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Using Simplified Kinetic Model of Fertilizer-P Availability Index to Monitor Soil Available P in Vegetable Field

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Soil available P as determined by chemical extractants is commonly used as a direct index for P fertility, which is correlated with plant P uptakes and crop responses to P that leads to actual fertilizer P recommendation. Accurate fertilizer P recommendation relies on appropriate interpretation of soil testing results. However, after application of fertilizer P into soils, it may go through many complicated reactions, i.e. adsorption, fixation, precipitation, etc. The P availability after fertilization is also dependent upon the P-fixation tendency of the soil, which is expressed as fertilizer-P availability index (F_{PI}) of the soil, and is estimated by the slope of the linear regression between chemical-extractable P and fertilizer P added. Several researchers had proposed an alternative approach to improve fertilizer P recommendation by taking into accounts both extractable P prior to fertilizer application and the fertilizer-P availability index of the soil. Moreover, many experiments have shown that after P application, labile P decreased rapidly with time due to the initial fast adsorption of P by soil, followed by a much slower decrease in labile P which continues for several years. Thus, in consideration of the additional "time" factor, we may further improve the accuracy of estimation on available P status after fertilizer P application. This research aims at understanding kinetic changes of soil available P after fertilization and establishing kinetic model for fertilizer-P availability index. An improved method for estimation of available P in vegetable fields based on simplified kinetic model of $F_{PI,}$ initial level of extractable Olsen-P before fertilizer P application (P_0) and P removals by vegetables is proposed.

Twenty soils collected from major vegetable-grown areas throughout Taiwan were treated with five rates of P and incubated for 0 to 180 days and Olsen-P was determined. For all tested soils at all incubation intervals, the extractable P was linearly correlated with P applied. Changes of the slopes of these linear regressions (as F_{PI}) with time were best fitted to Elovich kinetic models:

Fertilizer-P Availability Index (F_{PI}) = a + b* ln (t), where t is incubation time (days, t = 0.03~180) and a, b are model parameters. In most soils tested, F_{PI} decreased rapidly in first 10 days of incubation and reached a stable status afterward, indicating rapid reaction between soil and P in first 10 days. However, in calcareous soil, F_{PI} decreased continuously from 10 to 180 days, showing obvious slow reaction between soil and P. When t equals to 1 day, then $F_{PI} = F_{1day} = a$; while $F_{PI} = F_{10\ days} = a + b*2.3026$ if t equals 10 days, by solving these equations, we can obtain the kinetic regression model for individual soil. Therefore, F_1 and F_{10} can be treated as soil properties representing P-fixation tendency of an individual soil. Practically speaking, one can obtain the simplified kinetic regressions by measuring the extractable P at incubation time of 0, 1 and 10 days. With the kinetic regressions, we can calculate the F_{PI} at any time during a vegetable growth period. Together with the linear relationship between extractable P (P_{Olsen}) and applied P ($P_{Applied}$) for each soil: (P_{Olsen}) = $P_0 + F_{PI}* P_{Applied}$; we can easily compute soil available P at any time within the vegetable cultivation periods. Since most vegetables remove P (10-60 kg/ha) much less than the removal of N, it can be simply subtracted P removal from the amounts of P applied. Therefore, it is possible to monitor available P in vegetable fields with known amounts of fertilizer inputs for several vegetable cultivations.

The proposed method is validated in an incubation study and in several vegetable fields grown with tomato, cabbage and vegetable soybeans. Predicted available P values from proposed equations were highly correlated with actual amounts measured. These results indicate that the proposed kinetic model combined with the linear relations between applied P and extractable P provides an easier way to monitor available P in soils. The estimation can be computed based on individual soil, the determination of available P only requires a simple colorimeter and the F_{PI} of a particular soil is stable for several years, hence, the methodology is more applicable to locations where frequent soil analyses are not feasible.