Morphological Responses of Rice Plants to MCPA

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Phenoxyacetic acid herbicides and their mixtures are still in common use by rice farmers of Japan, although many excellent herbicides have been developed in these thirty years. They are not expensive for farmers but are effective for controlling broad-leaved annual and perennial weeds of rice fields, such as *Monochoria vaginalis* Presl., *Sagittaria pygmaea* Miq. and so on. The second is one of the most serious weeds of Japanese rice fields.

However, phenoxys are sometimes severely phytotoxic to rice plants, particularly under high or low temperature, even when they are applied at a proper application time before panicle differentiation stage of the crop. They cause various damages to rice plants, for instance, reduction of tillering, production of tubular and dwarfed leaves, death of lower leaves and aberrant root formation.

The majority of investigations on their phytotoxic effects on rice plants were carried out with 2,4-D, but, recently, MCPA has been more frequently used as mixtures with other herbicides than 2,4-D. Several researchers including those of Agricultural Experiment Stations all over Japan[1,2,4,6] studied gross morphological responses of rice plants to MCPA. However, information derived from these works was not sufficient to know precisely the injurious effects of MCPA applied at the vegetative stage on each leaf, each tiller and each group of roots of the crop.

In the author's study[5], an attempt was made to determine morphological effects of MCPA on a leaf, a tiller and roots of each shoot-unit of the rice plant under high (35–30°C), medium (27.5–22.5°C) and low (20–15°C) temperature conditions. Two figures in each parenthesis indicate day-time temperature and night temperature in that order. MCPA ethylester as 1.4% granule was applied at doses of 1, 2, 4 and 8 a.i. g/a to rice plants at the stage when the 7th leaf is emerging or elongating.

Results obtained are illustrated diagrammatically in Fig. 1, in which a leaf just emerging at the time of MCPA application is expressed as the N leaf. According to Kawata et al.[3], each shoot-unit consists of an internode with an apical leaf, a basal bud and two root zones, and the leaf emergence is usually synchronized with the emergence of a bud locating two shoot units below and with the emergence of roots locating three shoot units below. In this experiment, too, a bud of the N−2 shoot-unit (axillary bud of the N−3 leaf) and roots of the N−3 shoot-unit were found emerging when the N leaf was emerging as shown in Fig. 1A. Fig. 1B shows morphological injuries of leaves, tillers and roots caused by the MCPA treatment.

Effects on shoots of rice

The number of tillers was strikingly reduced by the MCPA treatment, especially under the high temperature or at the high dose of the chemical. And, in the treated plants, tillers of four shoot-units which developed after the treatment were damaged as shown by the damages of N−2, N−1, N, and N+1 shoot-units of Fig. 1B. The most severely damaged tiller buds were those of the N−1 and N shoot-units. Tillers at the nodal-position higher than these four shoot-units usually developed to normal ones and rice plants used to recover the number of tillers per hill in field conditions. No tubular leaf appeared under the high temperature in this

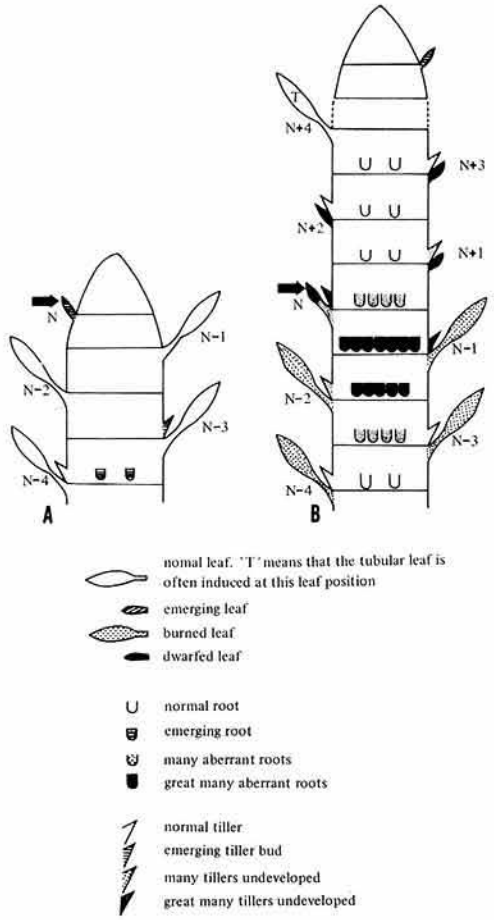

Fig. 1. Diagram of morphological injuries of rice plants treated with MCPA.
A : Rice plant at the time of MCPA treatment (the N leaf emerging stage)
B : Rice plant affected by MCPA treatment
Horizontal lines indicate nodes. Arrows indicate the N leaf which was just emerging at the time of MCPA treatment. The number of roots more than two means an increased number of roots emerged. Aberrant roots are those which stopped growing at their initial stage or are less than 3 cm in length.

experiment, but the lower the temperature was, or the higher the applied dose was, the more tubular leaves were formed by the MCPA treatment. They were mainly the leaves which located above the N leaf by four shoot-units, that is, N+4 leaf on each stem as shown in Fig. 1B. Their tubular structure was quite the same as that of 2,4-D induced one[2,4]. Many shoots which produced tubular leaves died later, and, therefore, in field conditions, rice plants were injured severely under low temperature because of increased dead shoots and of delayed recovery of their growth.

Yellowing and burning of lower leaves were common symptoms of rice plants treated with phenoxyacetic acid herbicides. In this experiment, too, the MCPA treatment caused the burning of lower leaves, particularly, of lower leaf blades. The burning were found to occur only on the leaves which had elongated fully or had been elongating at the time of treatment. Therefore, Fig. 1B shows that N−4, N−3, N−2 and N−1 leaves were burned and the N leaf which was elongating at treatment was occasionally burned. On the other hand, new leaves located above the N leaf that emerged after the treatment were not yellowed or burned at all in this experiment. The higher the temperature, or the higher the dose of MCPA, the more was the burning of lower leaves. In each leaf, blade burned more than sheath.

Reduction of leaf length appeared at successive three to four leaves which emerged after the treatment in this experiment. These dwarfed leaves were diagrammatically indicated in Fig. 1B as short ones, that is, N (emerging at treatment), N+1, N+2 and N+3 leaves. High temperature and high dose of MCPA enhanced the adverse effect on leaf length. Leaf blade was more susceptible to the treatment than leaf sheath.

Effects on roots of rice

When MCPA was applied at the 7th leaf emerging stage of rice plants, roots of the 4th shoot-unit were emerging. Aberrant root formation, which was designated with an abnormally increased number of roots per shoot unit and with increased proportions in them of both stunted ones less than 3 cm in full length and root initials which stopped growing, was particularly severe in successive four shoot-units which developed after the MCPA treatment. Fig. 1B shows diagrammatically these abnormalities of roots, where the number of roots, especially of aberrant roots, of N−2, N−1, N and N+1 shoot-units was found markedly increased. The number of roots of the most affected shoot-unit was as many as three times that of untreated control plants. Roots which emerged above these four shoot-units showed a normal development and their number was almost equivalent to that of the untreated control. The total number of roots of injured shoot-units was about the same under high, medium and low temperatures, but the proportion of undeveloped root initials in them was the more as temperature was the higher. When treated dose of MCPA was the higher, the number of roots of injured shoot units was the more and proportion of undeveloped root initials in them was the higher.

As mentioned above, phytotoxicity of MCPA to rice plants appeared on leaves, buds and roots of several definite shoot-units. By analyzing precisely their abnormalities, it is expected that the degree of injury of plants in MCPA treated fields and the posibility of recovery of their growth can be investigated more sufficiently. Furthermore, it is natural that the degree of MCPA injury of rice may be influenced by growth stages of the crop, temperature or various field conditions at treatment. These problems should be studied in future to use MCPA or other phenoxyacetic acid herbicides more safely in rice fields.

References

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