Chemical Control of Plant Growth and Development

(2) Effect of α -naphthaleneacetic acid and 2,3,5-triodobenzoic acid on growth of rice plant*.

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Introduction

With an aim of finding out the chemicals which are able to control growth of rice plant with practical purposes in rice culture, a series of experiments, in which naphthaleneacetic acid, indole-3-acetic acid, coumarin, maleic hydrazide, 2,3,5-triodobenzoic acid and some other chemicals were examined, has been carried out. Although the investigation is still on its way, some of the interesting results obtained with naphthaleneacetic acid and 2,3,5-triodobenzoic acid will be presented in this paper.

Material and Methods

Experiments were carried out with rice plant, variety Norin No. 29, grown in pot soil culture, by the use of pot of are/5000 size, under natural condition. Naphthaleneacetic acid (NAA) and 2,3,5-triodobenzoic acid (TIBA) were applied to the plants through the leaves by foliar spray. Aqueous solution of given concentration was prepared, to which few drops of surfactant, Neoesterin, were added. After spray, changes in plant appearance were observed, plant height was measured, and number of tillers counted.

In all experiments, a group of five pots was subjected to each treatment differing in kind and concentration of chemicals. A hill, consisted of two plants, was grown in each pot, under continuous submerged irrigation.

Result and Discussion

1. Effect of NAA on plant growth

In experiment 1, NAA was applied at the rate of 5 ml/pot on 11 and 30, July. As illustrated in Fig. 1, apparent reduction in tillering took place. Before the treatment was initiated, the plants had already produced about 26 tillers per hill. With control plants number of tillers increased up to 38, while the treated plants produced less tillers. There was a tendency that the higher the concentration of NAA applied, the less the number of tillers produced. Application of NAA, on the other hand, reduced the plant height. Plant height of control plot and of NAA 1,000 ppm plot is given in Fig. 1, those of other plots being intermediate between these two.

Fig. 1. Effect of NAA on plant height and tillering (Experiment 1).

It is apparent from this result that NAA applied at the end of effective tillering stage can reduce the production of ineffective tillers and consequently can increase the percentage ratio of effective tillers to the total tillers. This suggests a possibility of using NAA for controlling ineffective tiller formation.

In experiment 2, plants were grown under two levels of nitrogen application; ordinary level (N_1 plot) and higher level of nitrogen (N_2 plot). At early tillering stage (20, July), NAA was applied at the rate of 5 ml/pot. As shown in Fig. 2 and 3, the treatment induced an appreciable reduction in plant height and tillering, but the reduction was gradually disappeared at later growing stages, especially in N_2 plot. Appearance of plant as affected by NAA spray is given in Fig. 4 and 5.

In experiment 3, effect of NAA on the growth of each leaf was examined. Application was made at the time when the tenth leaf on the main stem (10/0) was just developing. Length of leaf blade and leaf sheath of each leaf was measured 10 days after treatment. As shown in Table 1, NAA inhibits strongly the growth of leaves which were just developing at the time of application. In N_2 plot, growth inhibition was apparent with leaf blade of 10/0, leaf sheath of 9/0, and leaf blade and

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Fig. 2. Effect of NAA on plant height and tillering (Experiment 2).

Fig. 3. Increase in plant height and number of tillers after application of NAA (Experiment 2)

... } = Increase during 25 days after treatment.
 ... } = Increase during 5 days after treatment.

sheath of 3/5 and 2/6, all these portions were just elongating at the time of application. In N_1 plot, because the growth was slightly delayed as compared with N_2 plot at the time of treatment, leaf blade and sheath of 9/0, and leaf blade of 10/0 were affected, and therefore leaf blade and sheath of 2/5, leaf blade of 3/5, as well as leaf blade and sheath of 1/6 and leaf blade of 2/6 were affected. The result clearly indicates that NAA inhibits the growth of organs which are just growing at time of application, whereas the organs grown subsequently are affected to a least extent if not completely unaffected.

In N_1 plot, height of control plant is represented by the height of 9/0, whereas that of treated plant is responsible for the height of 8/0. Similarly, the height of control plant in N_2 plot is represented by 10/0, whereas that of treated plant by 9/0. This is the actual cause of reduction in plant height

Fig. 4. Growth of plant as affected by NAA application (Experiment 4)

A = Control, B = NAA 10 ppm.

Fig. 5. Growth of plant as affected by NAA application (Experiment 2, N_2 plot)

A = Control, B = NAA 10 ppm, C = 100 ppm, D = 1,000 ppm.

induced by NAA.

MUROGA (1961) reported that spray application of NAA made the rice plant resistant to lodging, because NAA inhibited the elongation of basal internodes which were just growing at the time of spray. These results suggest a possibility of the practical use of NAA not only in preventing lodging but also in preventing supervetiveness (excessive vegetative growth) which is considered to lower grain yield in Japan (YAMADA 1956, MURATA 1961 and others) or in India (KANITKAR and PATIL 1961).

2. Effect of TIBA on plant growth

In experiment 1, TIBA was applied at the concentration of 3, 30, 300 and 1,000 ppm and at the rate of 5 ml/pot on 18, June and 21, July and 20 ml/pot on 31, July. As shown in Fig. 6, 7 and 8, TIBA was found to be very effective in promoting tillering. Maximum number of tillers produced

Fig. 6. Effect of TIBA on plant height and tillering (Experiment 1)

Fig. 7. Growth of plant as affected by TIBA application (Experiment 1)

A=Control, B=TIBA 1,000 ppm.

Fig. 8. Tillering as affected by TIBA application (Experiment 1)
A=Control, B=TIBA 1000 ppm.

Fig. 9. Effect of TIBA on plant height and tillering (Experiment 2)

n control plant was 38, while the treated plant (1,000 ppm TIBA) produced more than 45. The increase was as much as 20 %. Because of limited supply of nutrients due to small pot culture, the treated plant gave only few tillers more than the con-

trol plant in the final number of tillers. No harmful symptom was observed by TIBA application, except a slight reduction in plant height and in plant color.

In experiment 2, TIBA of 1,000 and 5,000 ppm was sprayed on 8, Aug. at the rate of 7 ml/pot to the plants growing under two levels of nitrogen application, N_1 and N_2 plot. Here again,

the increased production of tillers and decreased plant height were observed as shown in Fig. 9. Abnormally slender leaves were produced immediately after the treatment with 5,000 ppm, but not with 1,000 ppm. This abnormality, however, disappeared within few weeks.

TIBA had been shown by GALSTON (1947) to be capable of counteracting the action of auxin. ZIMMERMAN and HITCHCOCK (1942) found that tomato plants lost

much of their apical dominance and produced an abnormally large number of axillary branches in response to TIBA application. ASEN and HAMNER (1953) found that TIBA significantly increased the number of basal shoots per plant as well as the

Table 1. Effect of NAA application on growth of each leaf of rice plant (Experiment 3)

Nitrogen level			N ₂ plot			N ₁ plot		
Plant Part	NAA ppm		0	500	1,000	0	500	1,000
Plant height, cm			69.7	58.7	60.0	68.2	55.0	56.8
Root length, cm			22.0	20.0	18.7	23.8	20.8	20.0
Number of tillers per hill			15.7	13.0	9.0	12.3	12.3	8.7
Length of leaves on main stem, cm	5/0	{ LB	16.7	17.5	17.5	17.5	17.0	17.7
		{ LS	11.7	11.3	9.2	11.0	10.2	10.0
	6/0	{ LB	22.8	21.2	21.0	23.7	22.3	21.0
		{ LS	13.2	12.3	11.3	12.2	11.3	12.5
	7/0	{ LB	25.5	26.7	25.0	26.8	25.3	25.8
		{ LS	14.0	14.2	13.8	17.7	15.7	16.0
	8/0	{ LB	30.2	30.5	29.0	36.7	33.2	34.2
		{ LS	20.3	20.3	19.5	22.5	19.3	20.0
	9/0	{ LB	43.2	41.8	42.5	45.3	34.2	35.2
		{ LS	22.2	17.2	16.8	22.3	16.7	15.5
	10/0	{ LB	44.7	29.3	26.5	38.8	30.3	25.7
		{ LS	22.0	23.2	20.0	22.0	22.7	21.8
11/0	LB	22.5	23.3	24.3	3.0	13.8	12.8	
Length of leaves on tillers, cm	2/5	{ LB	29.3	29.7	28.5	31.0	23.0	26.7
		{ LS	18.3	15.2	14.2	18.2	12.2	12.5
	3/5	{ LB	37.0	24.8	21.8	39.5	23.5	20.8
		{ LS	20.2	18.3	16.0	18.5	18.3	18.8
	4/5	LB	26.3	31.5	24.5	9.8	22.2	20.2
	1/6	{ LB	20.5	18.8	20.2	18.3	10.5	14.3
		{ LS	16.5	14.8	12.0	13.8	10.8	9.8
	2/6	{ LB	31.3	25.8	16.0	27.5	19.0	15.2
		{ LS	18.7	17.8	14.3	12.0	13.3	14.3
	3/6	LB	20.0	13.2	24.2	5.5	14.0	14.2
Dry weight of top			11.49	10.35	9.45	9.85	7.80	7.78
Dry weight of root			2.60	2.85	2.95	2.54	2.25	2.55
Total dry weight per hill			14.09	13.20	12.40	12.39	10.05	10.33

Note: N₁ plot=ordinary level of nitrogen applicationN₂ plot=higher level of nitrogen application

LB=Leaf blade LS=Leaf sheath

Gothic letters indicate the strong reduction in leaf length induced by NAA application.

number of plants developing such shoots with greenhouse roses. Recently, COWETT and SPRAGUE (1962) found that tillering of established alfalfa plants was increased by anti-auxin, TIBA application.

LEOPOLD (1949) reported that TIBA was fairly effective in promoting tillering with winter barley and teosinte. Although the actual increase of tillers induced by TIBA application with barley was only 0.5 per plant, the result indicated that tillering in grasses can be controlled by auxin or anti-auxin, just as branching in dicotyledonous plants is. The authors' results presented here furnish a very clear evidence that the tillering of rice plant can be controlled by TIBA and NAA. Thus, the results give a new contribution to the mass of knowledge on the auxin relationships of tillering. In general, relatively high concentration of NAA and TIBA was required to induce increasing or decreasing effect on plant growth in this experiment. In the case of gibberellin spray, concentration as low as 10 to 20 ppm was sufficient enough in inducing remarkable elongation of internodes and leaves of rice plant (unpublished data). This might be due to the difficulty of penetration of NAA and TIBA into the leaves. The surfactant used in this experiment was Neoesterin, product of Toa-Noyaku

Co., which consists of poly-oxyethylenealkylarylether 20 %, polyoxyethylenefattyacidester and polyoxyethylenesine ster 10 %. Because the penetration of chemicals into plant is influenced to a great extent by the property of surfactant or wetting agent, it is desirable to give a further consideration on the kind of surfactant.

Summary

1. Foliar spray of aqueous solution of NAA is very effective in reducing plant height and tillering of rice plant. The chemical inhibits the growth of organs which are just growing at the time of application, but it is not effective to the organs which are to grow subsequently.

2. Spray of TIBA is highly effective in promoting tillering of the plant. The result indicates that tillering in rice plant can be controlled by auxin or anti-auxin, just as branching in many dicotyledonous plant is.

3. Possibility of practical use of NAA for controlling superve-

getativeness and of TIBA for promoting tillering is suggested.

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〔和 文 摘 要〕

作物の生長と発育の化学的制御に関する研究

(2) Naphthaleneacetic acid および 2,3,5-triiodobenzoic acid が
水稲の生育におよぼす影響

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水稲の生育を人為的に制御しうる物質を探索する目的を以て, Indole-3-acetic acid, coumarin, maleic hydrazide など多数の物質を供試して, 一連の研究を行ないつつあるが, そのうち naphthaleneacetic acid (NAA) および 2,3,5-triiodobenzoic acid (TIBA) についてえられた結果の若干を報告する.

(1) NAA の水溶液を水稻体に散布すると, NAA の濃度 100~1000 ppm において草丈と分けつの顕著な抑制が起る. この抑制は散布当時に生育しつつある部分に強く現われるが, 散布期以後, 新たに生育する部分に対してはほとんど影響がなく, したがって日数の経過とともに生育の抑制は漸次回復する. とくに多肥条件下ではその回復が早い. 有効分けつ終止期に NAA を散布すると無効分けつの発生を抑え, 有効茎歩合を高めることができる. 茎葉が過繁茂状態になる場合には NAA の利用によつてそれを防止することができるのではないかと考えられる.

(2) TIBA は以前から一種の anti-auxin であるとされている物質であるが, その水溶液 (100~1,000 ppm) を葉面に散布することによつて, 水稻の分けつの生成を顕著に増加せしめることができた. TIBA 5,000 ppm では薬害を生じ, 細長い異常葉を発生するが, 1,000 ppm 以下の濃度ではなんらの薬害を認めず, 草丈が若干抑制されるだけである.

分けつの増加のし方は, 対照無処理区で分けつが急増している間には処理との差がないが, 対照区で分けつ増加がゆるくなつても処理区ではさらにそのまま増加がつづくという状態である. すなわち分けつ発生の規則性は乱されていないが, その増加のテンポが低下しないと見られる.

(3) 以上の結果は水稻の分けつ発生が auxin あるいは anti-auxin によつて支配されていることを示唆する.

(4) NAA および TIBA とともに比較的高濃度においてその作用が発現することは, これら物質が水稻体内に侵入しにくいことを示していると考えられる.