韓作誌(Korean J. Crop Sci.) 35(4) : 309~314(1990)

Effect of Chemicals on Inducing Grain Sterility of Rice

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水稻의 不稔 誘起를 위한 몇가지 化學劑의 效果

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ABSTRACT : A pot experiment was carried out to find the effects of chemicals and its application time on the sterility and other agronomic characters of rice. Two rice cultivars, Samgangbyeo, a Tongil type, and Chuchungbyeo, a japonica type rice were treated with maleic hydrazide (6000ppm), ethephon (6000 ppm) and GA3 (10ppm) at five different growth stages. The application times of chemicals were comprised of two different stages of stem elongation and booting and panicle emerging stage. Grain sterility and panicle length were measured for panicles per pot. Culm length was measured for pot basis. MH induced complete grain sterility in rice, but caused severe plant damage (phytotoxicity) ; restricted spike emergence and drying out of plant leaves, sheath and panicles. Ethephon induced 50-60 % grain sterility in rice with the least in plant damage .

GA3 was not effective in inducing grain sterility in rice, but it increased culm length. The earlier application of chemicals, the higher sterility was induced. Both MH and ethephon reduced culm length and grain yield. Also observed was the varietal response in the occurrence of to chemicals : Samgangbyeo showed the higher response to chemicals than Chuchungbyeo.

The use of male sterility with cytoplasmic-genic system was considered a potential and the most reliable to obtain commecially large quanty of hybrid-seed. Several difficulties, however, exist in the maintaining male sterility lines, restore lines and maintainer lines.[3, 6, 11, 12, 13, 15] Hence researchers in self-pollinated crops are eager to induce male sterility by gametocides such as MH, ethephon and zinc methyl arsenate which may prevent the difficulties in using cytplasmic-genic male sterility in hybrid-seed production. MH induced complete pollen sterility, but considerable female sterility and plant damage were also encountered.[9] Foliar application of 2-chloroethyl phosphoric acid (ethephon or ethrel) induced male sterility in wheat without the significant influences on female fertility.[4, 10] However, poor spike emergence (phytotoxicity) and the need for precision on the time of its application (narrow target period) have limited the commercial utilization of the chemical.

When ethephon was terated to rice plant at 2-day intervals at early booting stage, pollen sterility was induced by 67% but female sterility and phytotoxic effects were also encountered.[8] An ideal gametocide should (1) selectively induce pollen sterility without affecting female fertility ; (2) be sufficiently persistent to sterility both early and late tillers ; (3) have a reasonable broad target periods of application and (4) have mininum side effects on plant growth. Unfortunately, any chemicals satisfying all the requirements necessary for a commercially usable gametocide have not yet been identified. This

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study was aimed to evaluate the effects of three chemicals, MH, ethephon and GA3 on per cent grain streility and other agronomic charaters of rice.

MATERIALS AND METHODS

The objective of this study were to find out suitable gametocide and its application time in rice. Three chemicals, maleic hydrazide (MH ; Sigma), ethephon (2-chloroethyl phosphoric acid ; Dongyang Chem.Co.) and gibberellic acid (BDH Ltd.) were applied to two rice cultivars, Samgangbyeo (Tongil type) and Chuchungbyeo (Japonica type) at five different growth stage. The details on growth stages for chemical application are shown in Table 1. Three rice seedlings to be applied with chemicals were transplanted in an Wagner pot (1/5000 a). Pots were kept in a greenhouse in a randomized complete block design with three replications. Plants were splrayed with chemicals when main culms of plant reached the appropriate growth stage.

The dosage of MH and ethephon was 6000ppm and that of GA3, 10ppm. Chemicals were applied to plant at 2 o'clock every day. The crystalin form of MH was melted in distilled water at 60 C. GA3 and ethephon were dilluted in distilled water just before application. Control plots were sprayed with distilled water for comparison. Per cent grain sterility and panicle length were measured on tiller basis. Six panicles per hill were sampled for measurment of grain sterility and panicle length. Grain yield, culm length and no. of panicles were measured on pot basis.

RESULTS AND DISCUSSION

1. Effects of chemicals and its application time on grain sterility.

The effects of three chemicals, MH, ethephon and GA3 and its application time on per cent grain sterility in two rice cultivars, Samgangbyeo and Chuchungbyeo are shown in Table 3. MH caused the highest per cent grain sterility among three chemicals by showing 99.0% in Samgangbyeo and 99.8% in Chuchungbyeo. Ethephon induced low per cent grain sterility than MH (Samgangbyeo and Chungbyeo, 59.7% and 45.3% respectibly). GA3 was not effective in inducing the sterility of rice. The varietal difference was recognized with high responses to chemicals in

Table 1. Description of the decimal codes for growth stages in cereals.[16]

Decimal code	Growth stage	Description
32	Stem elongation	Second node detectable
37		Flag leaf just visible
41	Booting	Flag leaf sheath extending
47		Flag leaf sheath opening
54	Inflorescense emergence	Half of inflorescence emerged

Table 2. Analysis of varience for effects of chemicals and its application time on grain sterility and 3 agronomic charactes in two rice cultivars, Samgangbyeo and Chuchungbyeo.

Source of variation	Grain sterility		Culm length		Panicle length		No.of panicle	
	A[1]	B	A	B	A	B	A	B
Chemicals	* * *	* * *	* * *	ns	* *	* * *	* * *	
Application time	* *	* *	ns	*	*	* * *	ns	ns
Chemical x application time	* * *	* *	* *	* *	ns	* *	* *	* *

1. A, Samgangbyeo ; B, Chuchungbteo.
2. *, * * and * * * ; significantly different at 5%, 1% and 0.1% level, resprectively

Table 3. Effects of chemicals and its application time on the occurrence of grain sterility in two rice cultivars, Samgangbyeo and Chuchungbyeo.

	Treatment	Grain sterility (%)	
		Samgangbygo	Chuchungbyeo
Chemicals	MH	99.0 a*	98.8 a
	Ethephon	59.7 b	45.3 b
	GA3	26.1 c	8.5 c
	Control	19.2 c	12.6 c
Application time	32	59.6 a	44.0 ab
	37	60.6 a	49.8 a
	41	50.8 b	42.9 b
	47	50.5 b	34.9 c
	54	53.3 ab	34.7 c

* Same letters in a culumn are not significantly different at 5% level within chemicals and application time, respectively See Table 1 for details on application time.

Samgangbyeo. The effect of application time of the chemicals was highly significant with the increasing grain sterility by the earlier application of chemicals. Also noted was the interaction between chemicals and application time. It was reported that the MH (250-1000ppm) induced complete pollen sterility but considerable female sterility and plant damage were encountered.[2] Foliar application of ethephon induced male sterility without significantly affecting female fertility.[3, 10] The application of ethephon, three times in two-day intervals at early booting stage, induced pollen sterility by 67% but female sterility and phytotoxicity were also encountered.

Parmer et al.[7] found that a single application of 6000-8000ppm 1 week before and at booting stage induced pollen sterility up to 94%, but extremely low seed set rate. Comparing three chemicals tested, MH induced almost complete grain sterility in rice but accompanied with severe plant damage. ethephon induced medium level of sterility and the plant damage was less severe than by MH. Because any chemicals tested in this experiment was not able to induce a complete sterility without significant phytotoxicty, the concept of practically higher hybrid seed set rate was suggested by Choe et al.[1] From this point of view, ethephon is considered to be as relatively more practical gametocide for inducing sterility with a purpose to produce hybrid-seed.

2. **Effects of chemicals and its application time on growth of plant.**

MH and etephon reduced culm length significantly by 10-20% comparing to control plot. GA3, however, slightly increased culm length of treated plant. Effects of application time on culm length was not distinct in Samgangbyeo but in Chuchungbyeo (Table 4). It is important to consider the effect of culm length on the hybrid -seed set rate because wind velosity affect seed set rate. When pollen descends following dispersal from an extended anther, there would be a positive effect on seed set if the male sterile parent were shorter than pollen doner. Fisher[5] found a significant decrease in seed set when a tall CMS line was matched with a semidwarf pollen doners are to be used in hybrid-seed production, chemicals will reduce the culm length of pollen donor and enhance the seed set rate very easily. The effects of chemicals and its application time on the panicle length are shown in Table 5. There are large varietal differences in the effects of chemicals and their application time on the panicle length. Chcmical treatment could not affect the panicle length in Samgangbyeo, but ethephon reduced panicle length in Chuchungbyeo. The early application of chemical was generally greater in the reduction of panicle length.

Considering the fact that parental lines with large number of panicles would enhance cross

Table 4. Effects of chemicals and their application time on the culm length in two rice cultivars, Samgangbyeo and Chuchungbyeo.

	Treatment	Culm length (cm)	
		Samgangbyeo	Chuchungbyeo
Chemicals	MH	25.2 d*	29.9 d
	Ethephon	42.8 c	32.9 c
	GA3	52.1 a	46.7 a
	Control	47.8 b	42.9 b
Application	32	41.5 b	34.4 b
	37	40.4 b	38.1 ab
	41	41.4 b	37.3 ab
	47	45.3 a	40.1 a
	54	41.6 b	37.7 ab

* Same letters in a culumn are not significantly different at 5% level with in Chemicals and application time, respectively. See Table for details on application time.

Table 5. Effects of chemicals and their application time on the panicle length in two rice cultivars, Samgangbyeo and Chuchungbyeo.

	Treatment	Panicle length (cm)	
		Samgangbyeo	Chuchungbyeo
Chemicals	MH	15.4 b*	12.9 b
	Ethephon	15.5 ab	12.3 a
	GA3	15.5 ab	13.3 a
	Control	15.8 a	12.8 b
Application time	32	14.5 c	10.4 b
	37	15.4 b	13.2 a
	41	15.3 b	13.1 a
	47	16.0 ab	13.1 a
	54	16.7 a	13.4 a

* Same letters in a column are not significantly different at 5% level with in Chemicals and application time, respectively. See Table 1 for details on application.

Table 6. Effects of chemicals and its application time on the no. of panicles per hill in two rice cultivaes, Samgangbyeo and Chuchungbyeo.

Cultivars		No. of panicles	
		Samgangbyeo	Chuchungbyeo
Chemicals	MH	11.8 b*	11.2 c
	Ethephon	18.1 a	15.9 a
	GA3	17.4 a	14.0 b
	Control	18.0 a	15.0 ab
Application time	32	15.9 b	14.9 b
	37	16.2 ab	14.5 a
	41	16.5 ab	14.2 b
	47	15.9 b	17.0 a
	54	17.2 a	13.6 b

* Same letters in a column are not significantly different at 5% level with in Chemicals and application time, respectively. See Table 1. for details on application time in

-pollination, ellimination of reduction of panicle length by chemical treatment would be desirable.[4] MH significantly reduce number of panicles per hill. It finally ascribe to low seed production in hybrid-seed production system.

Conclusively, we have two problems encountered

in this experiment. The most significant one is that the chemical inducing higher sterility caused higher plant damage. The other problem was that the optimum time for application of chemical was missed by changeable weather condition in field. And irregular growth stage of tillers in field and/or in one hill also prevent the precise application time of chemicals. In order to overcome these problems, a few recommendation are suggested as follows :

1. Unless the effective chemicals are released for chemical hybrid-seed production, a new concept in practical rates for hybridzation is to be adopted in the breeding scheme, that is, a concept of practically higher hybrid-seed set rate rather than a complete hybridization. In this aspect, ethephon was verified to be the most suitable chemical to be used in hybrid-seed prodction.

2. Soil application of granular chemical shall be adopted to overcome unsuitable weather codition for chemical application.

3. Phytotoxicity accompanined by the use of high dosage of the chemicals can be reduced by a split or recurrent application of the chemicals, however, this will require additional labor.

摘 要

本 試驗은 ethephon, maleic hydrazide (MH) 및 gibberellic acid (GA3) 의 處理 및 處理時期가 水稻의 不稔 및 다른 農業形質들에 미치는 效果를 究明하기 위하여 실시되었다. 인도형 品種인 三剛벼와 일본형 品種인 秋晴벼에 MH(6000 ppm), ethephon(6000ppm) 및 GA3(10ppm) 을 節間伸長初期, 節間伸長後期, 穗孕初期, 穗孕後期 및 出穗期의 다섯단계에 걸쳐 처리하여 種實不稔率, 株當穗數, 稈長, 穗長 및 種實收量을 조사하였던바 그 結果를 要約하면 다음과 같다.

1. MH는 完全不稔을 나타내었으나 出穗遲延, 잎마름, 줄기및 이삭의 마름등과 같은 植物體에 대한 害作用이 심하였다. Ethephon 은 50-60%에 가까운 不稔率을 나타내었으나 植物體에 대한 害作用은 MH 보다 그 程度가 낮았다.

2. GA3는 水稻의 不稔을 誘起하지 않았고 稈長을 약간 增加 시켰다.

3. MH 와 ethephon은 모두 水稻의 稈長 및 種實收量을 減少시켰으며 MH 는 株當穗數를 減少시켰다.

4. 化學劑의 處理時期가 이를수록 더 높은 不稔率이 誘起되었고 그에 따른 害作用이 큰것으로 나타났으며, 인도형品種과 일본형品種間에 不稔率差異를 보였다.

LITERAEURE CITED

1. Choe, Z.R., J.K.Kim, Y.H. Bin and S.H. Kim. 1987. Chemical induction of male sterility in self-pollinated crops for hybrid -seed production.Recent Progress in Molecular Biology and Genetic Engineering in Korea 1987. pp329-336.
2. Chopra, V.L.S.K. Jain and M.S.Swaminathan. 1960. Studies on the chemical induction of pollen sterility in some crop plant. Indian J. Genet. 20 : 188-199.
3. Heu, M.H. and Y.A.Chae. 1970. Studies on the male sterility in rice. Res.Rep.Rural Dev. (Crop) Korea 13 : 9-13.
4. Law, J. and N.C.Stoskopf. 1973. Some observations on ethrel as a tool for developing hybrid cereals. Can. J. Plant Sci. 53 : 765.
5. Lein, A. 1967. Über allopasmatischen Roggen. Vortr. Pflanzen Zucht 11 : 97-105.
6. Lin, S.C. and L.P.Yuan. 1980. Hybrid rice in China. In Inovative approaches to rice breeding. IRRI. Los Baños, Philippines. pp. 35-39.
7. Parmer, K.S., E.A.Siddiq and M.S. Swaminathan. 1979. Chemical inductioon of male sterility in rice. Indian J. Genet. 39 : 529-550.
8. Perez, A.T., T.T.Chang and M.H.Beachell. 1979. Induction of male sterility in rice with ethrel and RH-531. SABRAO Newl. 5 : 133-139.
9. Porter, K.B. and A.F. Weise. 1961. Evolution of certain chemicals on selective

gametocides for wheat. Crop Sci. 1 : 381.

10. Rowell, P.L. and D.G.Miller. 1974. Induction of male sterility in wheat with 2-chloroethyl-phosphonic acid. Crop Sci. 11 : 629.
11. Rutger, J.N. and C.Shimjyo. 1980. In "Innovative Approaches to Rice Breeding". pp 53-66. IRRI.
12. Shinjyo, C. and T.Omura. 1966. Cytoplasmic genetic male sterility in cultivated rice. Jpn. J.Breed 16 : 179-180.
13. Virmani, S.S., R.C.Chaudhary and G.S. Khusi. 1981. Current outlook on hybrid rice. Oryza 18 : 67-84.
14. Virmani, S.S. and B.E.Ian. 1985. Current status and future prospects for breeding hybrid rice and wheat. Advances in Agronomy 38 : 145-209.
15. Yuan, L.P. 1977. The execution theory of developing hybrid rice. Zhonguo Nongye Kexue 1 : 27-31.
16. Zadoks, J.C., T.T.Chang and C.F.Konzak. 1974 . Adecimal code for the growth stages of cereal. Weed Res. 14(6) : 415-421.