

THE ACTIVITY OF SPECIFIC GROWTH STIMULATING SUBSTANCES  
IN THE SOIL IN RELATION TO THE APPLICATION OF ORGANIC  
MATTER

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Introduction

An enormous array of soluble, soil-contained organic substances has been shown to affect different plant activities in a favourable manner. The effect of humates, fulvic acids, precursors of humus or related substances has been widely studied (Blanchet R, 1958; Flaig W., 1968; Guminska Z. & Guminski S., 1962; Kononova M.M. 1958; Novák B., 1971; Rochus W., 1971; Tichy V., 1959; Zladký Z. 1962). Many other water-soluble constituents, e.g. vitamins, hormones, amino-acids, organic acids, have been shown to act positively on plant performance in numerous publications ( Deuel H., 1958; Kloke A., 1963; Wiersum L.K., 1957).

First of all quite a number of toxic substances can be formed in the soil during the conversion of organic matter (Börner H., 1955; Kloke A., 1963; Patrick Z.A., 1971). Besides that, potentially stimulative substances may exist in too low a concentration to be reasonably effective or exist in supra-optimal concentrations, which are usually growth retarding.

From a more practical and ecological viewpoint one could raise the following question: Does it make sense to expect a noticeable enhancement of specific growth stimulation through these substances as a secondary effect of application of large amounts of organics?

Methods

The integrated response to the addition of soil extracts or soil samples is measured in two biological tests. The possibility of mineral influences is ruled out as the complete nutrient solutions contain all necessary ions in concentrations much larger than in the addition. Possible effects due to complexing properties are reduced by providing iron as Fe-EDTA.

One method consists in measuring the development of the mycelium growth of *Aspergillus niger* on a complete medium to which a small amount of soil or soil extract is added, in most cases 40-400 mg or the equivalent extract. The media were incubated at 32°C for 48 hours, following the addition of a spore suspension. Then the mycelial mat was collected, dried and weighed.

As plant production is dependent on root performance and development, the effect of extracts on root growth was also studied. In order to eliminate interaction with the shoot and possible effects by intermediary of the rhizosphere flora the growth of excised tomato roots in sterile culture was used as test.

Test solutions were generally obtained by adding 500 mg of the soil to 500 ml nutrient solution, shaking for some time and then filtering. To each flask 1 or 3 pieces of tomato root-tip, 1 cm long were added. The period of culture lasted 10-14 days, after which the roots were removed, dried and weighed.

#### Experimental results

The first series of tests were performed on two soil samples, one consisting of the untreated sandy clay soil and the other from a plot which had received an equivalent of 80 kg farmyard manure per 1 m<sup>2</sup> about half a year earlier.

In the test there was the following comparison; B1 = culture of *Aspergillus* or roots on the complete nutrient solution, A = culture with the added extract of sample A (soil without manure), Ag = same with ashed soil, F = culture with extract of sample F (soil with decomposing manure), Fg = same with ashed soil. The results with the two separate tests are summarized in Table 1. As the variation in yield level between the different single experiments was very large, the results are given as ranking numbers, 1 = highest, 5 = lowest yield in each test.

The sum of the ranking numbers of the *Aspergillus* test is lowest for A and F, denoting a certain stimulation of growth compared to the controls. The average relative yield obtained from the extracts of the ashed soils does not differ much from that of the blanks. In the root culture test the results are essentially the same. Thus we cannot distinguish between the stimulating effects of the two soil samples. Also the indication is that ashing destroys the stimulating effect, thus indicating that the effect must be due to organic substances.

Table 1.

Comparison of the order of effectiveness in growth stimulating properties of extracts derived from a sandy clay with or without a large addition of farmyard manure

Test method	Blank	A original soil	Ag soil A ashed	F soil + manure	Fg soil F ashed
Aspergillus growth (sum)	22 b*	9 a	16 b	8 a	20 b
Tomato root growth (sum)	22 b	15 a	28 $\frac{1}{2}$ b	16 $\frac{1}{2}$ a	23 b

\* The numbers marked "a" belong to the same statistical population, those marked "b" differ significantly from "a".  $P < 0.001$ .

In another experiment three essentially sandy soils were examined. These soils had been used for horticultural purpose for 1 year (P 19), 10 years (P 11) and 27 years (P 15). These soils were only investigated by means of the Aspergillus test. The results obtained - partly only on two of the soils - are summarized in Table 2.

Table 2.

Comparison of the levels of growth stimulation of three soils, in use for intensive horticulture for different periods of time, by means of the Aspergillus test

	Control	P 19 1 year	P 11 10 years	P 15 27 years
Order of effective- ness sum	20 26 b	10 14 a	11 - a	9 11 a
		$P < 0.001$		
% organic matter		3.4	3.6	3.4
pH-KCl		5.0	5.5	5.9
P.number		7+	9-	17+

As the sum of the ranking numbers for the three soils is about the same, there is no indication that long years of soil treatment, including large applications of organics, shifts the specific stimulative capacity towards a higher level, even though the percentage of humic acids in the organic matter has increased (2). Our result fits in with that of the chemical and physical studies on the whole range of 25 fields. In general the improvement in soil productivity could be ascribed to such factors as an increase in pH, P, K, and Mg level, N-mineralisation, exchange capacity, and amount of available water (2).

The soil samples investigated in the last series of experiments were derived from a field experiment, where a comparison had been made of the effect of applying different organic materials to the soil and of mineral fertilizing over a sequence of 9 years. The soil samples were obtained 1 year after termination of the applications. On this light sandy soil the treatments had all resulted in a noticeable increase in organic matter content.

Ultimately the results (Table 3) suggest the following conclusion, which is confirmed by statistical analysis. The stimulative effect in these test is highest for the soil samples from the plots treated with peat and farmyard manure. The least, and not always a positive effect, is obtained on the soils treated with town-refuse compost and sewage-sludge compost. The effect of the soil which has only received mineral fertilizers and which has the lowest content of organic matter, is intermediate. In comparison to the mineral treatment the effect of large applications of organic material may increase or decrease the specific stimulating effect somewhat. Also there is no correlation of the specific effects with the level of organic matter content.

#### Concluding remarks

In the course of these experiments quite a number of additional observations were collected.

In germination tests with *Lepidium sativum*, tomato in rye as well as in sand-culture of rye also a slight favourable effect, due to addition of soil extracts, might be evident.

Taking into account the results reported and the additional experience the following conclusions are warranted. All soils investigated contained water-soluble constituents, the mixture of which was in most cases able to stimulate growth. The effects were

Table 3.

Comparison of the effectiveness as regards growth stimulating properties of a sand soil after 9 years of applying large amounts of different organic fertilizers

	I	II	III	IV	V
	Control	sewage sludge town refuse compost 36 kg/m <sup>2</sup>	mineral fertilizers	moist peat mull 42 kg/m <sup>2</sup>	farm yard manure 2 42 kg/m <sup>2</sup>
% organ. matter	2.21	2.48	1.49	2.23	1.93
Order of effectiveness in Aspergillus test	6	2	1	4	3
	6	4	5	2	1
	6	4	2	1	3
	6	5	2	1	3
	4	5	2	3	1
sum	$\frac{23}{28}$	$\frac{20}{20}$	$\frac{12}{12}$	$\frac{11}{11}$	$\frac{11}{11}$
	c	b	a	a	a
Order of effectiveness in root growth	3	6	5	2	1
	1.5	6	3	4	1.5
	4	2	6	1	5
	6	4	2	1	5
	1	2	5	4	3
	6	4	3	2	1
	1	6	3	5	2
	2	6	4	1	3
	5	3.5	4	2	1
	6	3.5	4	1	3
sum	$\frac{37.5}{47.5}$	$\frac{47.5}{47.5}$	$\frac{44}{44}$	$\frac{24}{24}$	$\frac{30.5}{30.5}$
	b	b	b	a	a
					P < 0.001

not large and do not seem to be clearly related to the fact whether or not the soil has received large amounts of organic matter. Also no correlation with the humus content can be discerned.

Thus it seems that on account of the very numerous active substances involved - both in stimulating and in growth retarding concentrations - it is very difficult to shift the overall effect towards a distinctly higher level of specific growth stimulation by means of adding large amounts of organic materials to the soil.

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#### Summary

The influence of the total complex of water-soluble organic constituents of the soil on the growth of either *Aspergillus niger* in complete nutrient solution or that of tomato roots in sterile tissue culture was investigated. In most cases a slight stimulatory effect was observed, as was also the case when humic-acid extracts or crude fulvic acid preparations were added. But no clear increase in the overall stimulative effect could be observed in

soils having been heavily fertilized with organic material for a longer or shorter period as compared with soils only receiving mineral fertilizer.

#### Résumé

L'influence du complexe total de matières organiques solubles du sol sur la croissance d'*Aspergillus niger* dans une solution nutritive complète ou de racines de tomate dans une culture de tissu stérile, fut étudiée. Dans le plupart des cas un léger effet stimulant fut constaté comme il fut également le cas en ajoutant des extraits d'acide humique ou d'acide fulvique brut. Cependant, dans les sols fortement fertilisés avec des fumures organiques pendant une période plus ou moins longue aucune augmentation réelle due à l'effet stimulant ne peut être observée par rapport à ceux ayant reçu des engrais artificiels.

#### Zusammenfassung

Es wurde der Einfluss des ganzen Komplexes von wasserlöslichen Bestandteilen des Bodens auf das Wachstum von *Aspergillus* in vollständiger Nährlösung bzw. von Tomaten-Wurzeln in steriler Gewebekultur untersucht. In den meisten Fällen wurde eine geringfügige Stimulierung beobachtet, ebenso wie bei der Zufügung von Huminsäure-Extrakten oder Rohextrakten von Fulvosäuren. Eine deutliche Zunahme im Gesamteffekt der komplexen Extrakte von stark organisch gedüngten Böden im Vergleich mit nur mineralisch gedüngten Böden wurde nicht festgestellt.

#### Резюме

Было изучено влияние общего комплекса водно-растворимых органических веществ почвы на рост *Aspergillus niger* в полной питательной среде и на рост корней томата в стерильных культурах.

В большинстве случаев было отмечено слабое стимулирующее действие веществ, как и в случае прибавления раствора гуминовой кислоты или неочищенной фульвокислоты. Однако, в почвах, в которые в течение более или менее длительного срока вносились большие дозы органических удобрений, не наблюдалось явного стимулирующего действия всех этих веществ по сравнению с почвами, получавшими только минеральные удобрения.