Sustaining Crop Production in the Developing World through "The Nutrient Buffer Power Concept" – A Case Study with Black Pepper (*Piper nigrum*) growing at low pH in the laterite soils of India

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Abstract

Black pepper is the most important spice crop of the developing world and its acreage is the largest in India. It grows in the laterite soils of southern India, in the State of Kerala, where the soil pH is low (4.5-5.5). The importance of black pepper (*Piper nigrum* Linnaeus) is critical to the economy of the State because of the recently launched ASEAN FTA (Association of South East Asian Nations Free Trade Agreement), which will threaten the livelihood of black pepper farmers because of severe competition from Vietnam. black pepper can be devastated by the fungus *Phytophthora palmivora*, causing "Quick Wilt", and a deficiency of soil Zn leading to a deficiency in the plant tissues: and Zn deficiency is seen as the main cause for the onset of the disease. The black pepper farmers suffer severe economic losses because of this devastating disease. Conventional methods of soil application of Zn fertilizers has not led to a satisfactory outcome. A revolutionary soil testing procedure, now globally known as *"The Nutrient Buffer Power Concept"*, developed by the author, has brought about remarkable results on farmers' fields, leading not only to a recovery of the pepper vines, but, in a large measure saving of Zn fertilizer use, thus greatly helping the farmer economically.

Key Words

Black Pepper, Blanket Recommendation, Zn Buffer Power, Zn Fertilizer, Laterite Soils, Kerala State, India

Introduction

In the soil-plant continuum for sustainable crop production, the question of precisely defining and accurately quantifying nutrient bio availability has not been successfully addressed. If it has been the case, the so-called "green revolution", which hinges on a "high-input technology" (of fertilizers, pesticides and water), especially that of fertilizers, would not have failed the way it did, causing a number of soil-related problems on the Asian continent, in particular, India. This paper discusses the merits of a revolutionary soil testing procedure, based on the Zn buffering mechanism, in precisely defining the bio availability of Zn to black pepper, a deficiency of which is the prime cause for the devastating pepper disease, "Quick Wilt", caused by the fungus *Phytophthora palmivora.* The department of agriculture and the State University of Agriculture in Kerala, and its affiliated research stations, where black pepper is extensively grown, routinely recommend 25 kg Zinc Sulfate per ha to correct the problem, irrespective of the soil or region. The current research sets out to question this hypothesis, through a revolutionary and novel approach based on the Zn buffer power of soils.

Methods

Basic Concept: Using Fick's first law, $F = -D(dC/dx)$, where F = the flux, dC/dx = the concentration gradient across a particular section and D = diffusion coefficient, Nair (1984) proposed an operational model to define the Zn "buffer power" of soils, which was quantified by an adsorption – desorption equilibrium technique (Nair, 1996). The "r" values were calculated by correlating the Zn "intensity" values, as represented by electro-ultra-filtrable Zn or Zn in equilibrium solution determined by an adsorption-desorption equilibrium technique (x) with DTPA extractable Zn from soil incubated series (Y). The "b" values, referring to the Zn buffer power were compared with the "b" values obtained by another technique using electro ultra filtration and they compared very well (Nair, 1996). Zn buffer power of individual soils was integrated into the computations as a multiple regression function. Using this model, Zn uptake was accurately defined by growing pepper plants and a reliable Zn fertilizer schedule was practically devised, which was communicated to the farmers. The Zn fertilizer application was a single dose basal application based on the Zn buffer power of the soil.

Results

The investigation refers to three typical soils from the State of Kerala, India, where black pepper is extensively grown, whose Zn buffer power varied from as low as O.7824 to as high as 3.0358 (Table 1).

Table 1. Zn buffer power of Pepper Growing Soils

Soil (Region)	"r" value	"b" value
Peruvannamuzhi	0.8337 ***	0.7824
Thamarasseri	0.9304 ***	1.5786
Ambalavayal	0.9604 ***	3.0358

Note: *** Significant at a confidence level of 0.1 per cent. Note the very high correlation coefficients. "b" values represent the Zn buffer power.

Data in Table 2 clearly demonstrate how the different correlations are improved by integrating the Zn buffer power values in the different computations

Table 2. Correlation Coefficients ("r" value) for the Inter-Relationship between Routine DTPA soil test *versus* Zn concentration, Zn uptake and Dry Matter Production without (1) and with (2) Zn buffer Power Integration.

Details	1	2
Zn concentration ***versus*** DTPA test	0.884 ***	0.924 ***
Zn uptake ***versus*** DTPA test	0.782	0.862 ***
Dry matter production ***versus*** DTPA test	-0.745	0.777 ***

Note: *** Significant at a confidence level of 0.1 per cent

The most interesting data, however, are given in Table 3 (below).

Table 3. Pepper Yield from Farmers' Fields (kg/vine) Weighted Against the Zn Buffer Power of the Soil

	Yield		
Region	Targeted	Actual	Deviation (%)
Peruvannamuzhi	0.241	0.401	+66
Thamarasseri	0.490	0.487	+0.6

Target weighting was done against the highest yield obtained from the *Ambalavayal* region, (*Ambalavayal* yield taken as 100 per cent) which turned out to be the most ideal soil for black pepper cultivation, as it had the highest Zn buffer power (Table 1). For all comparisons, a specific area was chosen from each soil group, where the number of vines in each plot was the same. There was remarkable closeness between targeted yield and actual yield in the *Thamarasseri* region (just 0.6 per cent variation between the two, Table 3), which again, is a very good soil for black pepper cultivation like *Ambalavayal* soil, which is the most ideal for black pepper cultivation as it had the highest Zn buffer power. Note that the deviation between targeted yield and actual yield in the case of *Thamarasseri* soil is only 0.6 per cent, while *Peruvannamuzhi* soil which is an atypical soil for black pepper cultivation, showed a variation of 66 per cent between targeted yield and actual yield. This clearly suggests that the farmers are being wrongly advised to apply the same quantity (25 kg/ha) of Zn sulfate fertilizer as "blanket" recommendation. In other words, a black pepper farmer of Ambalavayal (a highly Zn buffered soil) needs to apply only about 25 per cent of the Zn fertilizer applied as in the case of *Peruvannamuzhi* soil (a very poorly Zn buffered soil) soil, and for the *Thamarasseri* soil the requirement is about half. The "b" values (Table 1) clearly substantiates this very important and crucial finding.

Conclusion

The results have established some very remarkable findings. Both Zn concentration and Zn uptake predictability were remarkably improved by the Zn buffer power integration into the computations, the former by a margin of 17 per cent and the latter by a margin of 15 per cent as shown by the coefficient of determination. The most striking observation was the negative correlation between the routine DTPA test and Black pepper dry matter production, which changed to a positive correlation when the Zn buffer was integrated into the computations. The cruciality of Zn buffer power in determining black pepper yield was demonstrated by the fact that the targeted grain yield in farmers' fields varied with only a minimal margin (0.6 per cent) in the *Thamarasseri* soils when the Zn buffer buffer power data was also incorporated into the computations lending further creditability to the fact that, in fact, using the Zn buffer would be the most reliable factor in devising precise Zn fertilizer schedules for field application by black pepper farmers of Kerala State, India, and not through the routinely employed DTPA test, as is being widely and currently practised.

References

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