On Dormancy of the Seeds of Echinochloa crus-galli Beauv. var. oryzicola Ohwi, a Paddy Field Weed

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Echinochloa crus-galli Beauv. var. oryzicola Ohwi, a variety of barnyard grass, is a major paddy field weed in Japan and the practical control of this weed is needed urgently.

To establish an effective control method of the weed, the life cycle of the weed should be investigated physiologically and ecologically from a viewpoint of fundamental studies.

The author has made studies on the emergence of this weed under field conditions and has recognized close relation between awakening of the seed dormancy and emergence. Therefore, the author investigated the effects of environmental factors on the dormancy of the barnyard grass seed in the field conditions.

The material seeds were collected from the barnyard grass plants which were found in the paddy fields of the Central Agricultural Experiment Station (Konosu City, Saitama Pref.) They were planted in the same way as the transplanting culture of rice to get uniform seeds.

Primary dormancy

The seeds of this barnyard grass are dormant (primary dormancy) before their shedding from ripened panicles. The environmental effect on awakening of this primary dormancy was investigated.

The primary dormancy of seeds is deepened with maturity and it depends not on the dormancy of the shell coat but on that of caryopsis (Fig. 1). The seeds in primary dormancy can absorb water up to the water content level of awakened seeds which are just before germination. They awaken gradually when they are air-dried and kept in doors and finally, the dormancy of almost all seeds is broken between August and October of the next year.

The primary dormant seeds of this barnyard grass, when they were placed on moistened filter paper, are awakened remarkably at the temperature of 45 to 50°C, but slightly at 40°C. Even at the low temperature of 5°C, the progress in awakening is recognized, while the temperature of 20°C and 30° which are optimum for germination are not effective on awakening of dormancy but these temperatures deepen the dormancy of seeds which was partially awakened by the air-dry storage.

Alternation of temperature and freezing (−5°C) are effective on awakening of the partially dormant seeds but not effective on breaking the deep dormancy of seeds which were just shed from panicles.

When seeds were stored in nitrogen gas with no oxygen, dormancy is remarkably awakened, and the awakening by this treatment is more effective on the light dormant seed than the deep one and in optimum temperature for germination than low one (Table 1).

At the low temperature (3 to 5°C), awakening of the primary dormancy of seeds in soil progresses independently to soil moisture, but the higher the moisture content, the earlier the awakening.

At the optimum temperature for germination, awakening of the deep-dormant seed

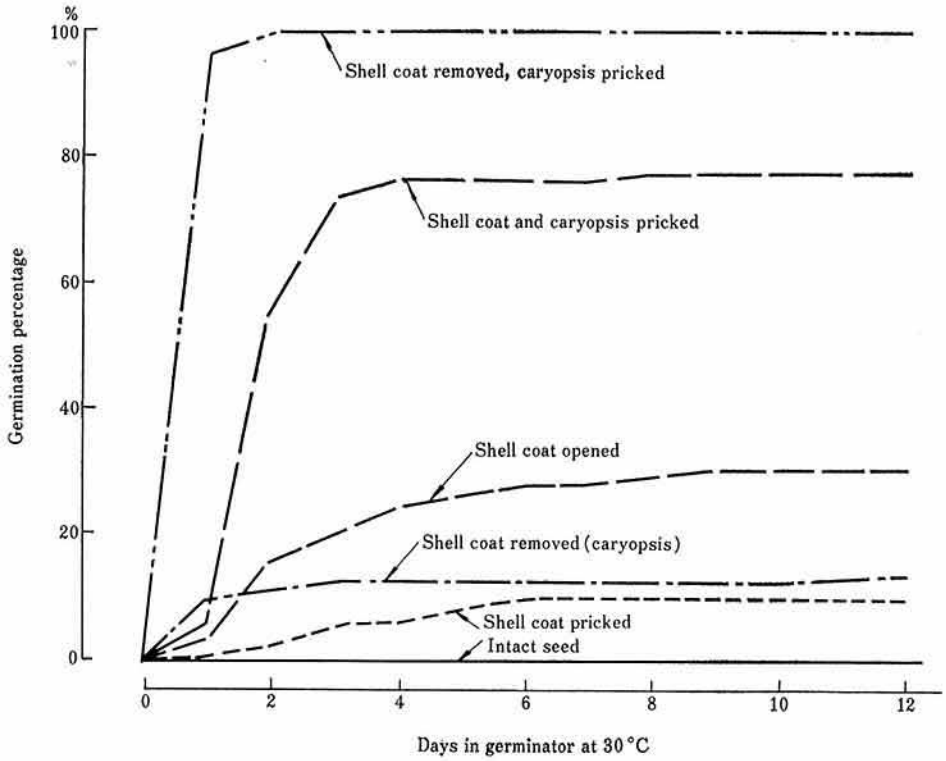

Fig. 1. Effect of various treatments of seed covering on the germination of primary dormant seed of barnyard grass

Table 1. Effects of storage in air and in nitrogen gas on the breaking of primary dormancy of barnyard grass

Kinds of seed	Germination in germinator at 30°C after storage of various conditions for 30 days					
	In air (opened)		In air (sealed)		In N-gas (sealed)	
	30°C	5°C	30°C	5°C	30°C	5°C
	%	%	%	%	%	%
Deep dormant seed	0	0	0.5	0.7	33.2	0.5
Partially dormant seed	0	5.0	3.5	8.5	92.4	18.4

progresses gradually in the air-dried soil, slightly in the submerged soil and little in the upland soil of which the water content is about 70 to 80 per cent of the water holding capacity.

As for the light dormant seed of which awakening has been already advanced to some extent, seed storage in the submerged soil makes rapid progress in awakening, while the storage in the upland soil is not effective in awakening but rather deepened the dormancy.

The effect of the seed storage in the submerged soil on awakening of the primary dormancy depends on the low partial pressure of oxygen which is caused by flooding, and this effect is variable according to the awakened degree of dormant seed and the storing temperature. That is, the effect is more remarkable even with short period storage when the dormancy is lighter or the storing temperature is higher (30 to 40°C).

The seed, which is awakened from the

Table 2. Stage of awakening of the barnyard grass seed from primary dormancy

Stage of awakening	Germination on the moistened filter paper		Breaking of dormancy by freezing	Breaking of dormancy of seed stored in submerged soil
	30°C	Alternated temperature		
1st	none	none	none	none
2nd	none	none	none	awakened
3rd	little	little	almost all awakened	〃
4th	a few	almost all	〃	〃
5th	all germinated	all germinated	—	—

primary dormancy in the soil is induced rapidly into dormancy again by drying, but this dormancy cannot become so deep as that of the seed just ripened.

In consideration of these results, the awakening process of the primary dormancy of this barnyard grass was divided into five stages (Table 2), and it was presumed that the primary dormancy of the barnyard grass in the field may be awakened by the low temperature from late autumn to early spring, the alternation of temperature in early spring and the flooding of paddy fields at the beginning of rice cropping.

Secondary dormancy

After awakening from primary dormancy, seeds of the branyard grass are induced into secondary dormancy in the submerged soil when there is no suitable condition for germination. Environmental effects for inducing seeds into secondary dormancy and for their awakening have been studied.

The seeds early awakened from primary dormancy can be induced earlier into secondary dormancy, and the seeds kept at 30°C can be induced earlier than that kept at 20°C into secondary dormancy.

Environment conditions affect the awakening of secondary dormancy almost in the same way as the case of primary one, except the following two points. As to the awakening of secondary dormancy under low temperature, the seed in the upland soil awakes earlier than the seed in the submerged soil, and freezing treatment of the seed reveals no effect on the awakening of the secondary dormancy.

From these results, it is presumed that the seed of the barnyard grass in the paddy field, after awakening from primary dormancy, is induced into secondary dormancy by the summer high temperature and flooding, and is awakened from secondary dormancy by the low temperature from autumn to spring and the flooding for rice cropping, in the same way as awakening from primary dormancy.

Death of the seeds in the process of dormancy awakening

In the experiments on the awakening from primary and secondary dormancy of the barnyard grass seed, many seeds are found dead in the process of dormancy awakening, and the factors influencing this phenomenon were studied.

When the barnyard grass seeds in primary or secondary dormancy were kept in the upland soil moisture condition under low temperature, dead seeds are found about one month after dormancy awakening. Though no abnormality was recognized optically in the embryo and endosperm of dead seeds at the beginning of their occurrence, the embryo shows no dehydrogenase activity for TTC.

The death rate of the seeds in the process of dormancy awakening is fairly variable according to the difference of the temperature and moisture of soils. It becomes high in the upland soil of which moisture is about 70 to 80 per cent of the water-holding capacity and temperature is less than germination temperature.

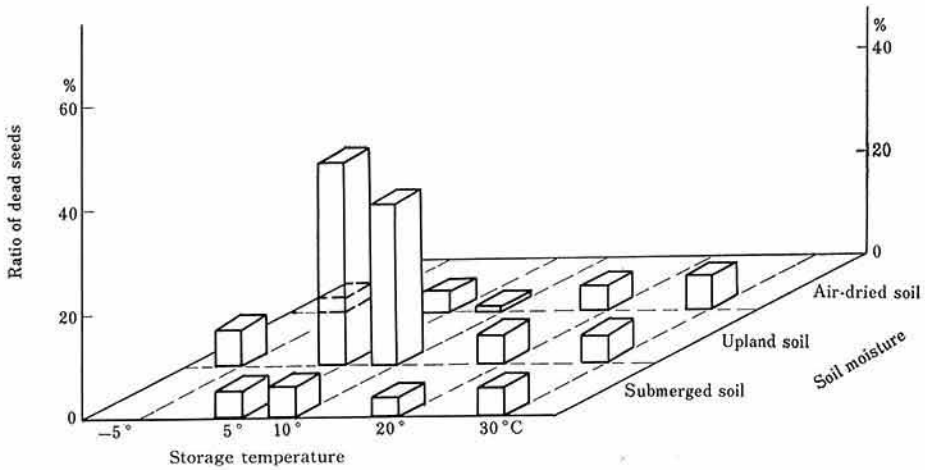

Fig. 2. The effect of soil moisture and storage temperature on the viability of barnyard grass seed in the process of dormancy-awakening

There is a close relation between the death rate and awakening of dormancy; that is, the death rate of the seeds increases under the conditions which promote the breaking of dormancy. But even under the promoting conditions, the seeds kept in the submerged or air dried soils do not die at all (Fig. 2).

From these results, it was manifested that the barnyard grass seeds die when dormancy is broken, water and oxygen are supplied and the temperature is less than the optimum for germination (especially at 5 to 10°C).

It was presumed, therefore, that the soil moisture from autumn to spring might be most greatly related to the death of seeds in the paddy field.

Existing state of seeds in the soil of paddy field

On the basis of the experimental results mentioned above, the existing state and

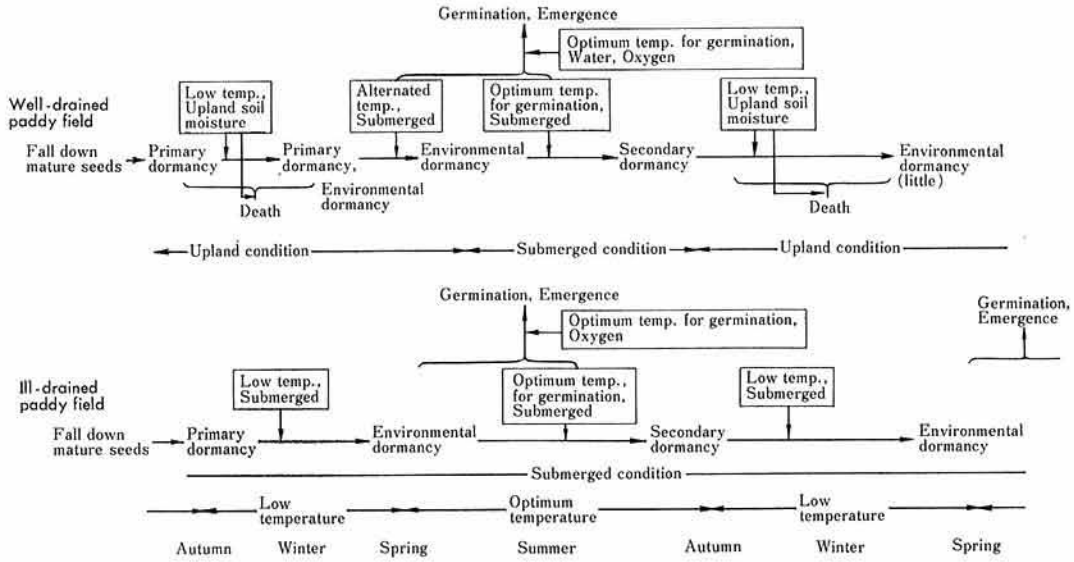

Fig. 3. Schematic description of existing state of barnyard grass seeds in paddy field

emergence of the barnyard grass seeds in the soil of paddy fields were investigated.

In a well-drained paddy field, many seeds die during the process of dormancy awakening. Majority of the seeds can survive only for about one year and a half, and the emergence of the seeds is very rare after more than two years. But, in an ill-drained paddy field, the seeds do not die in the process of dormancy awakening, so they can survive more than several years and many plants emerge after two years.

In a well-drained paddy field, the earlier the beginning of irrigation, the earlier the awakening, and the emergence becomes more uniformly. And the time and way of plowing also modify the degree of dormancy.

The results of these field investigations correspond fairly well to those described previously.

Consequently, the emergence of the barnyard grass in the paddy field is affected mainly by the decrease of survival seeds caused in the process of dormancy awakening, the degree of awakening of survival seeds at the planting time of rice and the induction into dormancy of the seeds during the rice-culture stage.

From these results, the environmental factors related to the dormancy of the barnyard grass seeds in paddy fields may be summarized as shown in Fig. 3, and mainly, they may be attributed to the temperature and moisture of soils.

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