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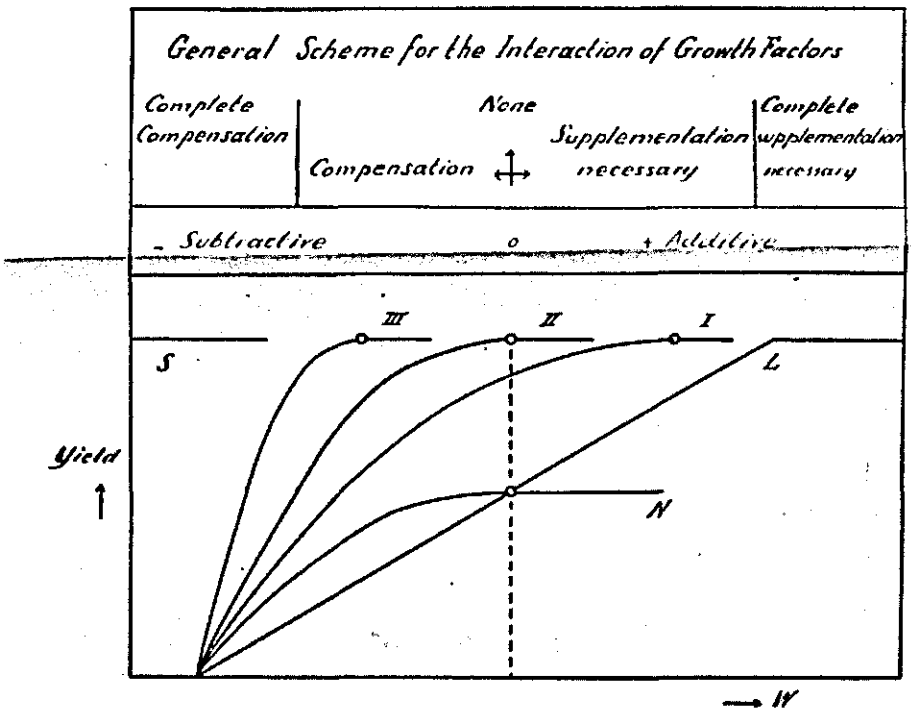
O. DE VRIES: **Yield curves and yield laws; the interaction of growth factors:** — J. v. LIEBIG's law of the minimum postulates proportionality between amount of growth factor and yield, as if the increase in yield were dependent on the formation of some chemical compound necessary for plant growth. This is shown by L in the general scheme, where the growth factor W is plotted as abscissae and the yield as ordinates. There is a linear increase in yield until the amount of another growth factor is exhausted and further increases in W do not increase the yield (horizontal part of L). G. LIEBSCHER supplemented these views with his law of the optimum; other growth factors may have an influence on the yield produced by a given amount of W, and when they are more favourable that yield may be higher, as shown in Curve I. MITSCHERLICH's "Wirkungsgesetz der Wachstumsfaktoren" and his law of the constant "Wirkungsfaktor" (nutrient effect factor) c are represented by Curve II; in Curve N and Curve II the maximum



is reached at the same value of W, independent of the influence of other growth factors and of the fertility level produced by them.

It has been shown by many workers (*cf.* summary by A. RIPPEL in: F. HONCAMP, Handbuch Pflanzenernährung und Düngerlehre, Berlin 1931, I, 602, and examples given by O. DE VRIES in: Bodenkunde und Pflanzenernährung 14: 1, 1939), that c, in many cases, is not constant and that, at a higher fertility level, the maximum yield is found at a higher value of the growth factor W. In our scheme this is represented by curves such as I, in which the maximum shifts to the right as compared with Curve N or Curve II. It has now been found in investigations carried out at the Groningen Rijkslandbouw-

proefstation by W. C. VISSER, F. v. D. PAAUW and P. BRUIN, that there also are instances in which the maximum shifts to the *left*, as represented by Curve III, and in which c *increases* with more favourable growth conditions. In such cases a shortage in growth factor W causes, at a higher fertility level (III), a smaller depression in yield than at a lower level (N). As examples we may take the following: the influence of *p*H on yield (rye, for instance, on fertile fields is not injured by a *p*H of 4.8 whilst on poor fields the *p*H has to be raised to 6 to obtain maximum yields); the reduction in the harmful effect of potassium shortage in sunny years (E. J. RUSSELL); the smaller effect of potassium shortage at a higher level of sodium salts etc. Whilst in case I the growth factors have to supplement each other in order to produce the maximum yield (*e.g.* necessity for higher doses of potassium or phosphate when more nitrogenous manure is given; stronger effect of potassium shortage and more marked deficiency symptoms at a higher nitrogen and phosphate level etc.), there is in Case III a substitution or compensation of some kind. Between these two groups of positive and negative interaction MITSCHERLICH's case of the constant Wirkungsfaktor c occupies a transitional or zero position, *i.e.* the assumption that c is constant holds only for intermediate cases. The general rule is that c is not constant, and that it decreases or increases at higher fertility levels according to the nature of the interaction of the growth factors involved.

Whilst for further details and data the reader may be referred to the papers in question (*cf.* Bodenkunde und Pflanzenernährung 14: 1, 1939), it may be pointed out that it is of importance, not only for scientific agricultural work but also for practical advisory work, that the soil fertility problem should be freed from the constraints of MITSCHERLICH's law. The action of growth factors should be viewed from the broader standpoint, outlined in the above scheme, in which the constancy of c is restricted to special transitional cases. Speculations such as those of O. W. WILLCOX (The A.B.C. of Agrobiology. *cf.* Chronica IV page 500) can thus be assessed at their true value; the value of MITSCHERLICH's pot method for determining the fertilizer need of a soil is brought back to the same level as that of other methods (extraction methods, NEUBAUER, *Aspergillus*, etc.), *viz.* it can be no more than an indication that has to be interpreted on the basis of the results of field experiments and of practical experience.

GRONINGEN, RIJKSLANDBOUWPROEFSTATION. *September* 1939.