اسمدة 3

*Mathematical models to describe relationship between soil fertility and plant growth (yields)

1- Liebig (1855) , Springl (1839)

Law of minimum (law of limiting factor) :

i- plant growth (yield) is determined by factor presents in lowest conc., regardless of any other factor.

ii- addition of other factor does not influence response to application of limiting factor.

iii- response of growth to limiting factor is linear.

Figure 5. **To get the highest possible yield no nutrient must be limiting**

The factors interact and a crop can make best use of the factor that limits growth when the other facotrs are close to their optima.

Crop yield cannot be greater than the most limiting soil nutrient permits

$$y = a\ x$$

yield — constant — quantity of nutrient in shortest amount

Boresch proposed Liebigs law to be

$$Y = c + a\ x$$

x ← amount of added factor

yield

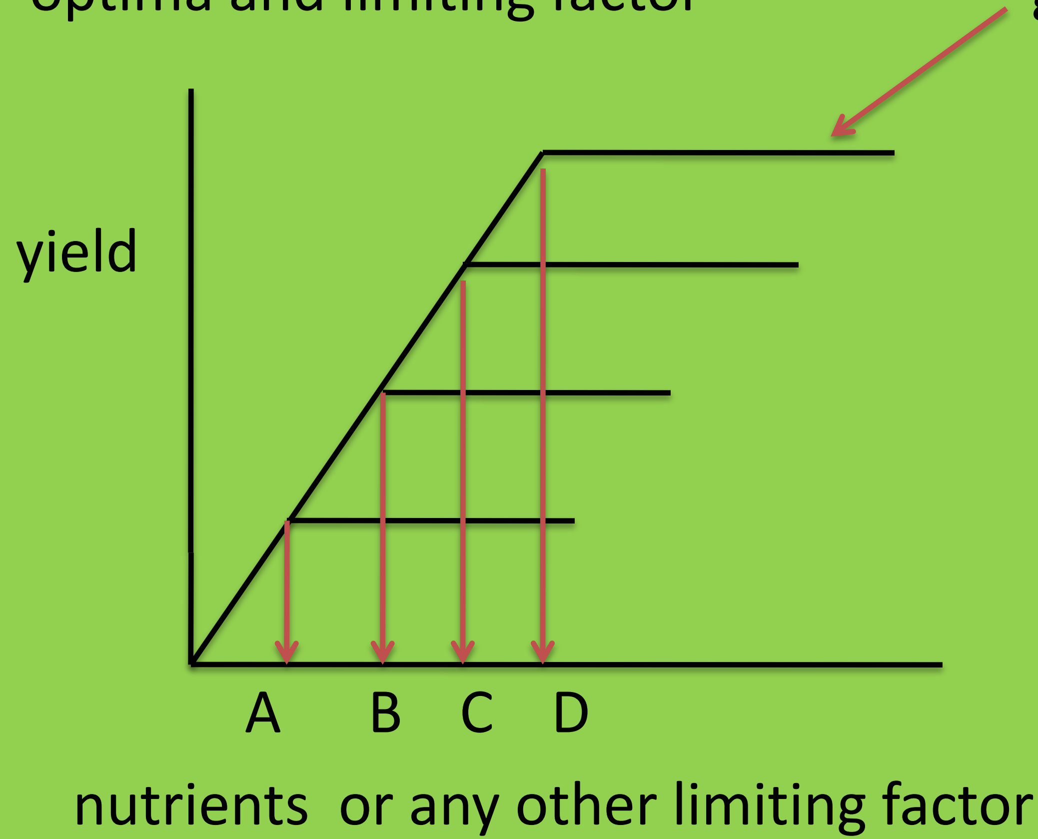
yield level in absence of x application

constant

2- Blackman

optima and limiting factor

concept



3- Mitscherlich Equation (law of diminishing returns)

when plants were supplied with adequate amounts of all but one nutrient their growth was proportional to the amount of this one limiting element which was supply to the soil. Plant growth increased as more of this element was added, but not in direct proportion to the amount of the growth factor added. The increase in growth with each successive addition of the element in equation was progressively smaller. Mitscherlich expressed this mathematically as

$$dy/dx = (A - Y) C$$

dy → increase in yield resulting from an increment of the growth factor dx

dx → increment of the growth factor

A → maximum possible yield by supplying all growth factors in optimum amounts

y → yield obtained after any given quantity of the factor x has been applied

C → constant depend on the nature of growth factor

(C is not constant varies widely for different crops)

integrated of above equation we obtain

$$\log A - \log (A - Y) = CX_1$$

X_1 ← (x+ b)

Micherlich eq. could be stated as

$$\log (A - Y) = \log A - 0.301 (X)$$

replaces (c) when yields are expressed as % (A=100)

if A , the max. yield, is considered to be 100 % , equation reduces to

$$\log (100 - y) = \log 100 - 0.301 (x)$$

if one unit of the growth factor x added then

$$\log (100 - y) = \log 100 - 0.301(1)$$

$$= 2 - 0.301$$

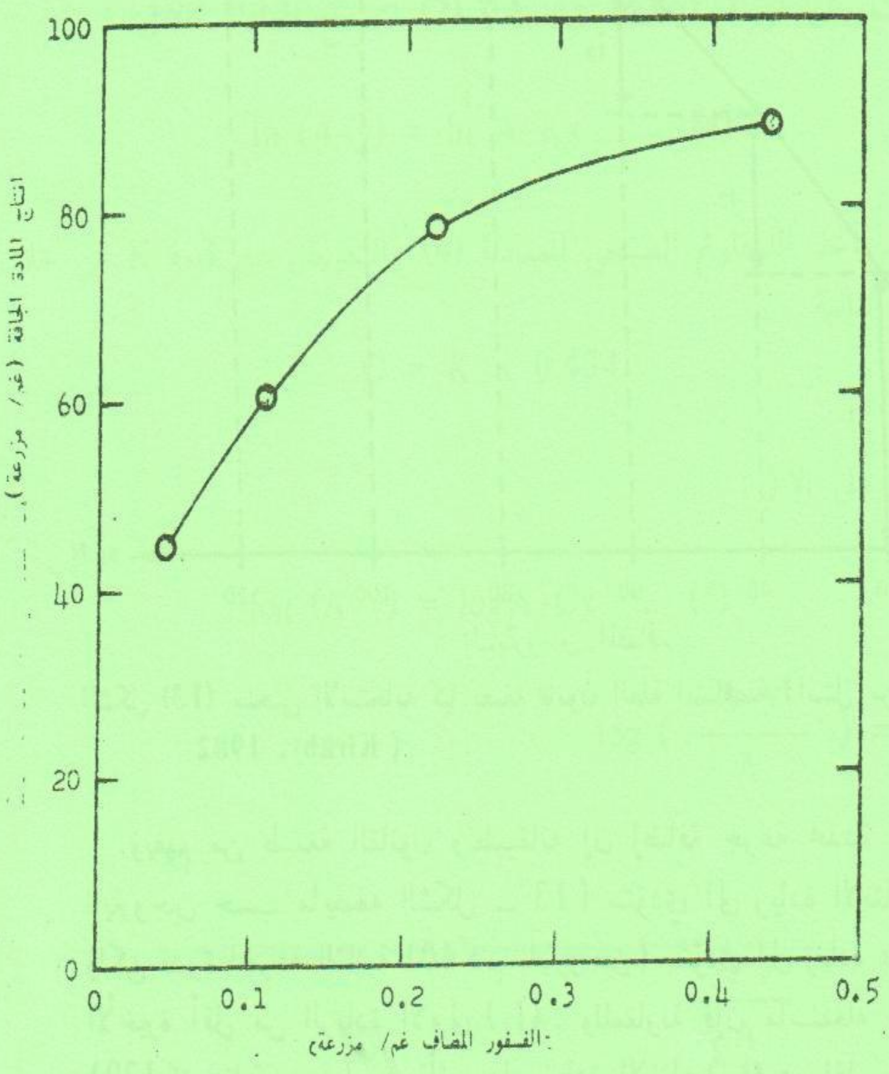
$$= 1.699$$

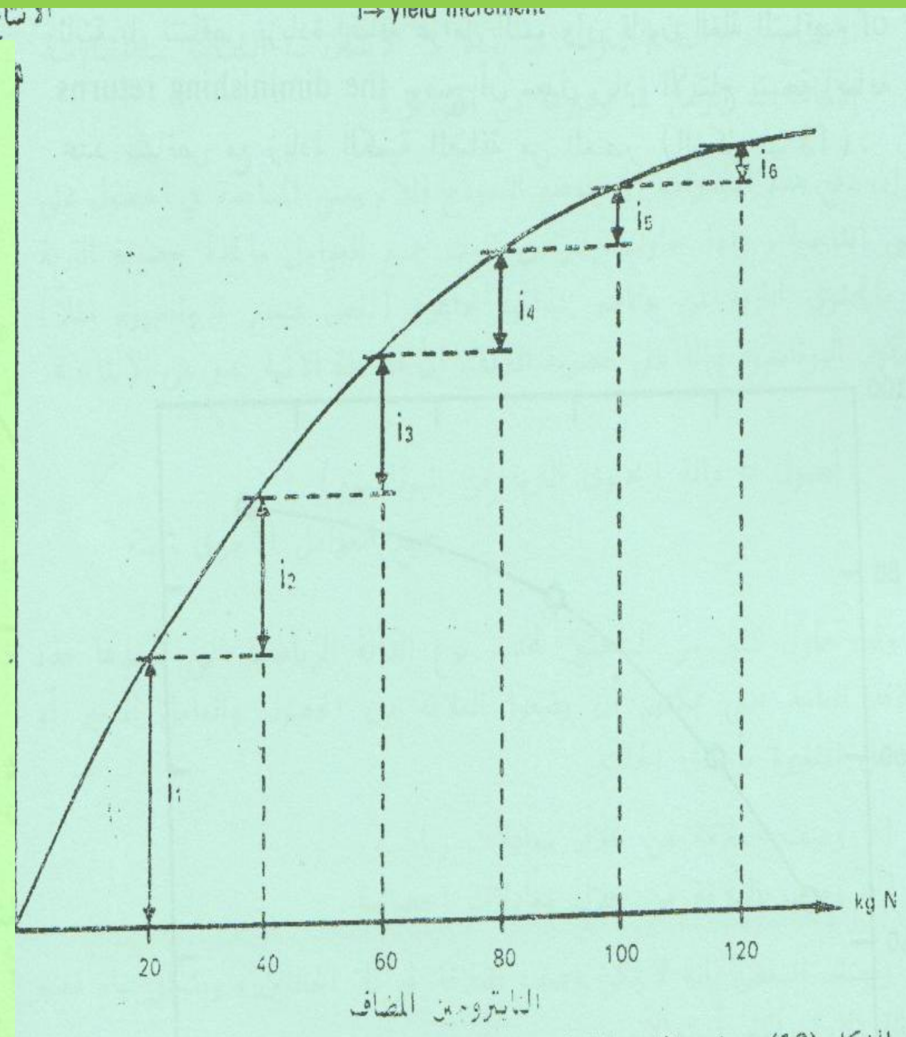
$$100 - y = 50$$

$$y = 100 - 50$$

$= 50$, so addition of first unit of growth factor results in a yield that 50% of max.

and so on for increasing addition of growth factors





الشكل (13) منحنى الاستجابة كما يصفه قانون الغلة المتناقصة (استل من & engel
(Kirkby, 1982

The Baule unit

unit of fertilizer, or any other growth factor, be taken as that necessary to produce a yield that is 50% of the maximum possible.

4- Bray ,s Nutrient Mobility Concept.

A modification of the Micherlich- Baule- Spillman

“ as the mobility of a nutrient in the soil decreases, the the amount of that nutrient needed in the soil to produced a max. yield increases from a variable net value , determined principally by magnitude of the yield and the optimum % composition of the crop, to an amount whose value tend to be a constant.”

* plants absorbed mobile nutrients from root system sorption zone while immobile nutrients absorbed from root surface sorption zone

* mobile nutrients follow liebig low and immobile nutrients follow percentage sufficiency of Micherlich

5- Spillamans Equation

$$y = A (1 — IO^{-CX})$$

A , C ,and x as above . Expanded for many nutrients

$$y = A (1 - 10^{-ClX1}) (1 - 10^{-C2X 2})......$$

Table 1. Nutrient removal by crops[1] in kilograms per hectare

	Yield kg/ha	Nitrogen N	Phosphorus P_2O_5	P	Potassium K_2O	K	Ca	Mg	S
Rice (paddy)	3 000	50	26	11	80	66	-	-	-
	6 000	100	50	22	160	133	19	12	10
Wheat	3 000	72	27	12	65	54	-	-	-
	5 000	140	60	26	130	108	24	14	21
Maize	3 000	72	36	16	54	45	-	-	5
	6 000	120	50	22	120	100	24	25	15
Potatoes	20 000	140	39	17	190	158	2	4	6
	40 000	175	80	35	310	257	-	23	16
Sweet potatoes	15 000	70	20	9	110	91	-	-	-
	40 000	190	75	33	390	324	28	9	-
Cassava	25 000	161	39	17	136	113	44	16	-
	40 000	210	70	31	350	291	57	-	-
Sugar cane	50 000	60	50	22	150	125	-	-	-
	100 000	110	90	39	340	282	-	50	38
Onions	35 000	120	50	22	160	133	-	-	21
Tomatoes	40 000	110	30	13	150	125	-	17	54
Cucumber	35 000	60	45	20	100	83	-	36	-
Alfalfa (hay)	7 000	215[2]	60	26	130	108	164	19	19
Soybeans	1 000	160[2]	35	15	80	66	-	-	-
	2 400	224[2]	44	19	97	81	-	18	-
Beans	2 400	155[2]	50	22	120	100	-	-	-
Groundnuts	1 500	105[2]	15	7	42	35	19	11	12
Cotton	1 700	73	28	12	56	46	6	4	5
(-seed + -lint)	5 000	180	63	27	126	105	-	35	30
Tobacco (dry leaf)	1 700	90	22	10	129	107	48	6	4

\- Data not available

1) Plant nutrients contained in the above-ground plant part, and the below-ground harvested portion where appropriate, at the indicated yields. Note that these are not the same as fertilizer requirements.

2) Leguminous crops can get most of their nitrogen from the air

Source: Fertilizer Industry Advisory Committee, FIAC

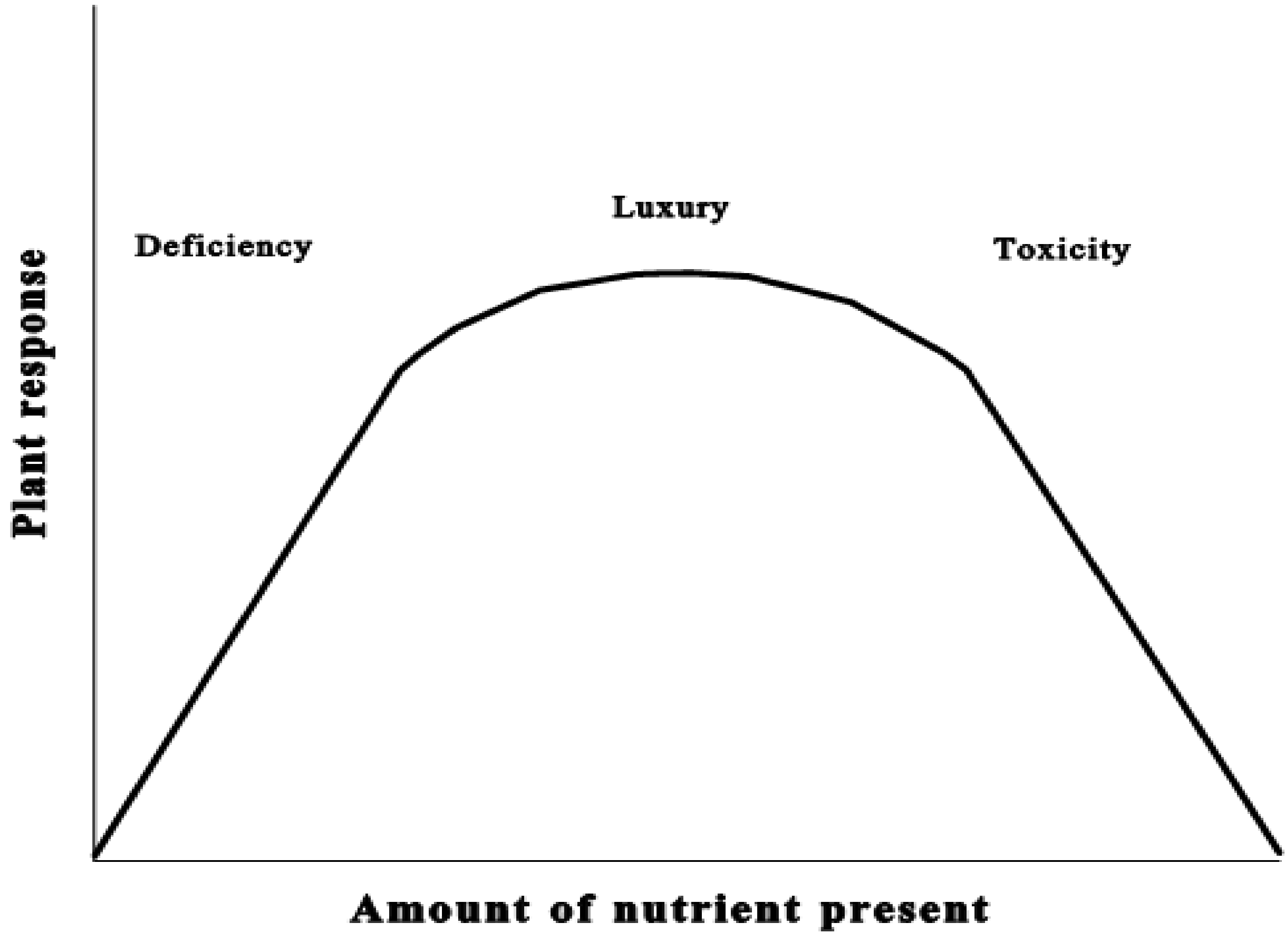


Figure 2 - Response of plant to amount of one nutrient