DRIS:
Theory and Practice

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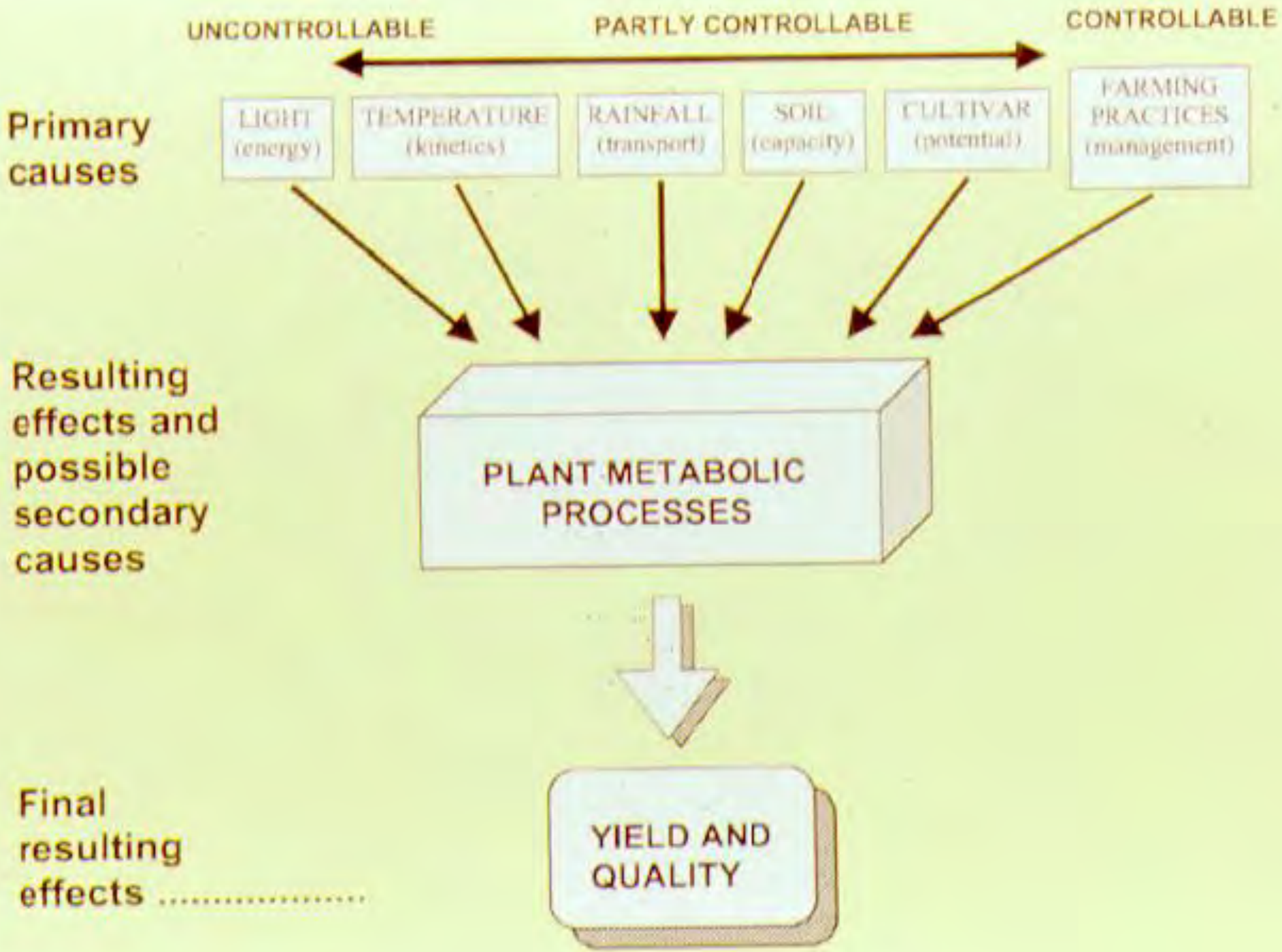
Introduction

- Foliar diagnosis useful tool in diagnosis
- DRIS approach
  - Nutrient balance
  - Applicable over wider range of ages than CV
- Crop growth affected by host of factors
  - Uncontrollable (light, temperature)
  - Partially controllable (drought, soil)
  - Controllable (row spacing, cultivar)

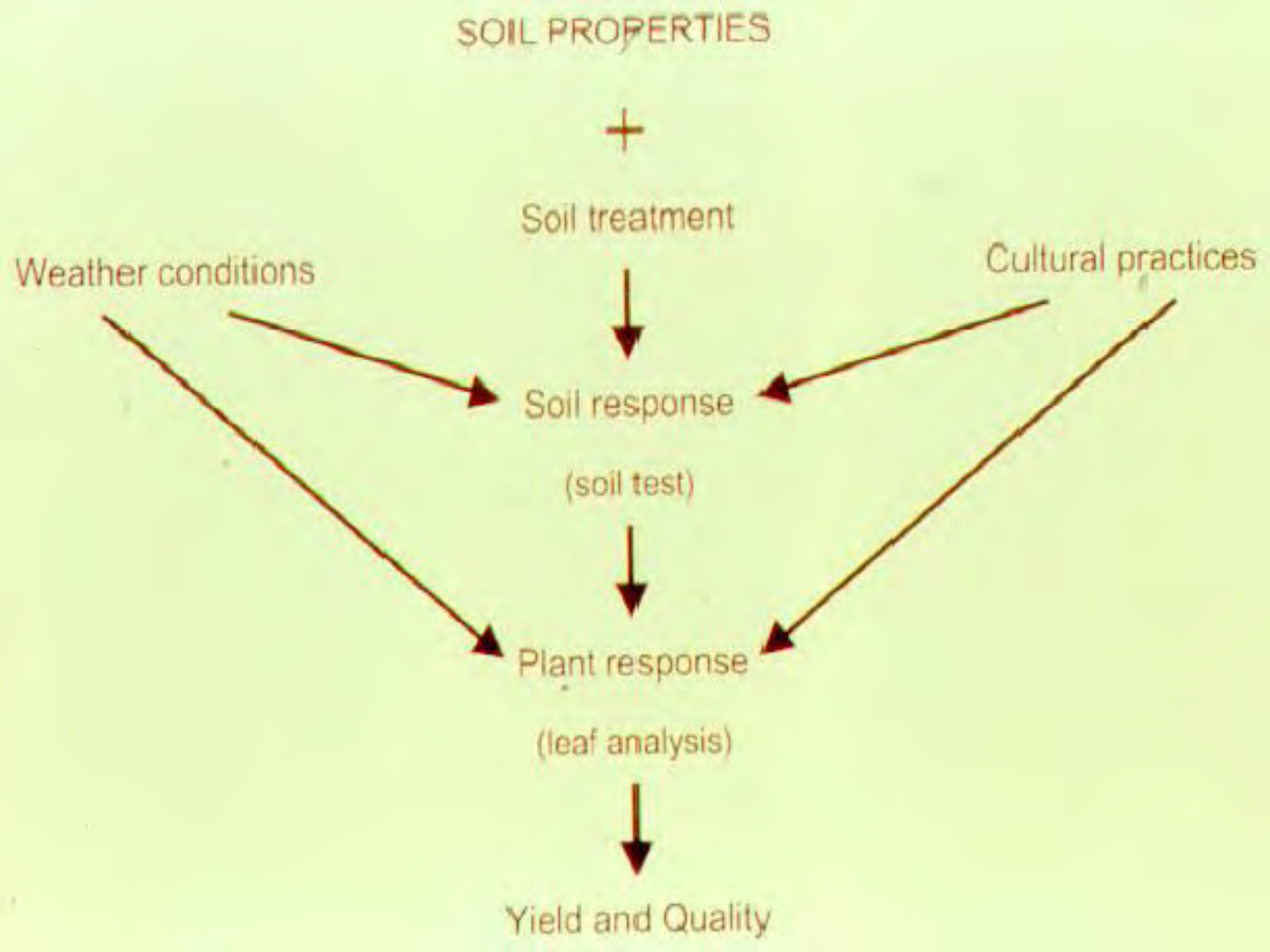

UNCONTROLLABLE
PARTLY CONTROLLABLE
CONTROLLABLE
Primary causes
LIGHT (energy)
TEMPERATURE (kinetics)
RAINFALL (transport)
SOIL (capacity)
CULTIVAR (potential)
FARMING PRACTICES (management)
Resulting effects and possible secondary causes
PLANT METABOLIC PROCESSES
Final resulting effects .....
YIELD AND QUALITY

Introduction

- Nutrient status not governed only by soil
- Other factors can play a role
- Limiting nutrient in plant not necessarily limiting in soil
  - Nematodes affect nutrient uptake
  - Leaf deficiency not necessarily deficient in soil
- DRIS assesses
  - Nutrient balance
  - Order of limiting importance on yield

Introduction

- Effective fertilizer recommendations
  - Combine foliar, soil and other diagnoses
  - Foliar diagnosis only gives status of plant
  - Advisor must use experience and other supporting information
  - CANNOT be automated by computer
- Interaction between fertilizer treatment and soil properties


SOIL PROPERTIES
+
Soil treatment
Weather conditions
Cultural practices
Soil response
(soil test)
Plant response
(leaf analysis)
Yield and Quality

Introduction

- Classical versus DRIS approach
  - Field experiments with limited factors
  - DRIS sampling scheme for norms
- Initial aim of DRIS
  - To set out parameters of problem
  - Not to solve it automatically
  - Recommendation requires bridging
  - Using experience, knowledge and observational qualities of specialist

Establishment of Norms

- DRIS approach
  - Employs survey
    - Large number of sites (fields and plots)
    - Each site analogous to plot in experiment
    - Record soil, tissue and other parameters
    - Store in computer
  - Data bank analogous to “field experiment” replicated in time and space
  - Norms (N%, P%, N/P, etc) from high yielding subpopulation

Calculation of Indices

- A index = {f(A/B) + f(A/C)… + f(A/N)}/z
- B index = {-f(A/B) + f(B/C)…+ f(B/N)}/z
- C index = {-f(A/C) – f(B/C)… + f(C/N)}/z
- .
- .
- N index = {-f(A/N) – f(B/N)… - F(M/N)}/z

Calculation of Indices

- Where $f(A/B) = 1000\{(A/B)/(a/b) - 1\}/CV$
  - When $A/B > a/b$
- Or $f(A/B) = 1000\{1 - (a/b)/(A/B)\}/CV$
  - When $A/B < a/b$
- CV = coefficient of variation of high population
- a/b, a/c, etc = norms (means) for expression
- A/B, A/C = values for leaf under diagnosis
- z = number of functions in index equation

Index Interpretation

- Index values are
  - Positive (excess) and negative (insufficiency)
  - Sum of indices is zero
- Nutrient Balance Index (NBI)
  - Sum of indices irrespective of sign
  - Measures intensity of insufficiency

N	P	K
%		
4.1	0.25	2.06
24	-18	-6

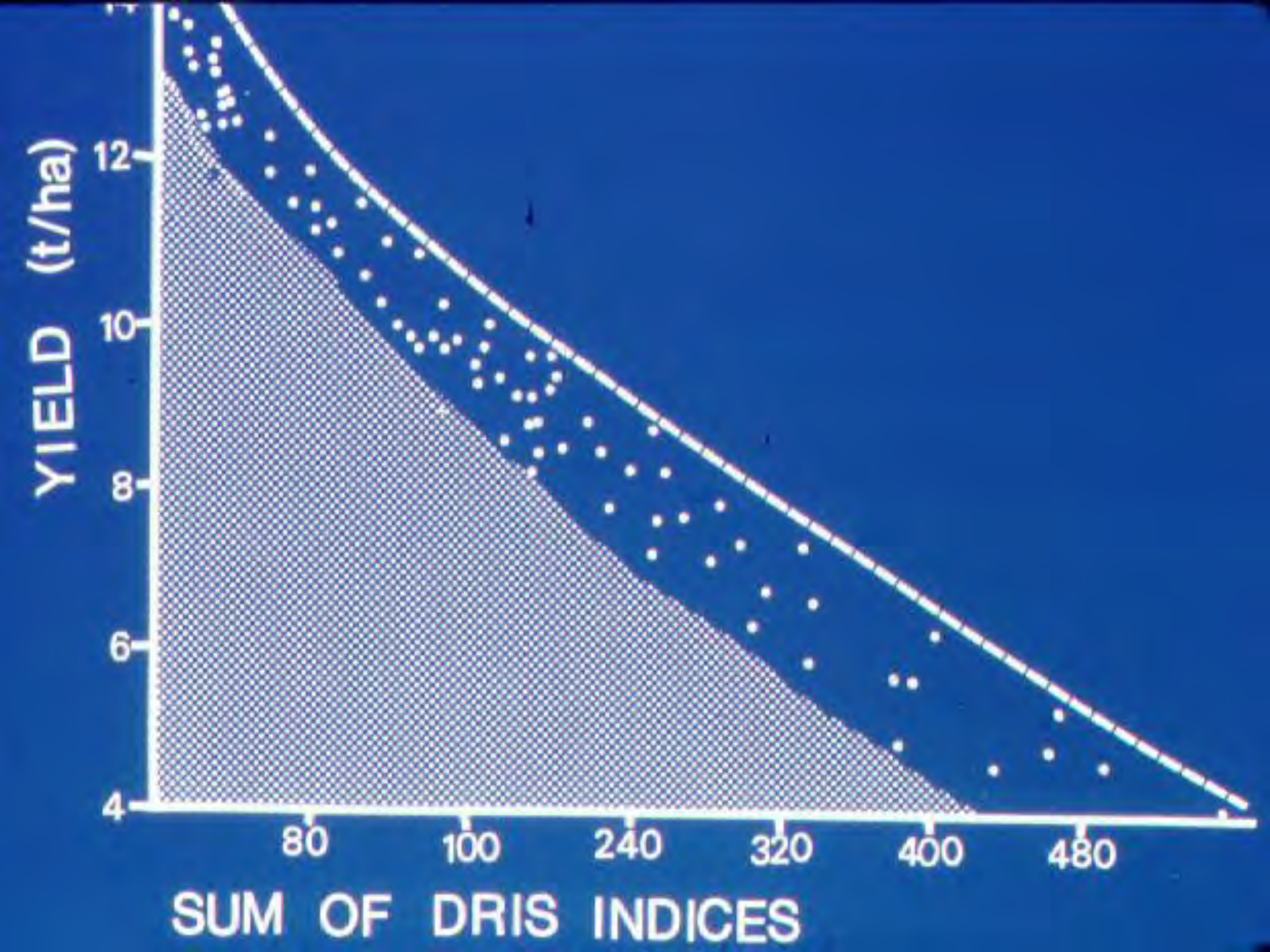
N	P	K	Ca	Mg
%				
4.1	0.25	2.06	0.55	0.18
16	-11	-3	5	-7

N	P	K	Ca	Mg	S	Zn	Mn	B	Cu
%						ppm			
4.1	0.21	2.06	0.55	0.18	0.24	17	82	10	13
11	-7	-3	2	-6	-1	-15	8	5	5

INTERPRETATION OF INDICES

- Relative balance

N	P	K	NBI	Order of requirement
4	-3	-1	6	P > K > N
24	-18	-6	48	P > K > N
48	-36	-12	96	P > K > N


YIELD (t/ha)
12
10
8
6
4
80
100
240
320
400
480
SUM OF DRIS INDICES

Meaning and Interpretation of a Ratio

N/P = →, N→/P → or N↑/P↑ or N↓/P↓

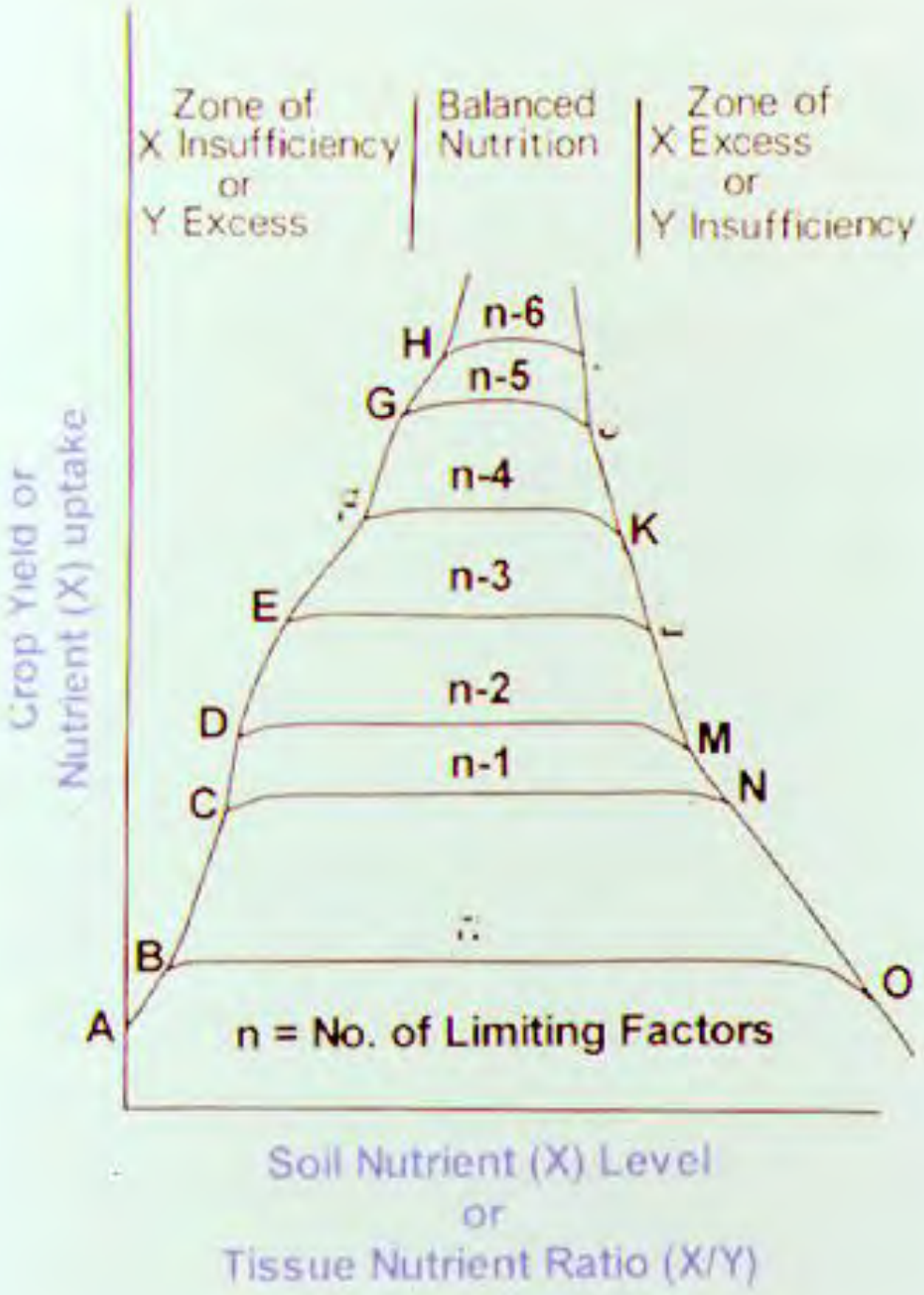
optimal excessive insufficient

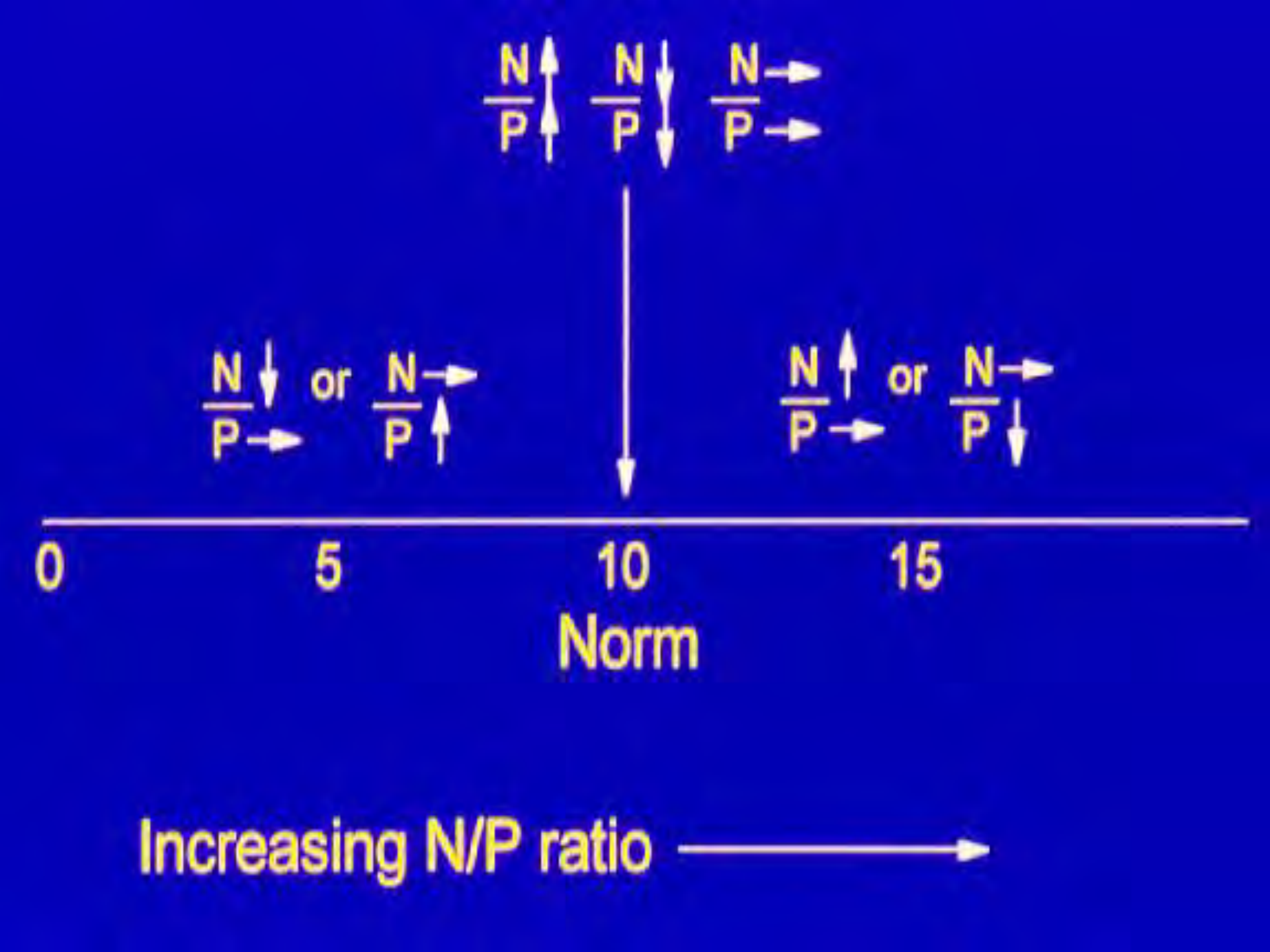
N/P = ↑, N→/P↓ or N↑/P→

P insufficiency N excess

N/P = ↓, N→/P↑ or N↓/P→

P excess N insufficiency


Zone of
X Insufficiency
or
Y Excess
Balanced
Nutrition
Zone of
X Excess
or
Y Insufficiency
Crop Yield or
Nutrient (X) uptake
n-6
n-5
n-4
n-3
n-2
n-1
H
G
K
E
D
M
N
C
B
A
O
n = No. of Limiting Factors
Soil Nutrient (X) Level
or
Tissue Nutrient Ratio (X/Y)


N/P
N/P
N/P
N/P or N/P
N/P or N/P
0
5
10
15
Norm
Increasing N/P ratio

Validation of Norms

- Test against independent responsive data
- Correct prediction validates indices

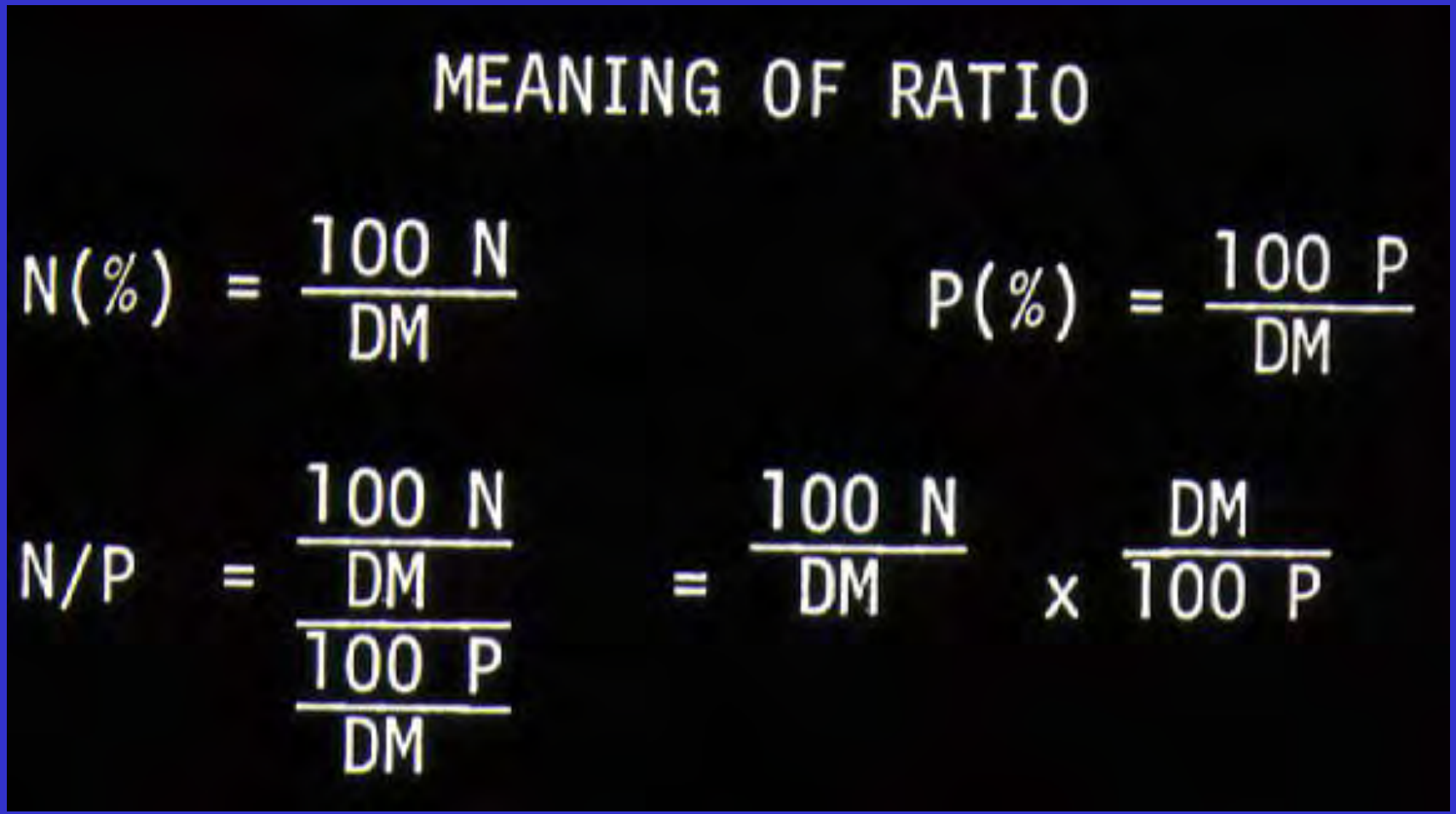
Validation of Norms

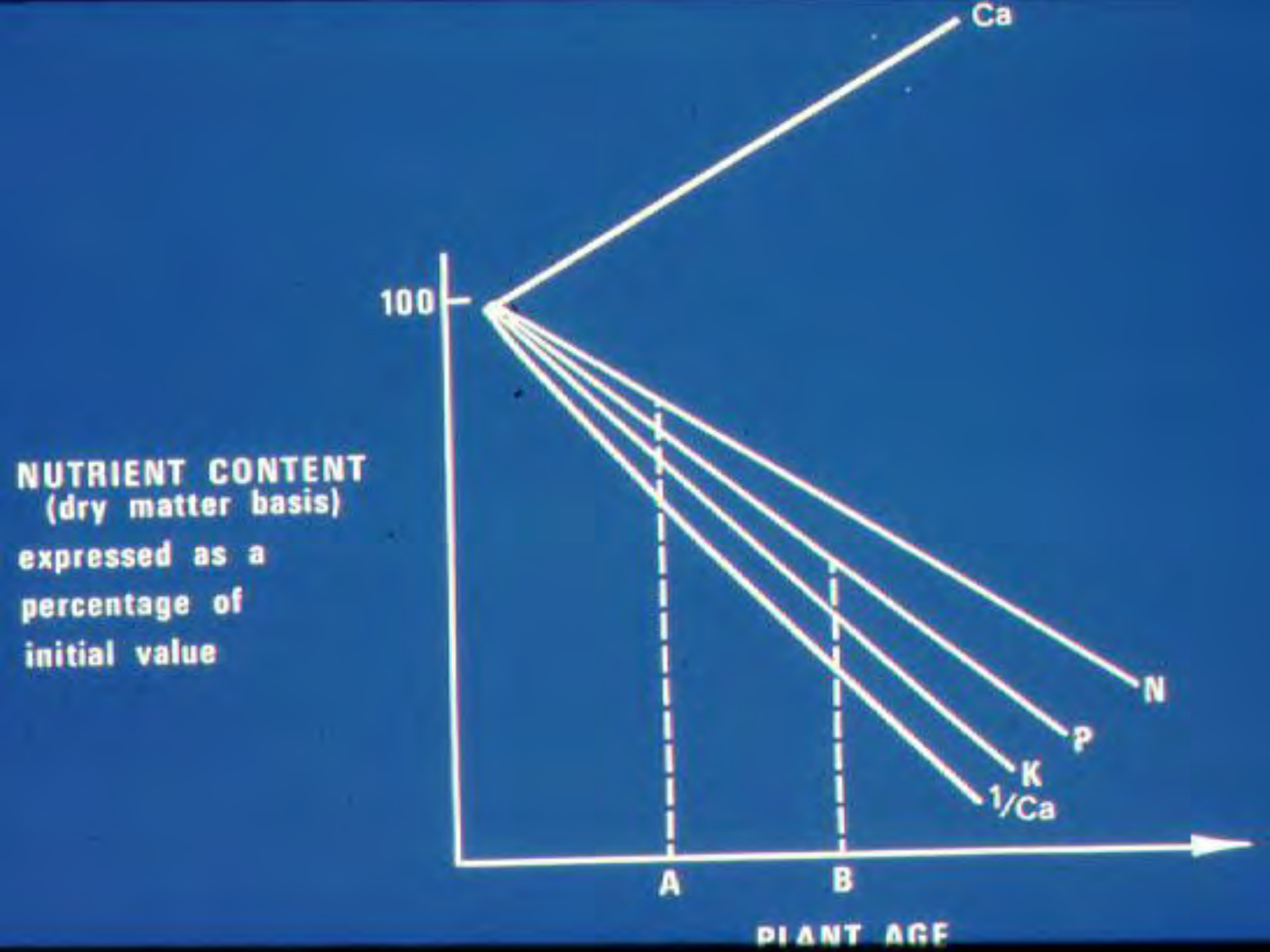
Treat	Leaf composition (%)			DRIS indices		
NP	N	P	K	N	P	K
160-0	2.62	0.205	2.42	1	-25	24
280-0	2.70	0.195	2.44	5	-30	25
160-25	2.73	0.265	2.11	-2	-5	7
280-25	2.79	0.250	1.99	3	-8	5
160-100	2.76	0.355	1.93	-11	15	-4
280-100	2.76	0.345	1.86	-9	14	-5

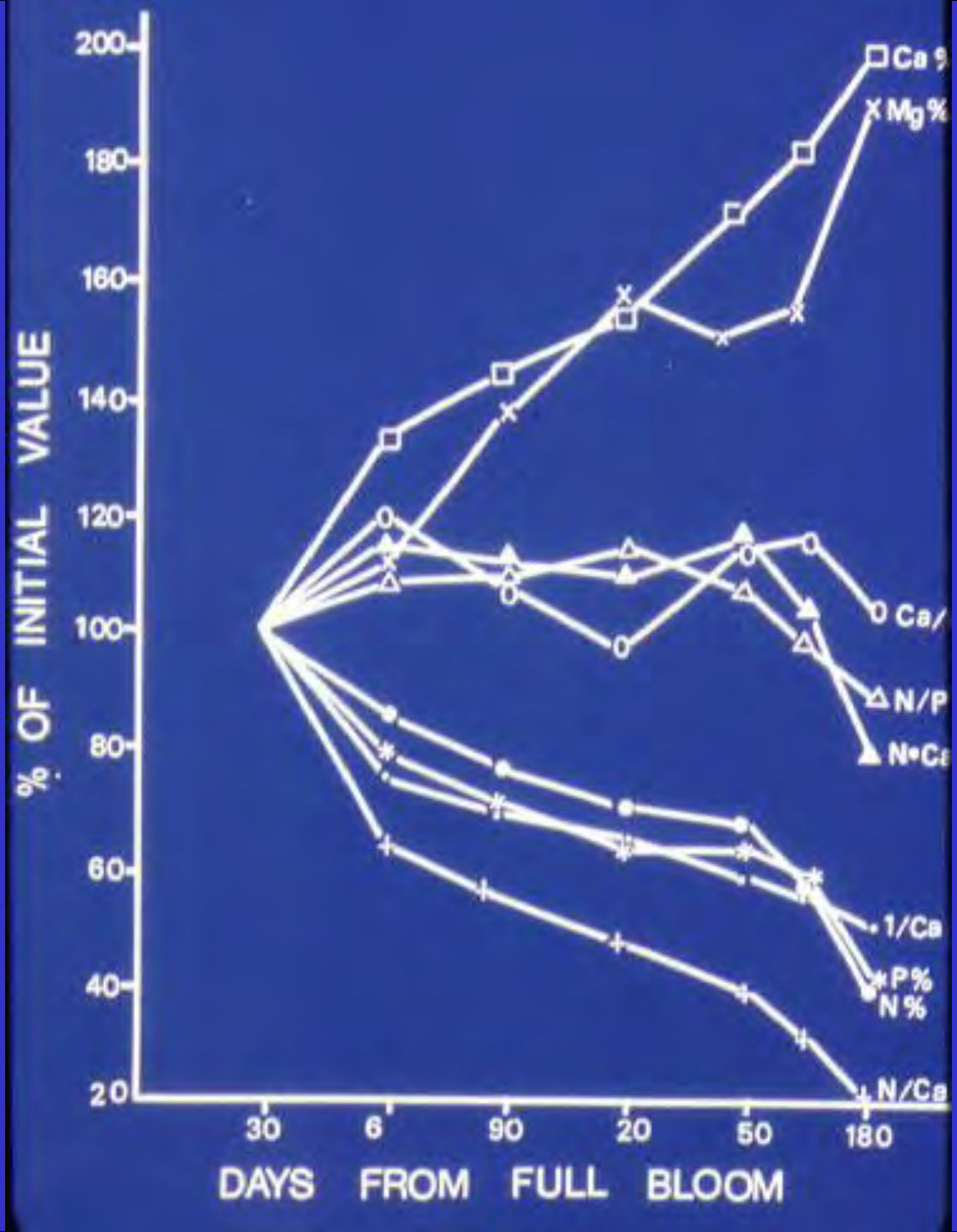
Effect of Age on Diagnosis

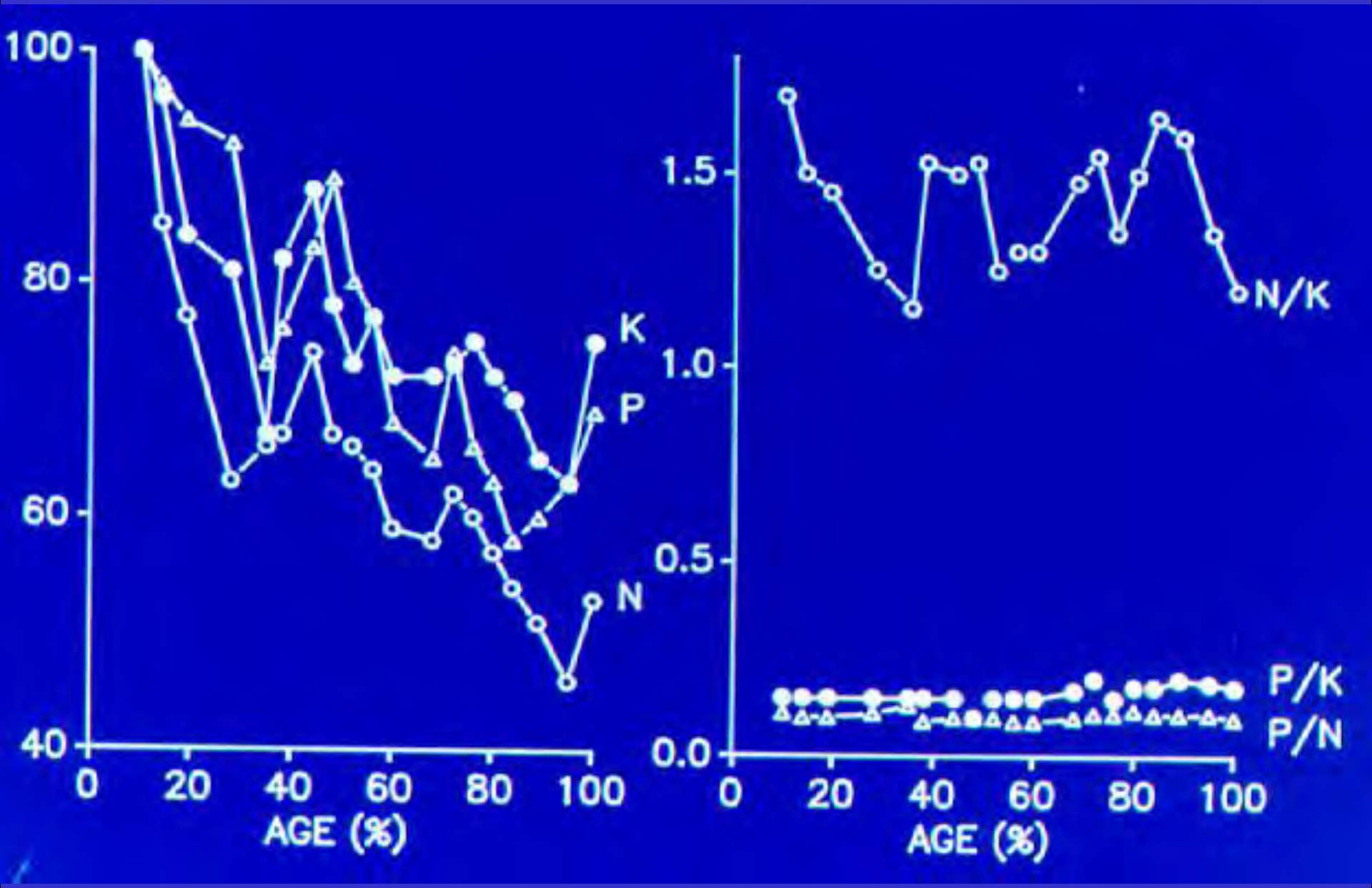
- On DM basis
  - N, P, K decrease with age
  - Ca, Mg increase with age
  - 1/Ca, 1/Mg decrease with age
- On ratio basis (nutrients that decrease with age)
  - Ratio constant with age
- On product basis (nutrients varying oppositely)
  - Product constant with age

Ratio Cancels DM




Ca
100
NUTRIENT CONTENT
(dry matter basis)
expressed as a
percentage of
initial value
N
P
K
1/Ca
A
B
PLANT AGE


% OF INITIAL VALUE
200
180
160
140
120
100
80
60
40
20
Ca %
Mg %
Ca/
N/P
N•Ca
1/Ca
P %
N %
N/Ca
30
6
90
20
50
180
DAYS FROM FULL BLOOM


100
80
60
40
K
P
N
0
20
40
60
80
100
AGE (%)
1.5
1.0
0.5
0.0
N/K
P/K
P/N
0
20
40
60
80
100
AGE (%)

Effect of Age (Corn)

Age	Leaf composition			DRIS indices			CV
	N	P	K	N	P	K	
30	4.6	0.30	3.4	16	-32	16	nd
60	3.9	0.26	2.4	19	-25	6	nd
80	3.4	0.24	1.9	19	-18	-1	P
110	3.0	0.20	1.8	20	-24	4	P, K

Effect of Age (Sugar)

Age	Leaf composition			DRIS indices			CV
	N	P	K	N	P	K	
53	2.60	0.235	1.52	14	-15	1	nd
101	2.03	0.202	1.42	7	-14	7	nd
135	2.87	0.207	1.48	28	-28	0	nd
240	1.96	0.207	1.28	5	-8	3	nd
295	1.70	0.175	1.22	4	-12	8	N,P
353	1.54	0.173	1.05	2	-5	3	N,P,K

Effect of Variety

Variety	Leaf composition			DRIS indices		
	N	P	K	N	P	K
Co 1001	1.92	0.172	1.56	6	-25	19
NCo 376	1.82	0.170	1.46	5	-21	16
N 52-219	1.78	0.140	1.58	9	-39	30
M 31-45	1.77	0.165	1.70	-1	-28	29
Co 462	1.74	0.162	1.49	3	-24	21
CB 40-77	1.54	0.155	1.80	-12	-30	42
N 55-805	1.73	01.72	1.43	1	-18	17

Use of Dry Matter Index

A index = {f(A/B) + f(A/C)… + f(A/DM)}/z

B index = {-f(A/B) –f(C/B)… + f(B/DM)}/z

C index = {-f(A/C) + f(C/B)… + f(C/DM)}/z

.

.

DM index = {-f(A/DM) –f(B/DM)… –f(M/DM)}/z

where A/DM = A%/100, etc

DM is a surrogate for C, H and O (also nutrients)

Use of Dry Matter Index

Nutrient	N	P	DM	S	K	Mg	Ca
Index	-20	-7	-2	-1	3	13	14

N	P	K	DRIS indices				Nutrients Limiting?
----------%			N	P	K	DM	
1.953	0.195	1.332	-15	-14	-11	41	YES
2.604	0.260	1.776	-5	-5	-5	16	YES
3.255	0.325	2.220	0	0	-1	1	BALANCE
3.906	0.390	2.664	5	4	1	-10	NO
4.557	0.455	3.108	10	8	3	-21	NO

Use of Ratios and Products

Nutrients that vary in same direction

Ratios

N/P = (N/DM)/(P/DM) = (N/DM)*(DM/P)

Nutrients that vary in opposite directions

Products

N*Ca = N/(1/Ca) = N*X

Use X in index calculations and change sign

PEACHES

(Batje and Westwood, 1958)

Days from full bloom	N	P	K	Ca	Mg
	%				
30	3.60	0.25	2.70	1.80	0.41
60	3.00	0.19	2.90	2.30	0.47
90	2.70	0.17	2.90	2.70	0.56
120	2.50	0.15	2.80	2.80	0.63
180	1.50	0.10	2.20	3.60	0.78

PEACHES

(Batje and Westwood, 1958)

Days from full bloom	DRIS Indices RATIOS					Order of requirement
	N	P	K	Ca	Mg	
30	1	-9	13	-1	-5	P > Mg > Ca > N > K
60	-7	-26	24	7	2	P > N > Mg > Ca > K
90	-14	-36	26	13	12	P > N > Mg > Ca > K
120	-18	-47	28	16	21	P > N > Ca > Mg > K
180	-56	-83	32	45	62	P > N > K > Ca > Mg

PEACHES (Batje and Westwood, 1958)

Days from full bloom	DRIS Indices PRODUCTS N	P	K	Ca	Mg	Order of requirement
30	-1	-7	4	3	1	P > N > Mg > Ca > K
60	-4	-14	11	6	1	P > N > Mg > Ca > K
90	-7	-18	12	8	5	P > N > Mg > Ca > K
120	-7	-21	14	7	7	P > N > Mg = Ca > K
180	-12	-22	27	5	2	P > N > Mg > Ca > K

DRIS Indices and Other Factors

- Sugarcane
  - Sampled at 2 months
  - Favorable moisture

Diagnosis

Nutrient	N	P	K	Ca	Mg	S	Zn
Index	-2	-21	-10	6	5	7	15

Parameter	pH	P	K	Ca	Mg	S	Zn
Rating	6.02	Hi	Med	Ade	Ade	Med	Hi

DRIS Indices and Other Factors

- Corn
  - 3 weeks old
  - Planted very early at high elevation

Diagnosis

Nutrient	N	P	K	Ca	Mg	S	Zn
Index	-7	-5	12	8	6	4	-18

Parameter	pH	P	K	Ca	Mg	S	Zn
Rating	5.85	Hi	Hi	Ade	Ade	Med	Hi

DRIS Indices and Other Factors

- Soybeans
  - Oxisol
  - 1 month old
  - Differential strips in direction of planting
  - Fertilized with P (banded) Sulpomag (broadcast)

Diagnosis

Nutrient	N	P	K	Ca	Mg	S	Zn
Poor	5	5	-13	6	-4	-5	6
Good	-3	0	3	2	1	0	-3