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Baule Units in Augmenting Analysis of Nutrient Interactions

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Abstract

Time-line of the development of Baule concept is traced. Baule concept is a useful tool to understand the interaction of nutrients in deciding the ultimate productivity achievable. Its' usefulness is brought out thru a analysis of fertilizer trials in tea.

Keywords

Baule concept, Units and equivalents.

Introduction

Crop responses are site specific and crop specific and are characterized by 1) threshold yield supported by soil inherent fertility or the base yield and 2) over and above that, the yield responses to nutrients reaches a plateau (Fig. 1), which progresses exponentially to infinity

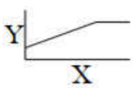

Fig. 1:

Several attempts were made to quantify the relationship using simple linear ones to complex curvilinear ones with multiple components (Colewell, 1977-79 and Cate and Nelson 1965).

1) Liebig (c. 1860, German) (linear)

$$Y = mX + b$$

Fig. 2:

Where

- Y = yield
- m = slope - i.e. rate of yield increase. It is a function of the environment and nutrient.
- x = amount of nutrient added.
- b = minimum yield, one would get this yield with no nutrient additions.

2) Mitcherlich (1910 German) Law of Diminishing returns (Fig. 3)

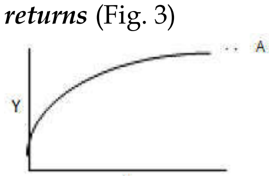

Fig. 3:

The response dy/dx Is exponential – The response goes on decreasing due to some limiting factor. The Mitcherlich concept is explained as

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below:

1. dy/dx =(A-Y) C On integration
2. log (A-Y) = log A – CX

Where

A = maximum possible yield (theoretical)

Y = actual yield

dy/dx = slope i.e. rate of increase in yield

X = the amount of nutrient added

C = constant (efficiency coefficient of factor 'x')

3) Bray (1920 Illinois)

Bray improved the Mitcherlich concept by recognizing the various interacting factors that determine 'dy/dx' and 'A' leading to widly accepted Mitcherlich-Bray equation.

$\text{Log (A-Y)} = \log (A) - C_1B - CX$

where

A = maximum possible yield (theoretical),

Y = actual yield

dy/dx = slope i.e. rate of increase in yield

X = the amount of nutrient added

C = constant (efficiency coefficient of factor 'x')

C_1= the efficiency coefficient of 'B' B=term to include soil nutrients (Ca, Mg, P, K, etc.,) and their interactions. In practice OM content is used as 'B'.

4) Baule (1920 German)

Extending the MItcherlich's concept Baule showed that;

$Y = A - A(1/2)^x$

Where 'x' in baule units

Y = actual yield and A= maximum theoretical yield.

Baule unit is defined as the amount of nutrient when added results in moving 'Y' (yield) one half way closer to 'A' (maximum possible yield).

Practically speaking one baule unit will give 50% yield, the second ball will give 50% of 50 i.e. 25% yield As such 2 baules will give 75% yield. Third baule will give 50% of second baules yield 12.5% i.e., 50% of 25. As such 3 baules will give 87.5% yield and so on.

It is useful to understand the impact of nutrient interactions on yield. For example if soil contains three baules of N (87.5% Yield possibility), two baules of P (75% yield possibility), four baules of K (94% yied possibility, the yield achievable is 62% i.e., 87.5 *0.75*0.94.

5. Application of Baule's concept to Mitchrlich-Bray equation

The responses to nutrients are studied using the Mitcharlich- Bray equation (Ranganathan et al. 1968).

$Y = Y_{max} - Y_{max} e^{-c1b1 - c2b2}$

$\text{Log } Y_{max} - \text{Log } y = \text{Log } Y_{max} - c_1b_1 - c_2b_2$

'Y' is the yield obtained at soil test value 'b_1' and at the quantity of nutrient added in the form of fertilizer 'b_2'.

'c_1 and c_2' are the efficiency coefficients of soil test value and added fertilizer respectively.

'Y_{max}' is the maximum yield obtainable under a given set of conditions.

With percent yield taking 'Y_{max}' as 100, the equation becomes as follows:

$\text{Log } 100 - \text{Log } Y = \text{Log } 100 - c_1b_1 - c_2b_2$

'Y' is the percent yield taking 'Y_{max}' as 100; 'c_1, c_2, $b_1$and b_2' have the same significance but with different magnitude. The efficiency coefficients 'c_1 and c_2' are fairly constants over widely varying conditions of soil, climate and variety paving the way for consolidating data into a single unified response equation. The actual yield depends on 'Y_{max}' which moves up on removing limiting factors.

Further improvement is made by expressing 'b_1 and b_2' in baule units by dividing baule equvilants so that 'c_1 and c_2' could be made into one i.e., 0.301. Baule equivalent of 'b_1 and b_2' could be obtained by dividing 0.301 by respective efficiency coefficients. Then the response equation could be stated as below.

Log100 –Log Y= Log 100 -0.301 (b_1+b_2) where 'Y' is the percent yield,'b_1' the soil test values in baule unit (soil test value divided by baule equivalent of soil test values, 'b_2' the added nutrient in baules (added nutrient divided by its baule equivalent. The percent yield achievable at application of nutrients in baule units are give in Table 1; The actual magnitude of yield or response to a nutrient depends on y maximum obtainable under a given set of conditions defined by stage in the pruning cycle, heath of bushes, type of jat, and climate. 'Y_{max}' is obtained from manurial trials as follows:

$$\text{Log } Y_{max} = \text{Log } Y_1 + \frac{(\text{Log } Y_2 - \text{Log } Y_1)\ 1/N_1}{1/N_2 - 1/N_1}$$

Where 'Y_1 and Y_2' are yields obtained at input levels 'N_1 and N_2' respectively

Table 1: Baules vs % yield

Baule	% yield	Baule	% yield
0.00	0.00	2.50	82.23
0.02	12.94	3.00	87.50
0.04	24.22	3.50	91.16
0.06	34.02	4.00	93.75
0.08	42.59	4.50	95.58
1.00	50.00	5.00	96.87
1.20	56.47	6.00	98.49
1.40	62.10	7.00	99.23
1.60	67.00	8.00	99.61
1.80	71.28	10.00	99.90
2.00	75.00	∞	→ 100

On an average Soil available 'N' is equql to 0.8 to 1.0 baule unit capable of supporting 45.9 to 50.0% of the maximum yield possible. SOIL 'P' is equal to 2.6 baules capable of supporting 83% of 'y_{max}'. Soil 'K' is equal to 1.6 baules capable of supporting 67% of 'y_{max}'.

The baule equivalent of applied Nirogen varies from 90 to 140 kg N/ha depending on soil pH, time and method of application, form of nutrient. Ammonium sulfate leads the list with highest efficiency at soil pH around 4.8 (lowest baule equivalent). Urea is the least efficient which could be improved by dibbling in the broadcast urea, proper timing of application and with more potassium. For all practical purposes, the baule equivalent of 'N' is taken as 120 kg n/ha.

The baule equivalent of 'P' varies from 13 to 15 P kg/ha. For practical purposes it is taken as 14 kg P/ha. The baule equivalent of 'K' is pH dependent. At soil pH is 70 kg K/ha and at ph above 5.0 it it about 23 kg K/ha. For South Indian Tea soils which have a pH of 4.8, it is taken as 70 kg K/ha.

The responses to N, P and K fertilizers obtainable in South India are presented in Table 2.

Table 2: Responses to N, P and K In South India

Nutrient	Baules	Kg ha^{-1}	% yield
Nitrogen			
Soil	1.0	0	50.0
1. Soil + nutrient	2.0	120	75.0
2. Soil + nutrient	2.5	180	82.3
3. Soil + nutrient	3.0	240	87.5
4. Soil + nutrient	3.5	300	91.2
5. Soil + nutrient	4.0	360	96.7
Phosphorus as P			
Soil	2.6	0	83.1
1. Soil + nutrient	3.6	14	92.7
2. Soil + nutrient	4.6	28	95.8
Potassium as K			
Soil	1.6	0	67.0
1. Soil + nutrient	2.6	70	83.1
2. Soil + nutrient	3.6	140	92.7
3. Soil + nutrient	4.6	210	95.8
4. Soil + nutrient	7.6	420	99.5

Conclusions

Baule concept is useful to understand and assess the nutrient interactions and their responses in terms of productivity. It could be used for fixing yield targets in intensive production programs.

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References

1. FAO -AGRONOMY (354): Soil fertility - Response curves, 1989.
2. Black, C. A. (Charles Allen). *Soil fertility evaluation and control*: ISBN 0-87371-834-8. 1993: CRC Press LLC Florida US.
3. Ranganathan V. Response curve for N fertilization in sugarcane, *Proc. 5th Bien. Conf. Sug. Res. & Dev. Workers,* Coimbatore, Dec. 1964.
4. Ranganathan V, and Natesan S. Agronomic pathways of yield response in tea to correction of zinc deficiency and control of pests Proc. Plactosym VI: 1984.
5. Ranganathan V, Balasundaram CB, Govindaraj K and Soundarajan R.1 Studies on the applicability of Mitscherlich-Bray equation for crop response studies. *Fertilite,* 1969:33.