Autecological Studies on *Cyperus iria* L. and *C. microiria* STEUD., Annual Cyperaceous Weeds

I. Seed Dormancy, Germination, and Seedling Emergence*

Muhamad Ahmad CHOZIN and Kyojiro NAKAGAWA

Institute for Agricultural and Biological Sciences,
Okayama University, Kurashiki 710, Japan

Introduction

Cyperus iria L. is a principal weed in paddy fields through the world, and also a common weed in upland fields in many countries³⁾. In Japan, KASAHARA^{6,7)} classified *C. iria* as one of the most harmful weeds in both types of fields. Another species morphologically similar to *C. iria* is *C. microiria* STEUD.; it is also one of the most harmful weeds in upland fields in Japan⁶⁾ and a common weed in Korea and China⁴⁾.

There is no available information on the life cycle of *C. iria* and very little on *C. microiria*. IWAO and HASHIMOTO⁵⁾ reported *C. microiria* had dormant seeds, and the dormancy could be broken by burying the seeds in the soil or by stratification at 15°C. NAKAYAMA¹¹⁾ reported that in the field *C. microiria* seeds began to emerge at 15°C and reached a peak of emergence at about 20°C. He further reported that the growth of this species was retarded under a shaded condition.

In order to devise more satisfactory and effective means of control, studies were conducted on various aspect of the life cycles of *C. iria* and *C. microiria*. The experiments described here deal with seed dormancy, germination and seedling emergence of these species.

Materials and Methods

Mature seeds used in these experiments were collected from fields naturally infested with *C. iria* and *C. microiria* and were stored in a dry and dark condition at 5°C. In all laboratory germination studies, seeds were placed on moistened sponges and Whatman No. 2 filter papers in covered petri dishes. For dark germination tests, the petri dishes were placed in a dark incubator or were wrapped with alluminum foil, and germinated seeds were examined under a safe green light. A seed was considered to have germinated when the radicle became visible. The germinated seeds were counted and recorded as a percentage of the total number of seeds in each replication. Three replications with 50 seeds each were used for all treatments, except for those in Experiment 4 which involved two replications.

Experiment 1. Effect of storage on seed germination

Seeds of *C. iria* and *C. microiria* were sown in pots filled with soil and then placed in the field. Some of the freshly harvested seeds germinated; the rest were dried in a greenhouse and then stored under various conditions:

- (1) laboratory, dry condition (room) ;
- (2) laboratory, dry condition (desiccator) ;

*A part of this work was reported at the annual meetings of the Weed Science Society of Japan in 1986 and 1987. The work was supported by a Grant-in-Aid from the Ministry of Education, Science and Culture, Japan.

(3) laboratory, dry condition (at 5°C in darkness) ;

(4) field, upland condition at a 20cm depth ;

(5) field, submerged condition at a 20cm depth.

Seeds were removed from storage every month for the next 12 months and subjected to germination tests. These tests were conducted at 20/30°C alternating temperature in the light; the light was provided by cool white fluorescent tubes.

Experiment 2. Germination of buried seeds

Some of the stored seeds of both species were buried in upland soil in the field at a 20 cm depth for various periods. Seeds were buried at different times and removed at same times. The burying periods were 3, 6, 9, and 12 weeks.

Germination tests were conducted at 27.5°C constant and 20/35°C alternating temperatures, both in the light and in darkness. In this experiment, the light germination test was conducted in a phytotron following the method developed by NAKAGAWA and OKI¹⁰⁾.

Experiment 3. Effect of temperature and moisture pretreatments on seed germination

Seeds of *C. iria* and *C. microiria* were stored in dry, wet, and submerged conditions in the dark at 5, 15, 25, and 35°C for one month. To obtain different temperature and moisture conditions, seeds were placed in empty bottles, petri dishes with moistened filter paper, and bottles filled with water, respectively, for dry, wet and submerged conditions, and then were stored in incubators at different temperatures. A germination test was conducted at 30°C in the light.

Experiment 4. Temperatures for seed germination

C. iria seeds and pretreated *C. microiria* seeds (stored at 15°C in a wet condition for a month) were germinated at various temperatures in the light and in the darkness. The temperature regimes were 15, 20, 25, 30, 35, 40, and 45°C constant and 20/30°C alternat-

ing.

Experiment 5. Seedling emergence

Seeds of the two species buried three months were sown in 1/10,000 are Wagner pots filled with soil at 0 (soil surface), 0.4, 0.8, 1.6, and 3.2cm depths. The pots were then kept inside temperature controlled water tanks in the phytotron. Water level in the pots was maintained at -4 or +1cm from the soil surface. Each treatment was replicated three times with 50 seeds per replication. The experiment was arranged in a split plot design, where the water level was considered the main-plot and the sowing depth a sub-plot.

Seedling emergence was counted for two months at four day intervals for the first month and seven day intervals for the second.

Results

Experiment 1.

Forty percent of the fresh seeds of *C. iria* germinated, and the dormant seeds mostly germinated at 20/30°C in the light after being stored for one month under all storage conditions (Fig. 1). *C. microiria* seeds, on the other hand, did not germinate at all, and required different periods of after-ripening depending on the storage condition they had undergone.

Burying seeds of both species in the upland condition resulted in high germination percentages, generally higher than the other storage conditions. Difference in soil moisture content during storage variously influenced seed germination. Lower germination percentages were found when the seeds were kept in the soil in submerged condition. This was clearly shown in *C. iria* seeds if kept in the submerged condition for four to seven months.

Storing seeds of both species at 5°C in the darkness also resulted in low germination percentages. This effect was more apparent in *C. microiria* seeds where the percentage was about 20% for all periods of storage.

Fig. 1. Effect of condition and length of storage on seed germination *C. iria* and *C. microiria*. Fig. 2. Effect of light and temperature on germination of buried seeds of *C. iria* and *C. microiria*.

(□ light 27.5°C ; ▨ light 20/35°C ; ▤ darkness 27.5°C ; ▩ darkness 20/35°C)

Fig. 3. Effect of temperature and moisture pretreatments on seed germination of *C. iria* and *C. microiria*.
(● : dry ; ○ : wet ; △ : soaking)

Experiment 2.

Figure 2 shows that unburied seeds of *C. iria* germinated as well as buried seeds, both at constant and alternating temperatures when they were incubated in the light. Under this condition, the burying period had no effect on seed germination. In the darkness, *C. iria* seeds did not germinate when incubated at constant temperature, except for those buried for six weeks; however, at alternating temperature, the longer the burying period the greater was the number of seeds that germinated.

The effect of temperature on germination of buried seeds was clearly shown in *C. microiria* seeds when they were incubated under a light condition; they germinated well in the alternating temperature, but only slightly in the constant temperature. However, in both conditions the germination percentages tended to increase with the increase in burying period (Fig. 2).

Experiment 3.

In all temperature treatments, higher germination percentages of *C. iria* seeds were obtained when they were kept in the wet

condition (Fig. 3). The similar pattern also was demonstrated in *C. microiria* seeds when they were stored at 5 and 15°C; germination percentages drastically decreased if they were placed in the wet or submerged condition at 25 and 35°C.

Experiment 4.

In the darkness, seeds of *C. iria* and pretreated seeds of *C. microiria* did not germinate at any of the constant temperature tested; at the alternating temperature (20/

Table 1. Seed germination of *C. iria* and *C. microiria* at constant and alternating temperatures in the light (Mean $\pm$ S.D.).

Temperature(°C)	<i>C. iria</i>	<i>C. microiria</i>
Constant :		
	(%)	
15	17.33 $\pm$ 5.24	0.00 $\pm$ 0.00
20	38.67 $\pm$ 2.49	1.33 $\pm$ 1.88
25	42.00 $\pm$ 1.63	16.67 $\pm$ 3.77
30	60.00 $\pm$ 6.53	84.00 $\pm$ 4.32
35	69.33 $\pm$ 2.49	67.33 $\pm$ 4.71
40	42.00 $\pm$ 16.97	78.00 $\pm$ 4.89
45	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00
Alternating :		
20/30	84.00 $\pm$ 6.53	93.33 $\pm$ 0.94

30°C) *C. iria* germinated slightly (2%), but *C. microiria* not at all (data not shown).

In the light, germination of seeds of both species was clearly affected by the temperature where they were incubated (Table 1). The germination percentages of *C. iria* seeds at constant temperatures of 15 to 35°C were higher with higher temperatures; however, at 40°C percentage decreased, and at 45°C it was zero. In contrast, *C. microiria* seeds did not germinate at 15°C, only slightly at 20 and 25°C, and germinated well at 30, 35 and 40°C; at 45°C seeds of this species did not germinate at all.

The highest germination percentages of both *C. iria* and *C. microiria* seeds were found at 20/30°C in the light.

Experiment 5.

Both types of seeds germinated well at the soil surface in both the -4 and +1cm water levels. However, at about one centimeter below the soil surface, very few seedlings of *C. iria* emerged and none of *C. microiria*.

Table 2 shows that seedling emergence percentages of *C. iria* in wet soil (-4cm) were higher than those in submerged soil (+1cm). In the wet condition, the emergence from a 0.4cm depth was 40%; it was clearly decreased at the 0.8 and 1.6cm depths. In the submerged soil, 0.7% of the seedlings of *C. iria* emerged from a 0.8cm depth, and none from the greater than that.

Below the soil surface seedling emergence percentages of *C. microiria* were very low: 10.7 and 1.3% from the 0.4 and 0.8cm depths, respectively, and 2.7% from 0.4cm depth in the wet soil. No seedlings emerged from the other depths.

Discussion

C. iria and *C. microiria* seeds were clearly distinct in their primary dormancy. The fresh seeds of *C. iria* are partially dormant, and 40% of them germinated, most of the dormant seeds germinated after storage for one month under all conditions (Fig. 1).

Freshly harvested seeds of *C. microiria* did not germinate at all, and required different after-ripening periods depending on the storage conditions they had undergone.

Burying seeds of the two species in upland soil resulted in greater germination than keeping them under other storage conditions. This result agrees with that of IWA0 and HASHIMOTO⁵⁾. The higher germination percentages in the upland than those in the laboratory storage seem due to the effect of moisture and alternating temperature during storage. Moisture in the soil may have hastened the process of imbibition and softened the seed coats, which led to the increase. However, results of this study showed that the excess of water during storage in submerged soil caused a decrease in seed germination. Lack of oxygen in the submerged condition can induce seeds to secondary dormancy^{1,12)}.

Burying the seed in the soil has been found to affect the sensitivity of the seed to light^{2,14,15)}. The present study showed that in the darkness, buried seeds of the two species did not germinate at the constant temperature (27.5°C), but at an alternating temperature (20/35°C) germination tended to increase with the increase in period buried.

The result of this experiment differs from that of Experiment 1 which showed that the germination percentages of the buried seeds were almost the same at all periods of storage. The difference is attributed to the difference in the precondition of the seeds used: freshly harvested seeds for Experiment 1 and stored seeds (at 5°C in the darkness for 14 months) for the present experiment. The stored seeds certainly had entered the state of secondary dormancy.

IWA0 and HASHIMOTO⁵⁾ reported that stratification at 15°C was effective in overcoming the dormancy of *C. microiria* seeds. Results of this study confirm this. The highest germination percentage of *C. microiria* seeds was obtained when they were stored at 15°C under

wet condition (Fig. 3). On the other hand, germination drastically lowered if seeds were kept at 25 and 35°C, under both soaking conditions. The present experiment did not cover the viability of non-germinated seeds, however, keeping seeds at high temperature in a submerged or in wet condition has been reported to cause them to enter into secondary dormancy^{9,12,13}. This type of dormancy can be relieved by stratification at low temperature or by the application of gibberellic acid⁹. Naturally, both primary and secondary dormancy can be overcome by overwintering period.

The range of temperatures for germination of *C. iria* and *C. microiria* seeds clearly differed: the former could germinate at temperatures of 15 to 40°C, whereas the latter only at 25 to 40°C (Table 1). However, the highest germination percentages of both seed species were found at 20/30°C; this is nearly the same as the diurnal temperature in early summer in Japan.

The result of Experiment 4 (Table 1) is in accordance with that reported by IWAQ and HASHIMOTO⁵) which showed that seeds of *C. microiria* germinated well at constant temperatures of 20, 25, and 30°C when previously stratified at 15°C for more than two months, but germinated little when the stratification was for less than this period. The present study also showed that stratification at 15°C

for one month did not appear to force the seeds germinate well at constant temperatures of 20 to 30°C.

Seeds of *C. iria* and *C. microiria* germinated well at the soil surface, but at about one centimeter below the soil surface *C. iria* seedlings rarely emerged and those of *C. microiria* not at all (Table 2). One of the factors contributing to the failure or the lower emergence from below the soil surface is the lack of light. Experiments 1 and 2 showed that seeds of these species require light for their germination.

Summary

The autecology of *Cyperus iria* L., a principal weed in paddy fields through the world, and a morphologically similar species, *C. microiria* STEUD., a serious weed in upland fields in Japan, was investigated in an effort to establish effective measures of control. First-run experiments were carried out on seed dormancy, germination, and seedling emergence. The results are summarized as follows:

1) Forty percent of fresh seeds of *C. iria* germinated, and in only a short period of after-ripening most of the dormant seeds could germinate; *C. microiria* seeds are dormant, and dormancy could be broken by burying the seeds in upland soil or by storing them at 15°C in a wet condition (Figs. 1, 3).

Table 2. Seedling emergence of *C. iria* and *C. microiria* at various sowing depths in different water levels (Mean $\pm$ S.D.).

Sowing depth (cm)	Water level			
	- 4 cm		+ 1 cm	
	<i>C. iria</i>	<i>C. microiria</i>	<i>C. iria</i>	<i>C. microiria</i>
	(%)			
0.0	82.7 $\pm$ 5.7	94.7 $\pm$ 0.9	60.0 $\pm$ 9.1	86.7 $\pm$ 2.5
0.4	41.3 $\pm$ 7.4	2.7 $\pm$ 2.5	12.0 $\pm$ 7.5	10.7 $\pm$ 3.8
0.8	8.0 $\pm$ 8.6	0.0 $\pm$ 0.0	0.7 $\pm$ 0.9	1.3 $\pm$ 1.9
1.6	2.7 $\pm$ 3.7	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0
3.2	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0	0.0 $\pm$ 0.0

2) Storage in the darkness at low temperature or in submerged soil caused the seeds of both species to enter into secondary dormancy. Moreover, it was considered that keeping *C. microiria* seeds in a wet or submerged condition at 25 and 35°C also caused them to enter into secondary dormancy (Figs. 1, 3).

3) Both species seeds required light for germination. However, in the darkness under an alternating temperature (20/35°C) their germination could be stimulated by burying them in upland soil: the longer buried, the more seeds germinated (Fig. 2).

4) There is a difference in the temperature requirement for seed germination between *C. iria* and *C. microiria*. Seeds of *C. microiria* germinated at 25 to 45°C whereas those of *C. iria* at a wider range of temperature, 15 to 40°C. However, the highest germination percentages of the two species were found at 20/30°C alternating temperature (Table 1).

5) Seeds of both germinated well at the soil surface, but at about one centimeter below the surface, few *C. iria* seedlings emerged and *C. microiria* not at all (Table 2).

References

- 1) ARAI, M. and M. MIYAHARA (1962): Physiological and ecological studies on barnyard grass (*Echinochloa crus-galli* BEAUV. var. *oryzicola*). III. On the secondary dormancy of the seeds. Proceedings of the Crop Science Society of Japan 31 (2), 186-189 (in Japanese with English summary).
- 2) BASKIN, J.M. and C.C. BASKIN (1985): Does seed dormancy play a role in the germination ecology of *Rumex crispus*? Weed Sci. 33 (3), 340-343.
- 3) HOLM, L.R., D.L. PLUCKNETT, J.V. PANCHO and J.P. HERBERGER: The World's Worst Weeds. Distribution and Biology. University Press of Hawaii, Honolulu, pp. 240-243 (1977).
- 4) HOLM, L.R., J.V. PANCHO, J.P. HERBERGER and D.L. PLUCKNETT: A Geographical Atlas of World Weeds. John Wiley and Sons. Inc., New York, pp. 116-117 (1979).
- 5) IWAQ, T. and Y. HASHIMOTO (1978): Seed germination of *Cyperus microiria* Steud. Weed Res., Japan 23 (special issue), 41-44 (in Japanese).
- 6) KASAHARA, Y. (1954): Studies on the weeds of arable land in Japan, with special reference to kinds of harmful weeds, their geographic distribution, abundance, life length, origin and history. Ber. Ohara Inst. landw. Forsch. 10 (2), 72-116.
- 7) KASAHARA, Y.: The agrestal weed flora and vegetation of the world: Examples and aspects (Japan). In "Biology and Ecology of Weeds" ed. by W. HOLZNER and M. NUMATA, Dr. W. Junk Publisher, The Hague, pp. 285-297 (1982).
- 8) MAYER, A.M. and POLJAKOFF-MAYBER: The Germination of Seeds. Pergamon Press., Oxford, pp. 61-94 (1963).
- 9) MIYAHARA, M. (1974): On the dormancy of the seeds of *Echinochloa crus-galli* BEAUV. var. *oryzicola* OHWI, a paddy field weed. JARQ 8 (4), 195-197.
- 10) NAKAGAWA, K. and Y. OKI (1984): Effect of stratification, alternating temperature and light on the dormancy and germination of *Cyperus serotinus* seeds. Weed Res. (Japan) 29 (special issue), 27-28 (in Japanese).
- 11) NAKAYAMA, K. (1977): Weed control in upland farming of Japan. JARQ 11 (2), 85-88.
- 12) NIKOLAEVA, M.G.: Physiology of Deep Dormancy in Seeds. Israel Program for Scientific Translation, Jerusalem, pp. 106-120 (1969).
- 13) VILLIERS, T.A.: Seed dormancy. In "Seed Biology", ed. by T.T. KOZLOWSKI, Academic Press, New York, pp. 220-276 (1963).
- 14) WASSON, G. and P.F. WAREING (1969): The role of light in the germination of naturally occurring populations of buried weed seeds. J. Exp. Bot. 20 (63), 402-413.
- 15) WASSON, G. and P.F. WAREING (1969): The induction of light sensitivity in weed seeds by burial. J. Exp. Bot. 20 (63), 414-415.

(Received October 2, 1987)

カヤツリグサ科一年生雑草コゴメガヤツリ・カヤツリグサの個生態学的研究

1. 種子の休眠、発芽および出芽

Muhamad Ahmad CHOZIN ・ 中川恭二郎 岡山大学農業生物研究所

摘 要

コゴメガヤツリは世界の多くの水田における主要雑草である。それとともにカヤツリグサ属に含まれるカヤツリグサは、日本の畑地の強害草であり、その形態がコゴメガヤツリに近似している。これらの効果的な防除法を確立する基礎として、両者を対比させながら個生態学的研究を行った。ここではまず種子の休眠・発芽および出芽に関する試験の結果を報告する。

1. 採種後1年の間種々の条件下に種子を貯蔵し、その間の休眠および発芽の変化を追跡した。コゴメガヤツリ種子の結実直後の発芽率は40%であったが、貯蔵処理開始後短期間で大部分の種子が発芽するようになった。しかしカヤツリグサの種子は結実直後には全く発芽せず、畑土壤中に埋蔵した種子だけが短期間で休眠から覚醒した。カヤツリグサの湛水土中の種子と実験室中に貯蔵しておいた乾燥種子は1年の間に徐々に休眠から覚醒したが、低温暗所に貯蔵しておいた種子の休眠覚醒は進行しなかった。なお低温暗所および湛水土中に貯蔵しておいたコゴメガヤツリの種子は一時的に発芽率が低下し、その間二次休眠の状態にあったとみられる推移を示した (Fig. 1)。

2. 畑土壤中に埋蔵したコゴメガヤツリとカヤツリグサの種子はともに明条件下で発芽が促進された。コゴメガヤツリの種子は、明条件下では変温でも恒温でも土中埋蔵期間に関係なく高い発芽率を示したが、暗条件の変温下では土中埋蔵期間が長くなるにしたがって発芽率が高くなった。カヤツリグサの種子は変温明条件下で土中埋蔵期間が長くなるにしたがって発芽率が高くなった。恒温明および変温暗の両条件下でも、低い率ではあったが、処理期間長くなるにともなって発芽率が高くなる傾向が認められた (Fig. 2)。

3. コゴメガヤツリの種子は乾燥状態よりも水浸状態で、さらに湿潤状態で発芽がより良好であった。カヤツリグサの種子は5℃と15℃とではコゴメガヤツリの場合と同じ傾向であったが、25℃と35℃とでは湿潤および水浸状態で発芽が甚だしく阻害された (Fig. 3)。

4. 明条件下における種子の発芽の温度に対する反応がコゴメガヤツリとカヤツリグサとで異なった。恒温の場合カヤツリグサの種子は25℃か40℃までの範囲で発芽したが、コゴメガヤツリが発芽した範囲はより広く、15℃か40℃までであった。また両種とも30℃と20℃の昼夜変温下でより高い発芽率を示した (Table 1)。

5. コゴメガヤツリ、カヤツリグサともに地表の種子はよく発芽したが、土壌中の種子は深くなるにともなって発芽率が急激に低下した。地表面下1 cm前後より深い土層にある場合、コゴメガヤツリはほとんど発芽せず、カヤツリグサは全く発芽しなかった (Table 2)。