https://doi.org/10.29321/MAJ.10.A02910

Madras agric. J. 66 (1) : 1—5, Jan., 1979.

Use of Mitscherlich Model for Efficient and Economic Fertilizer Use

C.S. BALASUNDARAM[1]

Field experiments were conducted at six different locations with sorghum to study the response to nitrogen. Based on the efficiency factors of soil and fertilizer nitrogen, the fertilizer recommendations were calibrated which can help to reckon the fertilizer dose in cognizance to the soil test value. Further, it provides an opportunity to the farmer to tailor the yield target in tune with his monetary considerations Also, an attmpt was made to work out the optimum rate of nitrogen with Mitscherlich model for arriving at cost : benefit details.

The patterns of yield response to fertilizers are complex. In an attempt to summarize data, simplify interpretation and to forecast fertilizer requirements, mathematical models have been used. One of the best known is that of Mitscherlich (1909) used by Crowther and Yates (1941) in their classical work on the development of fertilizer recommendations for agricultural crops. Since then many workers like Bray (1944), Wilcox (1955). Reith and Inkson (1963) and Scaife (1968) have successfully utilised this model for evaluating fertilizer requirements for various crops. For evaluating crop responses in relation to soil test Mitscherlich-Bray model was successfully employed by Mackay *et al.* (1963), Ranganathan *et al.* (1969), Dhanapalan Mosi *et al.* (1973) and Balasundaram *et al.* (1977) for nitrogen too contrary to the original mobility concept of Bray. In the present study, the same model was fitted to find out its usefulness in relating soil test with crop response so as to calibrate a site-specific nitrogenous fertilizer recommendation.

MATERIAL AND METHODS

Six field experiments were conducted at different locations of Agricultural Research Station, Bhavanisagar, with CSH.5 Sorghum as test crop. The randomized block design was adopted and the levels of nitrogen tried were 0, 50, 100, 150 and 200 Kg/ha, keeping phosphorus and potassium at sufficient levels. Nitrogen was estimated by alkaline permanganate method (Subbiah and Asija, 1956) for all the initial soil samples. The maximum possible yields were determined by plotting the log yields against the reciprocal of the dose of nutrient (x) and extrapolating to $1/x \rightarrow 0$ (Ranganathan *et al.* 1969). The percentage yields were calculated using this maximum yield. By substituting the soil test value in Mitscherlich-Bray model viz.,

$$Y = A(1-10^{-C_1 b - Cx})$$

1. Asst. Professor of Soil Science and Agricultural Chemistry, Cotton Research Station, Srivilliputhur.

TABLE I Soil test values, yield of grain and percentage yield of sorghum.

Location	Initial Soil test value N Kg/ha	Grain yield Kg/ha — N dose Kg/ha					Maximum possible yield	Per cent yield				
		0	50	100	150	200		0	50	100	150	200
Bhavanisagar 1	141	407	1585	2484	3996	4092	5248	7.8	30.2	47.3	76.2	78.2
Bhavanisagar 2	125	272	2501	2864	4075	3560	4385	6.2	57.0	65.3	92.9	82.2
Bhavanisagar 3	125	226	1924	3050	3962	3984	5012	4.5	38.4	60.9	79.1	79.5
Bhavanisagar 4	157	277	1737	3271	4267	4199	5623	4.9	30.9	58.2	75.9	74.7
Bhavanisagar 5	173	792	2275	3322	4471	3882	4898	16.2	46.5	67.8	91.3	79.3
Bhavanisagar 6	188	917	2547	3633	4473	3962	5152	17.8	49.4	70.5	86.2	76.9

the efficiency of soil nitrogen (C_1) and that of the fertilizer form (C) were calculated. The optimum rate of N was also arrived at as outlined by Balba *et al.* (1972).

RESULTS AND DISCUSSION

The usefulness of the soil nitrogen measurement by alkaline permanganate method has been well established earlier with different crops like rice, cotton, sugarcane (Ranganathan *et al.* 1969) and ragi (Balasundaram, 1975). Initial soil nitrogen by alkaline permanganate method, the grain yields besides the maximum possible yield and the percentage yields are presented in Table I. The initial nitrogen content of soils varied from 125 to 188 Kg/ha. The efficiency factors of soil form of N, C_1 values, for all the six experiments are presented in Table II. The C_1 values showed some variation owing to the textural make up of the soil. Therefore, the C_1 values were grouped into two on the basis of the textural class viz., sandy loam and loam.

TABLE II. C_1 Values and textural classes

Location	C_1 value	Texture of soil	Mean C_1
Bhavani-sagar 1.	0.00025	Sandy loam	
Bhavani-sagar 2	0.00022	Sandy loam	0.00019
Bhavani-sagar 3	0.00016	Sandy loam	
Bhavani-sagar 4	0.00014	Sandy loam	
Bhavani-sagar 5	0.00044	Loam	
Bhavani-sagar 6	0.00044	Loam	0.00044

The actual yield obtained and their corresponding calculated yields are presented in Table III for the various nitrogen levels tried. The ratios of C_1/C were also worked out (Table IV) to ascertain the efficient form of the nutrient and it was found that the added form of the nutrient to be more efficient than the soil form in all the experiments.

TABLE III The relationship between the actuel yield and the calculated yield for sorghum at different levels of N Application

Location	Grain yield Kg/ha									
	Control		50 Kg N/ha		100 Kg N/ha		150 Kg N/ha		200 Kg N/ha	
	Actual	Calculated	Actual	Calculated	Actual	Calculated	Actual	Calculated	Actual	Calculated
Bhavanisagar 1	407	315	1585	2342	2484	3495	3996	4240	4092	4654
Bhavanisagar 2	272	234	2501	1996	2864	2945	4075	3488	3560	3836
Bhavanisagar 3	226	268	1924	2281	3050	3367	3962	4042	3980	4440
Bhavanisagar 4	277	400	1737	2531	3271	3785	4267	4551	4199	4901
Bhavanisagar 5	792	788	2275	2477	3322	3472	4471	4088	3822	4403
Bhavanisagar 6	917	893	2547	2644	3633	3676	4473	4283	3962	4639

TABLE IV The ratios of C_1 to C values

Location	C_1/C
Bhavanisagar 1	0 0781
Bhavanisagar 2	0.0373
Bhavanisagar 3	0.0296
Bhavanisagar 4	0.0359
Bhavanisagar 5	0.0814
Bhavanisagar 6	0.0917

The need for refinement in the interpretation component for precise fertilizer recommendation has often been stressed. The need for adjusting the fertilizer rates on the basis of soil testing has also been well emphasised (Van der Paauw, 1973). Balasundaram *et al*. (1976) have clearly shown the economics and usefulness of considering the soil test values in evaluating fertilizer recommendations.

From C_1 and C values obtained it is possible to interpret a site specific recommendation for sorghum based on the given initial soil test value. Utilsing the mean C_1 and C values for the loamy and sandy loam soils ferritizer requirements were computed for the common range of soil test values from 100 to 400 Kg/ha of alkaline percentage N and is presented in Table V.

TABLE V. Nitrogen fertilizer requirement for sorghum*

Soil test value(Kg/ha) (Alk.$KMnO_4$ —N)	Nitrogen (Kg/ha) required to achieve the indicated levels of maximum possible yield					
	Sandy loam soil			Loamy soil		
	75%	88%	96%	75%	88%	96%
100	127	196	300	121	191	295
125	126	195	299	117	158	292
150	125	194	298	116	184	290
200	123	192	296	112	181	286
225	122	191	295	109	179	283
250	121	190	293	108	178	279

*Calculated based on the following equations

Sandy loam soil : $y = A\ (1\text{-}10\text{-}0.00013\ b - 0.0046\ x)$

Loamy soil : $y = A\ (1\text{-}10\text{-}0.00044\ b - 0.0040\ x)$

The optimum rate of nitrogen application was also calculated taking into account the cost of fertilizer nitrogen (x) and the cost of produce (y). To calculate the most profitable fertilizer application the differentiation of "y" with regard to "x" in the Mitscherlich equation was obtained and equated with the ratio of unit price of fertilizer to the unit price of sorghum grain and the resulting equation was solved for "x" (Balba *et al*. 1972).

$$C_1 \frac{dy}{dx} = -A.10^{-C_1 b.\ 10^{-Cx}}$$

$$\text{in}10(-c) = \frac{\text{Price of X}}{\text{Price of Y}}$$

By substitution of "A","b" and "C" with their corresponding values from the equations given in Table V. and knowing the price of one Kg of "X" for all the six experiments was calculated. Besides this, the obtainable yield with these doses were also calculated along with the cost of fertilizer and the value of grain yield presented in Table VI.

TABLE VI Optimum rate of N application and the obtainable yield with cost : benefit details

Location	"X" (Kg)	The obtainable yield "y" (Kg)	Value of required fertilizer (Rs.)	Value of obtainable sorghum grain (Rs.)
Bhavanisagar 1	211	4139	739	3311
Bhavanisagar 2	198	3877	693	3102
Bhavanisagar 3	209	4492	732	3594
Bhavanisagar 4	214	5555	749	4444
Bhavanisagar 5	208	4442	728	3554
Bhavanisagar 6	207	4678	725	3742

The fertilizer recommendation table would help the farmer to get at site specific fertilizer recommendation just by reading that table against the known soil test value. This also provides him a chance of choosing a yield target in accordance with the monetary aspects, thus, providing a dual benefit to the farming community.

REFERENCES

BALBA, A.M., T. SHETA and S.K. ATA. 1972. Corn response to nitrogen expressed by Mitscherlich - type equations. *J. Indian Soc. Soil. Sci.* 20 : 151-56.

BALASUNDARAM, C.S. 1975. Soil test crop response studies with ragi (*Eleusine Coracana* Gaertn.) *Madras agric. J.* 62 : 171-74.

BALASUNDARAM, C. S., R. CHANDRAMANI, T. BALAKRISHNAN, and M. SHANMUGAM. 1976. New concepts in soil test crop correlation with rice under conditions of fertilizer shortage. Il Riso XXV : 845-51.

BALASUNDARAM, C. S., R. CHANDRAMANI, H. HAMEEDKHAN and M. SHANMUGAM. 1977. Pour une meilleure utilisation de l'azote par le viz., grace a' l'etude des responses de la culture anx caracteristiques analytiques du sol. *L' Agronomique Tropicale*. 32 : 360.

BRAY, R.H. 1944. Soil-plant relations: 1. The quantitative relation of exchangeable potassium to crop yields and to crop response to potash additions. *Soil Sci.* 58 : 305-24.

GROWTHER, E.M. and F. YATES. 1941. Fertilizer policy in war-time: The fertilizer requirements of arable crops. *Emp. J. exp. Agric.* 9 : 77-97.

DHANAPALAN MOSI, A., R. NATARAJAN, T. PAJANISAMY, K. NATARAJAN, K. B. SRIPAUL and C. RAJARAMAN. 1973. Soil

fertility evaluation studies with rice varieties on major soil series of Thanjavur district. *Oryza* **10** : 51-76.

MACKAY, D. C., C. R. MacEAGHERN, R.F. BISHOP. 1963. The relation of soil test values to fertilizer response by Potatoes-II Nitrate production and nitrogenous fertilizer requirements. *Can. J. Soil Sci.* **43** : 242-49.

MITSCHERLICH, E.A. 1909. Das Gesetz des minimums and das Gesetz das abnehmenden Bodenertrages Land W. Jb **38**:537-52.

PAAUW, F. VAN DER. 1973. Adjusting fertilizer rates to soil fertility level on the basis of soil testing. Pontificiae Academiae Scientiarum Scripta Varia No. **38** : 427-66.

RANGANATHAN, V., R. SOUNDARARAJAN C.S. BALASUNDARAM and K. GOVINDARAJ. 1969. Studies on the applicability of Mitscherlich - Bray equation for Correleting Crop responses. Fertilite **33** : 31-41.

REITH, J.W.S. and R. H. E. INKSON. 1963. Effects of fertilizers and farmyard manure on swedes and turnips *J. agric. Sci.* **60** : 145-47.

SCAIFE, M.A., 1968. Maize fertilizer experiments in Western Thanjavur. *J. agric. Sci.* **70** : 209-22.

SUBBIAH, B. V. and G. L. ASIJA. 1956. A rapid procedure for the determination of available nitrogen in soils. *Curr. Sci.* **25** : 259.

WILCOX, O.W. 1955. Agrobiological percentage method of evaluating fertilizer test : 1. Potash and tobacco. Soil Sci. **79**:467-73.