

Some Tests on the Use of 2,4-Dichlorophenoxyacetic Acid for Controlling Weeds in Paddy Fields (1) *

By

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I. Introduction

Japan being situated in the monsoon region of Asia, sees abundant growth of weeds on arable lands during the warm and rainy period of June and July. Accordingly, farmers require much labor for weeding during this season. Weeding in paddy fields by hands is one of the most laborious works. We have been trying to eliminate this by using chemicals on weeds in this laboratory as early as 1940 using such chemicals and methods as sulfuric acid, ferrous sulfate, calcium cyanamide, etc., mulching with straw or compost. These tests are reported in twelve papers including⁽⁴⁾⁽⁵⁾⁽⁶⁾ and others.⁽⁹⁾ These methods were found to be effective for controlling weeds, but under the present Japanese agricultural conditions of economy and practice, most of them proved expensive from the lack of material and technical difficulties in their application.

The 2,4-D (2,4-dichlorophenoxyacetic acid) was compounded by R. POKERNY⁽¹²⁾ (1941) in America. Following the discovery of the growth-regulating properties of 2,4-D by P. W. ZIMMERMAN and A. E. HITCHCOCK⁽¹⁴⁾ in 1942, its effect as a selective weed killer was proved for the first time in 1944 by C. L. HAMNER and H. B. TUKEY,⁽¹⁾⁽²⁾ P. C. MARTH and J. W. MITCHELL,⁽¹⁰⁾ J. W. MITCHELL and C. L. HAMNER.⁽¹¹⁾

At present this chemical seems to be used mainly on the fields of corn, wheat, barley, oats, rye, sugar-cane, sorghum, and crops grown in paddy fields. It is well known that it caused a sensation in agricultural circles of America. So far as the author is aware, there are some 200 treatises on 2,4-D. An outline content of them was published in Japanese in *Nogaku Kenkyu* of this institute⁽⁸⁾. In regards to the weeding in the rice field, T. C. RYKER and C. A. BROWN⁽¹³⁾ (1947) applied a spray of 0.1 per cent 2,4-D solution, 100 gallon per acre, (approximately 90 liters per 10 ares with 90 g. of 2,4-D) and 10 or 15 per cent dusts applied at the rate of 10~20 lbs. per acre (approximately 1~2.25 kg. per 10 ares with about 100~300 g. of 2,4-D) just before or within two weeks after flooding effectively controlled broad leaf weeds, and increased the yield of rice substantially.

In our country H. INOUE and T. IWAMOTO⁽³⁾ succeeded in utilizing an American

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product (chiefly 2,4-D amine salt) in 1948. The author made experiments in 1948: (a) in rice nurseries, (b) in fields of rice plants in growth, and (c) in open fields prior to cropping. 2,4-D acid used in the above test was kindly supplied by Mr. G. SHINTANI of Kyoto University and also by the Japan Gasolin Co. The chemicals given by the latter was, however, 95 per cent sodium or ammonium salt containing about 80 per cent of 2,4-D acid.

The results of (a) and (c) were rather unsatisfactory, but in (b) a favorable result was secured and upon which it is briefly reported below.

II. Test on 2,4-D during the growth of rice plants

1. *Experimental method*

On a paddy field $\text{NH}_4\text{-2,4-D}$ or Na-2,4-D was sprayed over the leaves of the weeds in dilute solutions of 0.05, 0.075, and 0.1 per cent at the rate of 75~150 liters per 10 ares with a sprayer or a sprinkler within 2 to 4 weeks after the rice plants were transplanted. Plants were set in squares, rows and ridges on June 30th, 1948.

Further details are given in the accompanying tables.

2. *Results of observation of weeds sprayed with 2,4-D on paddy field*

When 30~120 g. of 2,4-D was applied on a drained field, all of the weeds except the gramineous plants such as *Echinochloa crusgalli* BEAUV. were killed. *Eleocharis acicularis* KOCH. reappeared in the 30 g. treatment plot, only after it was damaged momentarily. The killing effect of 2,4-D on some of the more common weeds is as follows: the petioles of *Monochoria vaginalis* PRESL. made a single revolution and the plant dropped to the ground the day after the spraying. (Fig. 3) It then began to discolor, and decayed in few days. It took about 10 days for *Aneilema Keisak* HASSK. to decay. The leaves of *Dopatorium junceum* HAMILT. and *Rotala indica* var. *uliginosa* KOFHNE curled and decayed near the ground, but the nodes of the stem became easily separated. They were killed in about 10 days, though *D. junceum* HAMILT. was slightly resistant. On *Fimbristylis miliacea* VAHL., *Cyperus Iria* L. and *C. difformis* L. no abnormal symptom was seen at first, but after 5 or 6 days, stalks started changing the color near the ground, and the parts became brittle and loose, finally dropped and decayed in two weeks. Most of *Eleocharis acicularis* KOCH. were killed. Although slightly resistant, most of *Elatine orientalis* MAKINO, *Eclipta alba* HASSK. and *Lobelia radicans* THUNB. were well controlled by the spray. All weeds that were killed became like a compost in a week or two, and the tempo of decomposition was quite rapid.

3. *The weights of remaining weeds that were hand-picked from all test plots recorded in the latter part of September.*

In A and B plots of Table 1, two sprayings were made on a paddy field that remained in flooded condition, one on 17th and the other on 29th of July. The total amount of 2,4-D applied was 120 g. per 10 ares. In this treatment it took more than 2 weeks to kill weeds. Those that survived were somewhat more than when a spray was made on the drained field.

In C plot of Table 1, where it was drained on July 17th and sprayed roughly by a sprinkler with 60 g. of 2,4-D of 0.1 per cent solution at the rate of 75 liters per 10 ares, the solution did not spread over the weeds completely owing to the shortage of solution, a part of the weed remained alive from the beginning, and resulted in much weeds. A successful result was got in D plot where 45 g. of 2,4-D in a larger volume of water 112 liters per 10 ares, was also applied by a sprinkler. On E, F and G test plots 75 liters per 10 ares of 2,4-D was sprayed with a fine rose sprayer on July 26th after drainage. A thorough dispersion of fluid over weeds killed almost all except *Echinochloa crusgalli* BEAUV.

The amounts of weeds that survived in the E and F plots (45~60 g. of 2,4-D per 10 ares) equalled the plot that was normally weeded 4 times. A good weeding effected by the combination of hand and simple mechanical weeder is referred as "hand-weeded 4 times" in this report. The remarkable weeding effect of 2,4-D is shown in Fig. 4. In G plot, however, the test failed because the amount of 2,4-D sprayed was only 30 g., which allowed *Eleocharis acicularis* KOCH. to grow again. In the unweeded plot, fresh weeds weighed 1100 kg. (138 kg. when dried).

Tdble 1. Yields of rice and weights of weeds from 2, 4-D treated flooded rice field planted in squares, 1948.

Plot (0.13 ares)	Treatment		Date of application	2,4-D solution per 10 ares	total weigh of dry rice plants	Weight of unhulled rice	weight of fresh weed	Yield of unhulled rice per 10 ares
	Condition of plot	Concent- ration of 2,4-D salt						
A)	Flooded	% (0.2 0.1)	July 17 July 29)	112(120)	18.42 ^{kg.}	5.54 ^{kg.}	3.31 ^{kg.}	415.5 ^{kg.}
B)	Flooded	(0.1 0.1)	July 17 July 29)	150(120)	18.78	5.57	4.62	417.8
C)	Drained	0.1	July 17	75(60)	20.19	5.52	4.98	414.9
D)	Drained	0.05	July 17	112(45)	21.85	6.32	2.13	474.0
E)	Drained	0.1	July 26	75(60)	20.74	6.15	0.71	461.3
F)	Drained	0.075	July 26	75(45)	20.91	6.18	0.39	453.5
G)	Drained	0.05	July 26	75(30)	18.01	5.35	6.53 ⁺	401.3
H)	Hand-weeded 4 times			—	21.78	6.19	0.32	464.2
I)	No weeding			—	14.07	3.98	15.03	298.5

Remarks.

- 1) Rice variety : (Asahi x Dokaishinriki), planted July 30. 171 bunches per plot.
- 2) Plots A~D applied with a sprinkler; E~G with a fine rose sprayer. In A and B the solution per 10 ares is the sum of two applications.
- 3) At the time of spraying, rice plants were 40 cm. tall. Weeds were: *A. Keisak* 25 cm., *M. Vaginalis* 20 cm., *C. Iria* 25 cm., *L. Pyxidaria* 10 cm., *D. Juncem* 10 cm., and *R. india* var. *uliginosa* 5 cm.,
- 4) The weights of fresh weeds were taken on September 26th. + Denotes the subsequent occurrence of *E. acicularis*.
- 5) In plot C, 75 liters of solution applied with a sprinkler failed to spread fully over the weed and caused some weeds to survive throught the test.
- 6) The amount of fertilizer used per 10 ares: Ammonium sulphate 30 kg., Calcium superphosphate 15 kg., and Potassium chloride 3,75 kg.

In a rice field planted in rows as shown in Table 2, 2,4-D was sprayed again on July 29th because *Rotala india* var. *uliginosa* KOEHN, *Dopatorium junceum* HAMILT. and others survived from having been flooded with water the night it was first sprayed on July 17th. The total amount of 2,4-D was 72~120 g. The surviving weeds, in I plot with 120 g. of 2,4-D, was equal to the plot hand-weeded 4 times, showing the remarkable weeding effect of 2,4-D.

In the test of Table 3, rice having been transplanted on the ridge, there was considerable difference in the kinds of weeds that normally occur in the furrow. Among the weed in furrows *Monochoria Vaginalis* PRESL. was plentiful, compared to *Lepto-*

Table 2. Yields of rice and weights of weeds from 2,4-D treated flooded rice field planted in rows, 1948.

Plot ($\frac{1}{16}$ ares)	Treatment		2,4-D solution per 10 ares		Total weight of dry rice plants	Weight of unhulled rice	Weight of fresh weeds	Yield of unhulled rice 10 ares
	Condi- tion of plot	Concent- ration 2,4-D salt	%	L g.				
I)	Drained	0.05	188	(72)	19.64	6.75	2.31	405.0
II)	Drained	0.1	150	(120)	18.70	6.55	0.89	393.0
III)	2 times hand weeding	—	—	—	21.24	6.73	4.03	403.8
IV)	4 times hand weeding	—	—	—	21.62	6.98	0.84	420.8
V)	No weeding (untreated)	—	—	—	17.00	5.04	9.52	302.4

Remarks :

- 1) Rice variety: Asahi, planted July 30th, 243 bunches per plot.
- 2) Since weeds that were submerged by flooding on the evening of the first application made on July 17th survived, a second was applied on 29th of July. The volumes and quantity of 2,4-D per 10 ares are the sum of two applications.

Table 3. Yields of rice and weights of weeds from 2,4-D treated ridged rice field, 1948.

Plot (0.1 ares)	Treatment	2,4-D solution per 10 ares		Total wei ght of dry rice plants	Weight of unhulled rice	Weight of fresh weed	Yield of unhulled rice per 10 ares
		%	L. g.				
1) ⁺	0.1	70	(55)	11.62	3.50	R. 1,308 F. 3,100	350
2)	0.075	100	(60)	11.96	3.56	R. 1,662 F. 69	356
3)	0.05	100	(40)	12.30	3.85	R. 1,240 F. 200	385
4)	Weeded	—	—	12.35	3.79	R. 299 F. 308	379
5)	No weeding	—	—	8.23	2.20	R. 7,714 F. 3,050	220

Remarks :

- 1) Rice variety. Asahi, planted June 30th. The furrow was always flooded.
- 2) R. and F. in weight of the fresh weeds denote those of ridge and furrow respectively.
- 3) 141 bunches per plot.
- 4) + This plot was sprayed in solution on the ridge only.

chloa chinensis NEES and some *Fimbristylis miliacea* VAHL., on the ridge. The effect of weeding in furrows was about same as in the flooded paddy field, but on ridge, the quantity of surviving weeds was more, as the proportion of gramineous weeds was greater.

Table 4. Yields of rice from 2,4-D treated flooded rice field, planted in squares, 1948.

Record of individual rice plant.

Treat- ment plot	(1) Total wei- ght of rice plant	(2) Weight of panicle	(3) Number of tiller	(4) Panicle length	(5) Number of full grain per bunch	(6) Weight of 1000 hul- led rice	Percent weight of panicle to straw
A)	g.	g.	g.	g.	no.	g.	%
B)	93.3±3.72	50.5±1.64	19.8±0.66*	18.7±0.12*	1693	26.1	106
C)	96.0±2.78	51.0±1.61	19.8±0.51*	17.9±0.25	1761	26.2	97
D)	98.8±2.09	52.9±1.59	22.6±0.57*	17.9±0.23	1877	26.4	107
E)	98.0±2.50	53.2±1.32	23.1±0.65	17.9±0.20	1898	26.5	98
F)	96.4±2.23	54.2±1.20	21.4±0.46*	18.2±0.14*	1804	27.5	112
G)	85.6±1.55*	45.5±0.73*	19.7±0.39*	17.5±0.20	1615	26.3	91
H)	99.3±1.41	53.0±0.66	26.4±0.37	17.0±0.15	1941	25.3	91
I)	70.2±1.52*	33.1±0.76*	18.5±0.14*	15.6±0.26*	1075	26.2	69

Remarks:

- 1) The treatment corresponds to Table 1. (1) (2) and (3) are the measurements of 20 bunches taken diagonally on each plot. Figures in (4) and (5) were taken from panicles of 2 bunches chosen as mode bunches of (1) (2) (3).
- 2) *, denotes the difference of means between treated and 4 times weeded, grater than 5 times the probable error of difference.

Table 5. Yields of rice from 2,4-D treated flooded rice field planted in rows, 1948.

Record of individual rice plant.

Treat- ment plot	Total wei- ght of rice plant	Weight of panicle	Number of tiller	Panicle length	Number of full grain per bunch	Weight of 1000 hul- led rice	Percent weight of panicle to straw
			no.	cm.	no.	g.	%
I)	71.9±1.66 ^{g.}	40.3±0.97 ^{g.}	16.4±0.43*	18.2±0.21	1340	27.1	115
II)	71.0±1.31	41.6±0.84	15.2±0.30*	19.3±0.14	1348	27.7	131
III)	73.7±1.06	38.3±0.62	18.9±0.44	16.8±0.04	1312	27.9	111
IV)	81.0±1.64	43.6±0.91	19.7±0.42	18.0±0.17	1459	26.7	102
V)	63.2±1.65*	33.1±0.64*	15.8±0.38*	17.8±0.16	1099	27.9	96

Remark:

Treatment corresponds to Table 2. The details items are same as in Table 4.

4. Effect of 2,4-D on the growth of the rice plant and its yield

The 46~60 g of 2,4-D applied on the rice scarcely show any external damage on the plant. The height of the rice plant and the number of tiller were measured every

10 days from the time of spraying, (Fig. 1) The plant was longer and the number of tiller was greater in the plot sprayed with 2,4-D than in unweeded plot. By comparing the hand weeding plot with those with 2,4-D, the number of tiller in the 2,4-D plots was less than in the plot hand-weeded 4 times, their yields were expected to show a little reduction. But the yield of all treated test plots D, E, F of Table 1 and 3 of Table 3 where the weed control was considerably effective, equalled the 4 time hand weeding plot. In other words, 40~60 g. of 2,4-D per 10 ares dissolved in 75~100 liters of water and sprayed with a sprayer, or 45 g. dissolved in 112 liters and applied with a sprinkler gave about the same result as hand-weeded 4 times.

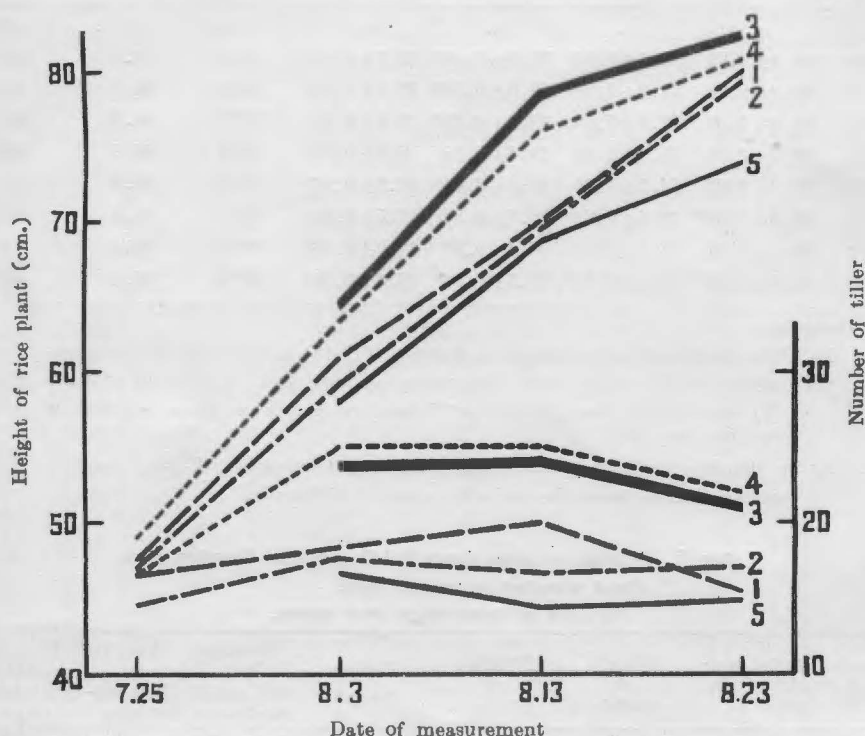


Fig. 1.....The effects of 2,4-D treatments after draining on the growth of rice plant in row in a flooded field.

Above : The height of rice plant.

Below : Number of tiller..

1.....2,4-D 72 g; 2.....2,4-D 120 g. 3.....4 times hand weeding

4.....2 times hand weeding 5.....No weeding (untreated)

The amount of 2,4-D are the sum of two application on July 17th, and 29th.

Both in test plots A, B under flooded condition, and in C under drained condition where the quantity of the spray was insufficient, the yield was reduced by 10 per cent. This seems to be due to the abundance of surviving weeds. But when compared to the unweeded plot, their yields were about 20 per cent more.

Although from the records on the individual rice plant in Table 4 the number of tiller on 2,4-D test plots D, E and F was less, the length of its panicle was rather long, and the number of full grains almost the same as the 4 time hand weeding plot, and its 1000 grains weight rather heavy. After all, the weight of unhulled rice was same as that of the plot hand-weeded 4 times; and so, the percentage of the weight of grain with respect to straw is higher than that of the hand-weeded 4 times and the no weeded plots. This shows the phenomenon of Hogoe or effect of fertilizing for panicle formation.

The weeds that were killed by 2,4-D are considered to become an effective fertilizer as they decompose quickly, although an effect as a hormone can not be overlooked.

The records of test gathered on the direct seeded rice plant on the ridged field are given in Table 6. They almost correspond to the rice transplanted in the ridged field in Table 3.

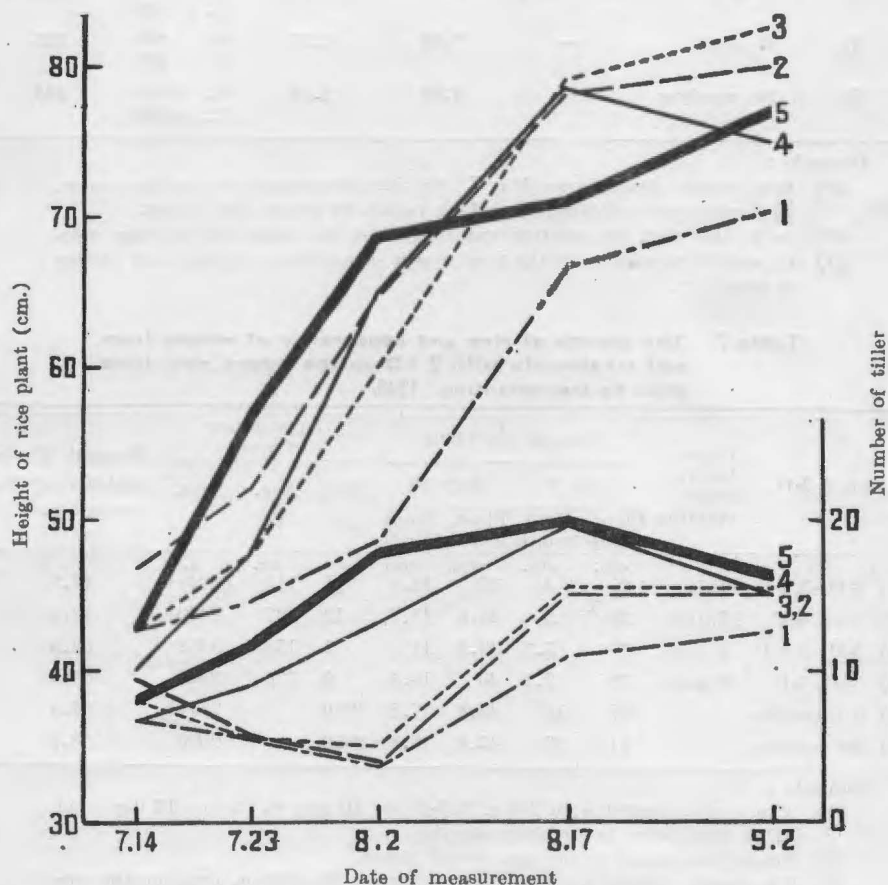


Fig. 2The effects of 2,4-D treatments after draining on the growth of rice plant in pots under a glass house
Above: The height of rice plant. Below: Number of tiller.
1.....2,4-D 200 g. 2.....2,4-D 160 g. 3..... 2,4-D 80 g. 4.....
2,4-D 40 g. 5.....Contrast

The limit of toxicity on rice plant was tested in pots. As far as the chemical was used at the rate of 40 g. per 10 ares, it did not show any damage on the rice plant, but 80~200 g. of 2,4-D retarded the growth (Fig. 2), and within the limit of 320g, the panicles bore grains; and at 640 g. a few plants showed abnormal ears; while some were killed by 1.2~2.0 kg. of 2,4-D.

Table 6. Yields of rice and weights of weeds from 2,4-D treated ridged rice field seeded directly, 1948.

Plot ($\frac{1}{10}$ ares)	Treatment	2,4-D solution per 10 ares		Total weight of dry rice plants	Weight of unhulled rice	Weight of fresh weed	Yield of unhulled rice per 10 ares
		L.	g.				
1) ⁺	0.1	75	(75)	7.23	2.29	R. 1,866 F. 1,054	343
2)	0.1	150	(120)	7.95	2.41	1,850	361
3)	0.05	105	(52.5)	7.30	2.37	R. 1,295 F. 82	355
4)	Weeded	—		7.58	2.57	R. 299 F. 188	385
5)	No weeding	—		6.68	2.03	R. 2,613 F. 1,390	304

Remarks:

- (1) Rice variety Asahi, sown May 7. On June 29 watered only in the furrow. The upper part of ridge flooded by rained. 96 bunches per 1 plot.
- (2) + In this plot, the solution was sprayed on the upper part of ridge only.
- (3) R. and F. in weight of the fresh weeds denot those of ridge and furrow respectively.

Table 7. The growth of rice and appearance of weeds from soil treatments with 2,4-D on the ridged rice field prior to transplanting, 1948.

Plot 2, 4-D	Days before trans-planting	Size of rice plant				Appearance of weed			Percent of un-hulled grain to weeded plot
		July 7		July 20		July	Aug.	Sept.	
		Plant length	Root length	Plant length	Root length	12	14	25	
		cm.	cm.	cm.	cm.	no.	no.	g.	%
(1) ⁺ NH ₄ -2, 4-D	14 days	26.	4	37	12.8	11	110	(894) ⁺	77.9
(2) Na-2, 4-D	14 days	26	5	43.6	13.7	12	127	2440	72.3
(3) NH ₄ -2, 4-D	2 days	29	5.7	39.5	11	2	150	3452	62.5
(4) Na-2, 4-D	2 days	28	7.1	40	14.4	0	120	2440	63.3
(5) No weeding		27	16	45.8	17.8	1950		7714	58.6
(6) No weeding		31	17	45.8	16.3	2650		9090	58.6

Remarks:

- (1) Every plot applied with 240 g. 2,4-D per 10 ares 0.1% for 14 days and 0.2% for 2 days before transplanting.
- (2) Size of rice plant is the average of plants.
- (3) The weeds counted on July 14th is from a 50×330cm. area on the upper side of ridge.
- (4) The weed appearance in the furrow was almost the same as that in the plot without the treatment
- (5) The weight of weeds counted on September 25 is that of the fresh weeds in $\frac{1}{20}$ ares of the upper part of ridge.
- (6) + In this plot, 40 g. of 2,4-D was sprayed again on August 16.

III. Soil treatment with 2,4-D prior to transplanting

For controlling the weeds in the fields before planting, 145~240 g. of 2,4-D per 10 ares were applied in the solution of 0.1 or 0.2 per cent on ridged field on 16th and 28th of June, 14 and 2 days before the date of transplanting respectively. Fields were then filled with water on June 29th. Rice plants were transplanted on both sides of the ridge, and the water was always held in the furrow. Its result is shown in Table 7. Though the weeds on the ridge were scarce up to the middle of August, they occurred in the furrow in equivalent amount to no weeding plot. Weeds on the ridge were abundant at latter part of August. The amount of weeds at the end of September was about one-third of the unweeded plot. These weeds must not be left unweeded. In this treatment, the rice plants were damaged considerably by the residual poison at about the time when it was planted. At the same time, an experiment on the poisonous action of 2,4-D was conducted in the flooded field where the chemical can be washed away and causes little damage to the rice plant. The effect of weed control, however, was small under such condition, since 240 g. of 2,4-D per 10 ares is not effective.

In a test using a concrete enclosure in the flooded paddy field, the pre-treatment of 2,4-D at the rate of 480 g. resulted in considerable weeding effect. But at the same time, there was much damage to the rice plant.

The percentage of yield as compared to hand-weeding plot of Table 7, shows the respective 2,4-D plots yielded a little more than in unweeded plot, but were only 63~72 per cent of the plot hand-weeded 4 times.

In the paddy field that received the pre-treatment in the soil before planting, 2,4-D was again sprayed over the weeds at the middle of August, and about two-thirds of the weeds were killed, the yield of 1 plot of Table 7 was 78 per cent of the hand weeded plot.

As it has been mentioned above, the pre-planting application of 2,4-D in the soil can not be expected to be practical in the paddy field at present.

IV. Summary

1. Tests on the effect on weeds and the influence upon the growth and yield of rice were conducted with 2,4-D acid, Na-2,4-D, and NH_4 -2,4-D during the period from June to August, 1948 in paddy nursery and fields. Rice was either transplanted in squares and rows or direct seeded.

2. Tests in the paddy field showed that the water should be drained 2~4 weeks after planting the rice, before 50~75 g. of 2,4-D salt (40~60 g. 2,4-D) dissolved in 75~112 liters of water is sprayed over the leaves and stalks of the weeds. All weeds will rot within one or two weeks except the gramineous plant. The weeding effect is equal to that done 4 times with hand and hand-weeder. The yield of treated plot equalled the latter. Since *Eleocharis acicularis* Koch. grew luxuriantly again in the plot of 30 g. 2,4-D per 10 ares, the reduction in yield was 15 per cent of ordinary weeding, also the amount of the weeds in unweeded plot was 1100 kg. per 10 ares resulting in a 35 per cent decrease in yield.

3. In test in the ridged rice field, the weeds in the furrow died considerably, while a rather abundant Gramineous plants survived on the ridge. 40 g. of 2,4-D per

10 ares applied controlled the weeds effectively. The yield was equal to the plot that was hand-weeded 4 times.

4. If 2,4-D is applied under the flooded condition, it damaged the rice plants, because more than 120 g. of 2,4-D is needed for controlling weed.

5. For the 2,4-D pre-treatment of the soil before the planting of rice plant, 145~480 g. in solution for each 10 ares was used, and a use of 240 g. was considerably more effective for the weed control on the ridge up to the middle of August, but it had no effect in the furrow. Though the rice plants are damaged by the chemical at the beginning, they will normally revive, but if the weeds are left to themselves, they will grow luxuriantly and cause a reduction in yield. In 240 g. 2,4-D plot on paddy field, completely filled with water, the effect on the weeds are very little, and the damage to the rice plants was also very little as they revived soon. In the plot of 480 g. it had a great effect, but it also caused much damage to the rice plant.

6. These results showed that best weed control was secured when 40~60 g. of 2,4-D in 75~100 liters of water per 10 ares, is applied on the drained field with a sprayer 2~4 weeks after transplanting the rice plants, and reflooded one or two days later. This method is suggested for general use under Japanese conditions.

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PLATE XXVI



Fig 3.....Representative response of *M. Vaginalis* PRPSL in rice field the days after 40 g. of 24-D dissolve 75 liters of water per 10 ares was sprayed.

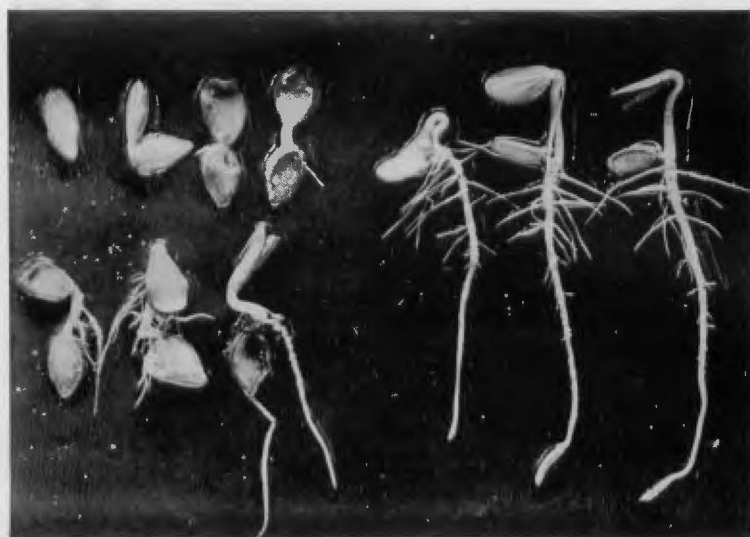


Fig. 4.....The condition after NH₁-24-D of 0.075% solution was used at the rate of 75 liters per 10 ares, 45 g. of 2,4-D per 10 ares on 26th July. Photographed 5th August.



Fig. 5.....No treatment (comparison with figure 4).

PLATE XXVII



Abnormal

Normal

Fig. 1. The abnormal seedlings of Squash (*Cucurbita moschata* Duch.)



Abnormal

Normal,

Sinpaku

Abnormal

Bizen

Normal

Fig. 2. The growth of normally and abnormally germinated plants, days old May 7