ON THE GROWTH STIMULATING ACTION OF D-D EMULSION

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On the Growth Stimulating Action of D–D Emulsion

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It is a well-known fact that the application of D–D for the control of nematodes results in the increase of yield of various crops. Although it is believed that the nematode control causes the increased yield, the authors have some doubt about it since increased yield is often experienced when the population of nematodes is not so big. It is considered to be due to the fact that a small amount of D–D stays in the soil and stimulates the growth of the plant. With the assumption that the soil application of small amount of D–D in the form of EC be effective similar to or better than in the case of its application as nematicide, the experiment was carried out. Unexpectedly satisfactory results were obtained both in the laboratory and field tests. Now authors are reporting this fact since it is interesting to be utilized widely as a stimulant to be applied in the soil.

MATERIALS

D–D soil fumigant (commercial sample) supplied by Shell Sekiyu K.K.

D–D EC—The above mentioned D–D 90% +10% emulsifier to make emulsion (w/w).

The test seeds used for the laboratory test—

Paddy rice, "Shin-Sembon"
Naked barley, "Tokai Hadaka No. 1"
Lettuce, "Shiro Kaki Chisha" obtained in the market.
Cucumber, "Ao-Dai-Kyuri" obtained in the market.

METHODS

Laboratory test—In order to find out the favourable or unfavourable effect of D–D EC to the growth of root of the plant after germination, 5 cc each of D–D EC diluted at fixed concentrations were put into a petri dish where a piece of cheese cloth was placed. 15 or 20 seeds were placed on the cheese cloth and kept at 25°C for 72–120 hours. Then the length of the main root or the total root length was measured. In the case of paddy rice, the soaked seen had already been kept at 25°C for 3 days and germinated 1–2 mm long before the experiment. One trial consisted of 6–9 different D–D EC concentrations with 3 replications was carried out from 8th January to 4th February.

Pot test—Rice seedlings sown on dried seedbed on 9th July were transplanted on 3rd August to pots (1/1,000 a.) treated as follows:

1. D–D at 2 cc per pot (equivalent to 20 ℓ./10 a.)
   D–D was injected at 15 cm depth on 28th July and soil was aerated on 2nd August.
2. D–D EC treatment before flooding at 0.4 cc per pot (4 ℓ./10 a.)
   D–D 90% EC diluted with water at 1:400 was sprinkled on the surface of the soil.
3. D–D EC treatment after flooding at 0.4 cc per pot (4 ℓ./10 a.)
   D–D EC 90% diluted with water at 1:100 was poured in the pot after irrigation followed by paddling.
4. D–D EC treatment after flooding at 0.2 cc per pot (2 ℓ./10 a.)
   0.2 cc of D–D EC 90% were treated in the similar way to (3).
5. No treatment.

A square 1/1,000 a. concrete pot was used for the experiment, planted with 3 seedlings per hill, 4 hills per pot, and 3 pots per treatment. Ammonium sulphate, potassium chloride, calcium superphosphate were applied as basic fertiliser at 5 g. each per pot. Top dressing was not made.

Fig. 1. The yield of spinach. Left—D-D EC 4 litre plot, Middle—D-D EC 2 litre plot, Right—Check.

Since the starting of the experiment was late, a long-day treatment was made by lighting 60 w. white electric bulbs fixed at 30–50 cm above the top of the rice plants for two hours (from 2–4 o'clock in the morning). On 23rd October, the examination was made on the plant height, length of the 3rd leaf (the 3rd from the last leaf), and the number of stems which would bear heads.

Field test—

Soil property: The test field was of granite alluvial and sandy loam (clay content 10%).

Plots: 0.15 a. per plot, no replications.

1. D–D EC 4 *ℓ./10 a.*
2. D–D EC 2 *ℓ./10 a.*
3. No treatment.

Treatment: Two days before seeding, D–D emulsions were sprinkled at 100 *ℓ./a.* in the seeding row where the water had been applied at 200 *ℓ./a.* and covered with soil. On 5th September, the seeds of spinach soaked in water for 24 hours were sown in the seeding row.

Fertilisation: No basic fertiliser was given but on 27th September ammonium sulphate dissolved in water was given at the rate of 1 kg./*a.*
The distance between the plants was about 30 cm × 15 cm after thinning.

Examination: On 21st December, 20 plants each were sampled at random from the centre of each plot, and the examination on the state of galls and yield was made. The state of gall infestation is expressed in the form of "root-knot index" shown below.

$$\frac{\sum(\text{grade value} \times \text{No. of plants in same grade})}{\text{Total number of examined plants} \times 4} \times 100\%$$

Grade value–4–Severe infestation
3–Many
2–Medium
1–Little
0–None

The examination on yield was made on the length and weight of the root, height of plant and weight of foliage of individual plant.

Results

Laboratory test—The average root length by each petri dish with 3 replications obtained is shown in Table 1. The significant difference between treatments at 1% level was observed by analysis of variance.

Paddy rice was treated for 3 days and 5 days. In the 3 day treatment D–D treated plots did not show better root growth than check plots. In higher concentration plots, e.g. 90 ppm plot, the root growth was inferior to that in the check plots. It is thought that the phytotoxic effect inhibited the root growth of the plant. In 5 day treatment plots, the length of the roots in the treated plots at 9×10^{-5}–9 ppm was superior to that in the check, which is considered to be due to the stimulating action of D–D. The fact that the growth of the root in the treated plots at 90 ppm was not much better than the check plot may be the result that the stimulation action offset the inhibition of the plant growth.

Table 1. The effect of D-D EC application to the growth of the root of the crop after germination (25°C).

D-D Concentration	Average length of the root (mm)				
	Paddy rice		Naked* barley	Lettuce	Cucumber
	3 days	5 days	3 days	5 days	4 days
Check 0	31.7	54.3	110.3	33.3	33.3
90	27.3	58.7	146	30.0	40.7
9	33	66.0	127	24.7	46.3
0.9	29.7	66.7	127	29.3	47.7
0.09	32.3	61.7	129.3	37.0	46.3
0.009	33.0	61.7	137.3	36.0	49.3
0.0009	—	64.0	119.3	40.3	52.0
0.00009	—	68.3	116.7	40.7	47.0
0.000009	—	56.0	—	—	49.3
L.S.D. 5%	1.67	5.32	20.1	5.65	3.84
L.S.D. 1%	2.37	7.32	27.9	7.84	5.29

* Total length of the roots

In the naked barley trial, roots were significantly longer in 90 ppm and 9×10^{-3} ppm plots. Since the root length of the plant in the 90 ppm-9×10^{-3} ppm plots indicated 15% more growth than that in the check plots, concentrations between $9\times10^{-3}-90$ ppm can be said to have stimulant action to the plant.

In the lettuce trial, inhibition of the root growth was observed in treated plots between $9\times10^{-1}-90$ ppm, while at the lower concentrations than 9×10^{-5} ppm significant stimulating action was observed. Similar to the case of rice, it is considered that the inhibition of root growth and stimulant action offsets each other between concentrations $9\times10^{-1}-90$ ppm.

In the cucumber trial, the same stimulant action in the case of other plants was observed.

Pot test—The growing state of rice plants transplanted to the experiment pot in general was rather satisfactory except that some light phytotoxic effect was ob-

Table 2. The examination on the growth of paddy rice in D-D treated pots.

Application of D-D per pot cc	per 10 a. litre	Time of application	Plant height cm	Length of 3rd leaf cm	No. of stems with the last leaf*
D-D 2	20	Before irrigation	99.3	55.9	12.3
D-D EC 0.4	4	〃 〃	102.1	56.3	13.9
〃 0.4	4	After 〃	90.4	50.6	10.9
〃 0.2	2	〃 〃	93.5	52.8	10.6
Check —	—		94.9	53.0	9.0
L.S.D. 5%					2.09
1%					3.05

* Which would bear heads.

served in the D–D treated pots immediately after transplanting with unhealthy colour of leaves and late rooting. At the time of early tillering, no difference between treatments was observed. Later the leaf-colour and plant height of the plants in the plots where 0.4 cc of D–D EC were applied before irrigation, became better than in other plots, showing conspicuous difference at the beginning of September. The examination on yield was impossible due to the late transplanting resulting in late heading and incomplet ripening. The last examination on the plant growth is shown in Table 2.

The number of stems with the last leaf which would bear heads in the plots where 0.4 cc of D–D EC were applied before irrigation was many, being 150% of that in the check. This means that the application of D–D EC at 4 *ℓ*./10 *a*. gave better yield of rice than that of D–D soil fumigant at 20 *ℓ*./10 *a*. The above phenomena may be due to the phytotoxicity caused by D–D at the beginning.

Field test—Table 3 shows the yield of spinach and the state of infestation by rootknot nematodes.

Table 3. The yield of spinach and the state of infestation by rootknot nematodes.

Application per 10 a.	Rootknot index	Root			Plant height cm	Weight of leaves & stems g.	Total wt. g.
		Diameter mm	Length of tap root cm	Weight g.			
D–D EC 4 *ℓ*.	37.5	11.4	19.3	7.4	30.0	48.0	55.4
〃 2 *ℓ*.	23.8	8.8	15.5	3.4	26.9	24.7	28.1
Check	32.5	6.7	14.4	2.6	22.9	15.4	18.2
L.S.D. 5%	—	1.49	1.81	1.58	2.42	11.35	12.67
1%	—	2.00	2.42	2.11	3.24	15.17	16.93

State of infestion of *Meloidogyne incognita acrita* is shown in rootknot index. There was not much difference on the gall index between D–D EC 4 litre plot and the check. However, the yield in D–D 4 litre plot was almost as three times as much of that in the check.

Thus the application of D–D EC at the dosage rate of 4 *ℓ*./10 *a*. is not enough to control nematodes (1/5 of the usual dosage rate), but to accelerate the growth of the crop resulting in the remarkably increased yield. It was concluded that D–D EC application at 2 *ℓ*./10 *a*. was too little to affect the yield significantly.

Discussion

Casida and Allen and many other researchers have reported that many organic fungicides and insecticides indicate stimulating action as well as inhibiting action of plant growth. It has been clarified by the authors that a small amount of D–D stimulates the growth of the root of the crop through examination of the length of the root of the germinating seeds. (Table 1.) When the concentration of D–D was higher, the inhibition of root growth was observed on some plants, e.g. lettuce

at 9×10^{-1}—9 ppm., though in the range of proper concentration the growth of the root was stimulated, e.g. lettuce at less than 9×10^{-4} ppm. As shown in Fig. 2, this range is fairly wide, though it differs by the kind of the object crop.

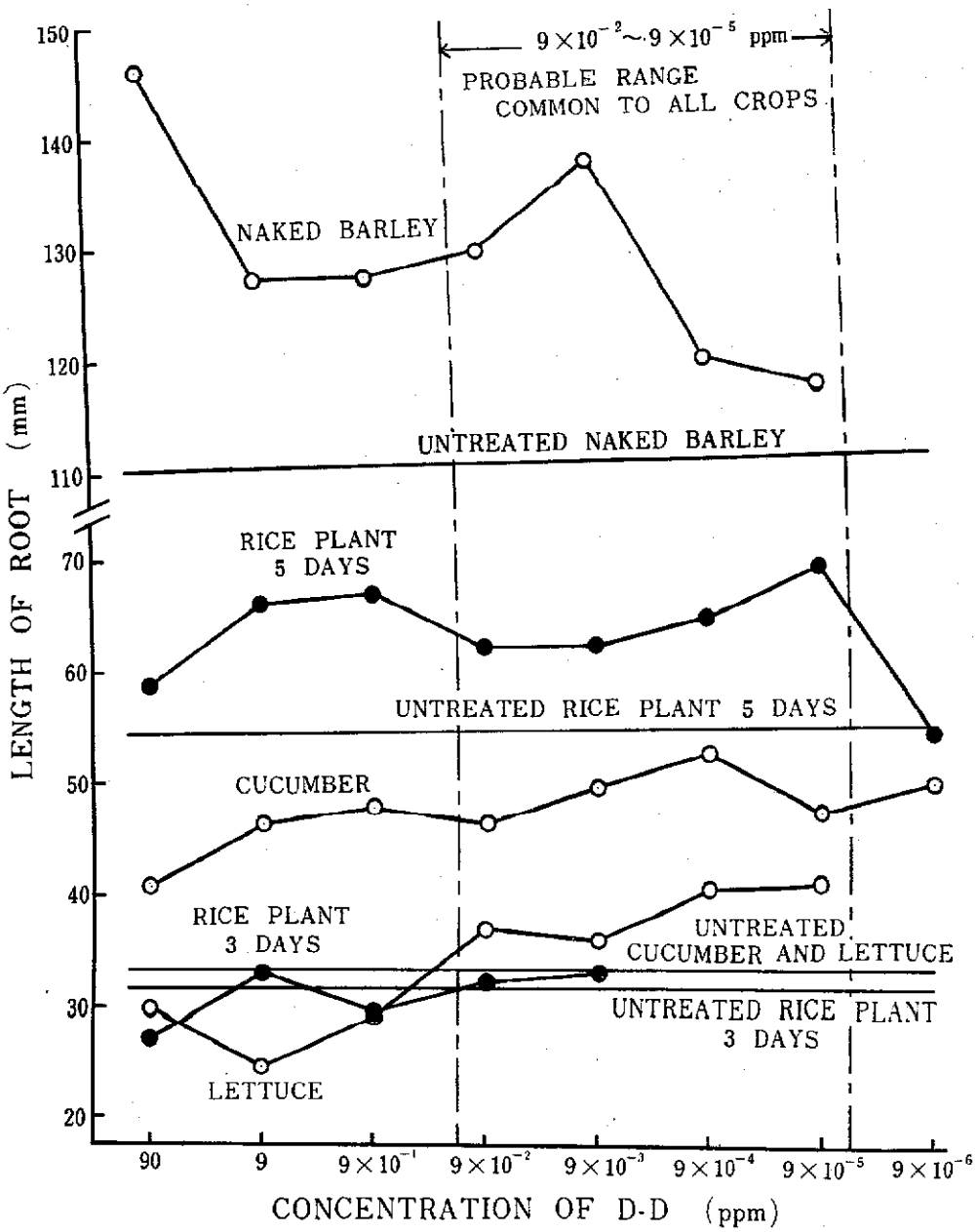

Fig. 2. Root length of some crops in several D–D concentrations.

Since distilled water was used in this germination experiment, the secondary effects found in the usual D–D application test in the soil such as the increase of ammonia or total-N content do not interfere the result, so that it can be assumed that this vigorous growth of the root is entirely due to the direct stimulation of D–D to the growth of the root. In the pot experiment, the application of 4 *ℓ*./10 *a*. (1/5 of usual dosage rate) gave better effect than the application at 20 *ℓ*./10 *a*. It is also thought that the small amount of D–D remained in the soil after the gas

evaporation stimulated the root of rice plants in the similar way to the EC application, which resulted in the increase of stems in the D–D application at 20 ℓ./10 a. plot. When D–D EC was applied in the irrigated water, D–D might not directly contact with the root, and it was not so effective as in the case of D–D application to the soil before irrigation.

In the field test, the D–D EC application of 1/5 amount of the usual dosage rate did not show any noticeable nematicidal effect as shown in the gall index, however, the yield was more than 3 time as much as that in the check plot. Thus it may be concluded that in the similar way to the germination trial, a small amount of D–D existing in the soil gave stimulating action to the crop for a long time, resulting in the increase of yield.

D-D の作物生長刺戟作用

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D-D乳剤を使用して、室内での発芽試験と圃場試験を実施した。

発芽試験では水稲、裸麦、きうり、ちしゃの種子をD-D乳剤の濃度90～9×10^{-6} ppm の稀釈液 5 cc を入れたシャーレー内に15～20粒づつ並べ 25° C で 3 ～ 5 日放置後根長を測定した。供試種子の根長はすべて 0.1 % 水準で処理間に有意差があり、9×10^{-3}～9×10^{-5} ppm の範囲で明らかな伸長刺戟作用が認められた。

水稲のポット試験では湛水前に土壌面から D-D 乳剤を 4 ℓ/10a 処理した区の有効茎数は無処理区の150%を示し、D-D油剤 20 ℓ/10a 土壌中処理区よりすぐれていた。

圃場ではD-D乳剤 4 ℓ/10a、2 ℓ/10a をそれぞれ水にうすめてまきみぞに灌水後かるく覆土し、2 日後の 9 月 5 日にほうれんそうをは種した。12月21日に区の中央部よりランダムに20個体をとり、生育収量およびネコブセンチュウの寄生状況を調査した。D-D乳剤 4 ℓ/10a 処理区の収量は標準区の 3 倍強を示し、2 ℓ/10a 処理区では標準区との間に有意差が認められなかった。一方ネコブセンチュウのゴール着生状況の調査結果では処理間には差がなかった。

以上の結果から D-D の微量の存在が作物の根に対して伸長を刺戟する作用があり、この作用が作物の増収をもたらすものと結論した。