P will take up to 5 years to reach acceptable levels or in the worst-case scenario may require as much as 15–20 years of continuous cropping, with no added P during that time, to reduce high P levels. Therefore, a practical approach would be to skip application of high analysis or complex fertilizers containing P in such soils. Besides, reducing or total avoidance of manure with high P levels is a good option. This is especially true if manure is being added to increase N levels in the soil. Also, periodical soil testing from recognized laboratories and soil test-based nutrient management are imperative to deal with the possible fall-outs from excessive P accumulation in the soils of Kerala.

1. Rajasekharan, P., Nair, K. M., Rajasree, G., Sureshkumar, P. and Narayanan Kutty, M. C. (eds), *Soil Fertility Assessment and Information Management for Enhancing Crop Productivity in Kerala*, Kerala State Planning Board, Thiruvananthapuram, 2013, pp. 1–514.
2. Havilin, J. L., *J. Anim. Sci.* (*Suppl. E.*), 2004, **82**, E277–E291.

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