Germination and Seedling Development of Rice and *Echinochloa* Species

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벼와 피의 發芽 및 幼苗發達 樣相

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ABSTRACT

An experiment was carried out at the International Rice Research Institute in 1987 to understand the seed germination and seedling development of rice and *Echinochloa* species.

The percentage germination of rice cultivars(IR64 for lowland-type and UPLRi-5 for upland-type) was extremely high(>90%) regardless of temperature while that of *Echinochloa* species ranged from 10 to 80% depending on the species. Among these, *E. crus-galli* ssp. *kispidula* had the lowest germination with less than 20% at the high temperatures(30℃, 35℃) and about 45% at the low temperature(25℃).

Original seed weight gradually decreased with time while root and shoot weight increased for both rice and *Echinochloa* species. However, increase in root and shoot weight did not compensate for the loss of stored carbohydrate during the experimental period.

The root of *E. glabrescens* grew from the seed on the opposite side of the shoot while for rice it grew from the same side of the seed as the shoot.

Echinochloa glabrescens had a leaf blade-like expanded first leaf that contained chlorophyll while rice had an incomplete first leaf that had no leaf blade and no chlorophyll. Due to this *E. glabrescens* could grow independently 2 to 3 days earlier than rice.

INTRODUCTION

Weeds usually emerge faster than crop plants, absorb the available nutrients earlier, perpetuate their independent growth earlier and thus, establish good seedling stand ahead of the crop resulting in suppression of crop growth. A very small advantage to one species during seedling establishment results in a very significant vested right to this species in later competition with other species. This aspect has not been emphasized in competition studies and thus there is little information available on this subject.

There are two fundamental components of fitness or adaptation. These are survival and reproduction. Seed dormancy is one of the important mechanisms for survival. In the plant evolutionary process, weeds are the resultant of natural selection while crops are the resultant of artificial selection. Therefore, weeds usually have their own unique and efficient strategy for adaptation.

Echinochloa species which belong to the C_4 pathway might have a different strategy for adaptation from rice that has a C_3 pathway. Seed

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dormancy of *Echinochloa* species and rice varies depending on the species or ecogeographic race. *Echinochloa colona*(L.) Link does not have seed dormancy(Chun, 1982) while *E. phyllopogen (Stapf) Kossenko and E. crus-galli*(L.) Beauv. var. *oryzicola* Ohwi have (Arai and Miyahara, 1960; Miyahara, 1972, 1974). For rice, indica-type and tongil-type cultivars usually have strong seed dormancy compared to japonica-type cultivars(Nishiyama 1985; Takahashi, 1984).

Carbohydrate metabolism is considered as the most important factor for seed germination process. Takahashi(1984) reported that there are three physiological phases during rice seed germination which are discrete but closely related to each other. These are (phase A) water uptake or imbibition stage, (phase B) activation stage that activates respiration and metabolism of carbohydrate and (phase C) growth stage that accumulates dry matter.

Only a few authors give the biochemical composition of seed and seedling beyond the first stages of germination(Penning de Vries, 1975; Penning de Vries et al., 1979; Vertregt and Penning de Vries, 1987). However, none of the reports contained sufficient information for a detailed comparison of the observed growth of the young plant and its predicted value, the latter being based on the decrease in weight of seed components and on the chemical composition of the seedling. Tamiya(1932) and Tamiya and Yamaguchi(1933) were among the first to use and quantify the concepts "growth respiration" and "maintenance respiration" by measuring glucose uptake, dry weight, oxygen consumption and carbon dioxide production of a growing *Aspergillus niger* culture.

The research reported in this paper investigated the germination habit and seedling development of rice and *Echinochloa* species to understand the relationship between the change in seed weight and the change in biomass during germination under dark condition.

MATERIALS AND METHODS

The experiment was carried out at the International Rice Research Institute in 1987. Two rice cultivars, IR64(lowland) and UPLRi-5(upland), and three *Echinochloa* species, *E. glabrescens*, *E. crus-galli* ssp. *hispidula* and *E. colona* were used in this experiment. Before the germination test all seeds were soaked for 1 day in 0.1N nitric acid solution to break dormancy. There were four replicates of 50 seeds each. The seeds were placed on water-moistened 5.5cm diameter filter paper in 5.5cm petri dishes and maintained in three temperature controlled incubators at 25℃, 30℃ and 35℃, in the dark.

Seeds which germinate in darkness provide a suitable system to evaluate some aspects of a quantitative biochemical approach to utilization of substrates for synthesis and maintenance of biomass. With this approach, the increase in dry weight of a seedling can be predicted from the decrease of the weight of the seeds. This approach in based on the use of biochemical reaction equations to determine the relative weights of substrate, oxygen and minerals, which are converted by the plant into biomass, carbon dioxide and water(Penning de Vries and Van Laar, 1975). Dry weight of shoot+root and seed were measured every day in each temperature regime to compute germination rate and consumption of stored carbohydrate during germination period. For determining the germination rate, the protrusion of the radicle or coleoptile from the seed was the criterion for germination.

To understand seedling development three additional petri dishes containing 50 seeds of each species were maintained at 25±2℃ under fluorescent light and the developmental features of shoot, root and chlorophyll formation were observed. For these, three seedlings from each petri dish were selected at random at daily intervals.

RESULTS AND DISCUSSION

The germination of the two rice cultivars was extremely high being greater than 90% at all temperature regimes (Fig. 1).

Temperature had an affect only during the early stages of rice germination. Germination started from the third day for both rice cultivars and the highest germination rate was at 30℃ followed by 35℃ and 25℃. This result was similar to that of several previous reports (Nishiyama, 1985; Yoshida, 1981; DeDatta, 1981). However, no differences in germination between temperature regimes were observed from the fifth day for UPLRi-5 and from the seventh day for IR64.

For *Echinochloa* species, the germination percentage was generally lower than for rice. Among these, *E. crus-galli* ssp. *hispidula* had the lowest germination, less than 50%, while the other two *Echinochloa* species had 70 to 80% germination at all temperature regimes (Fig. 2). Temperature also affected germination of the *Echinochloa* species. *Echinochloa glabrescens* had the lowest germination rate and the lowest germination at 35℃ while no difference was observed between 30℃ and 25℃. Germination of *E. crus-galli* ssp. *hispidula*, on the other hand, decreased significantly when temperature increased from 25℃ to 35℃, the difference between 35℃ and 30℃ being greater than that between 30℃ and 25℃.

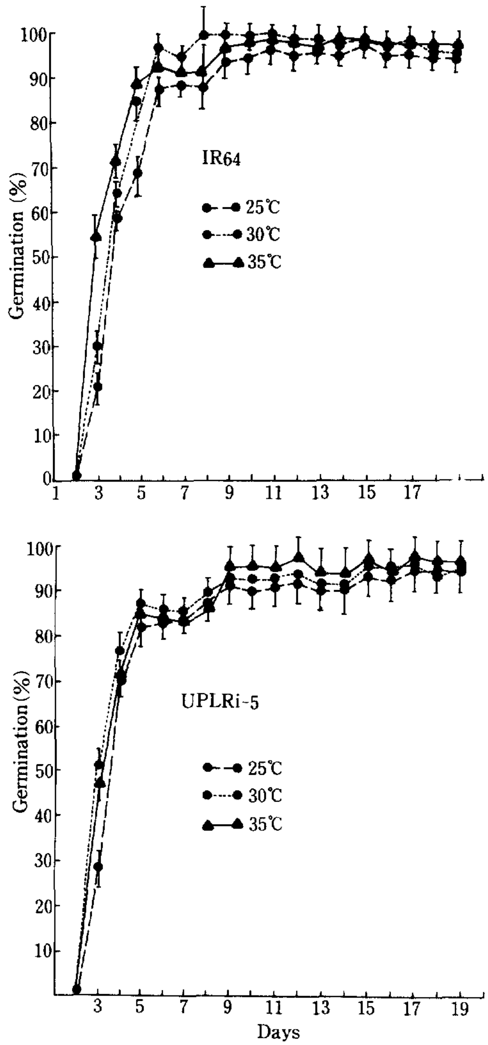

Fig. 1. Changes in germination of rice at three different temperatures.

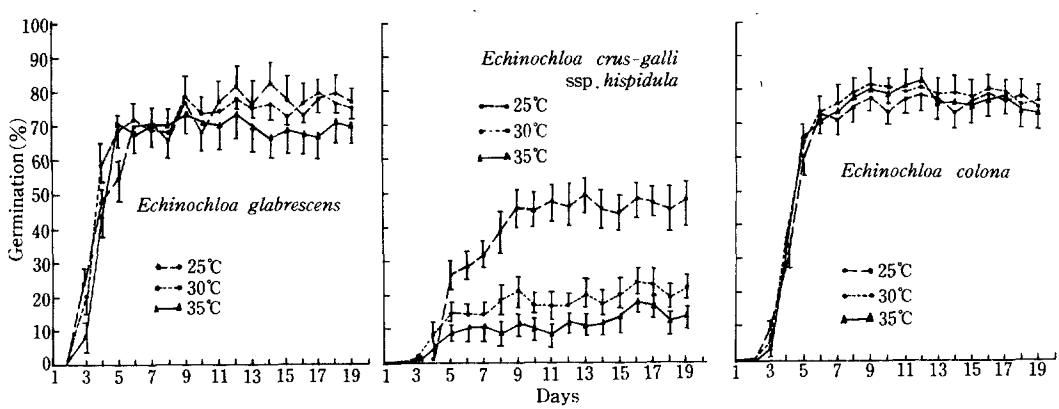

Fig. 2. Changes in germination of *Echinochloa* species at three different temperatures.

Germination of *Echinochloa colona* was not affected by temperature.

Seed weight of rice decreased significantly with time while shoot and root weight increased, the rates increasing as temperature increased (Fig. 3). However, no further decrease in seed weight or increase in shoot and root weight was observed after a certain period. This result may be due to the fact that seed weight becomes lighter when stored carbohydrate is consumed but the seed hull will maintain the same weight. For the roots and shoots, almost 50 seedlings could increase only up to a certain amount within 5.5cm petri dishes particularly when grown in the dark. Increase in shoot and root weight could not compensates for the loss of carbohydrate for both rice cultivars at all temperature regimes throughout the germination period (19 days). This might be due to the respiration loss and lack of photosynthesis in the dark.

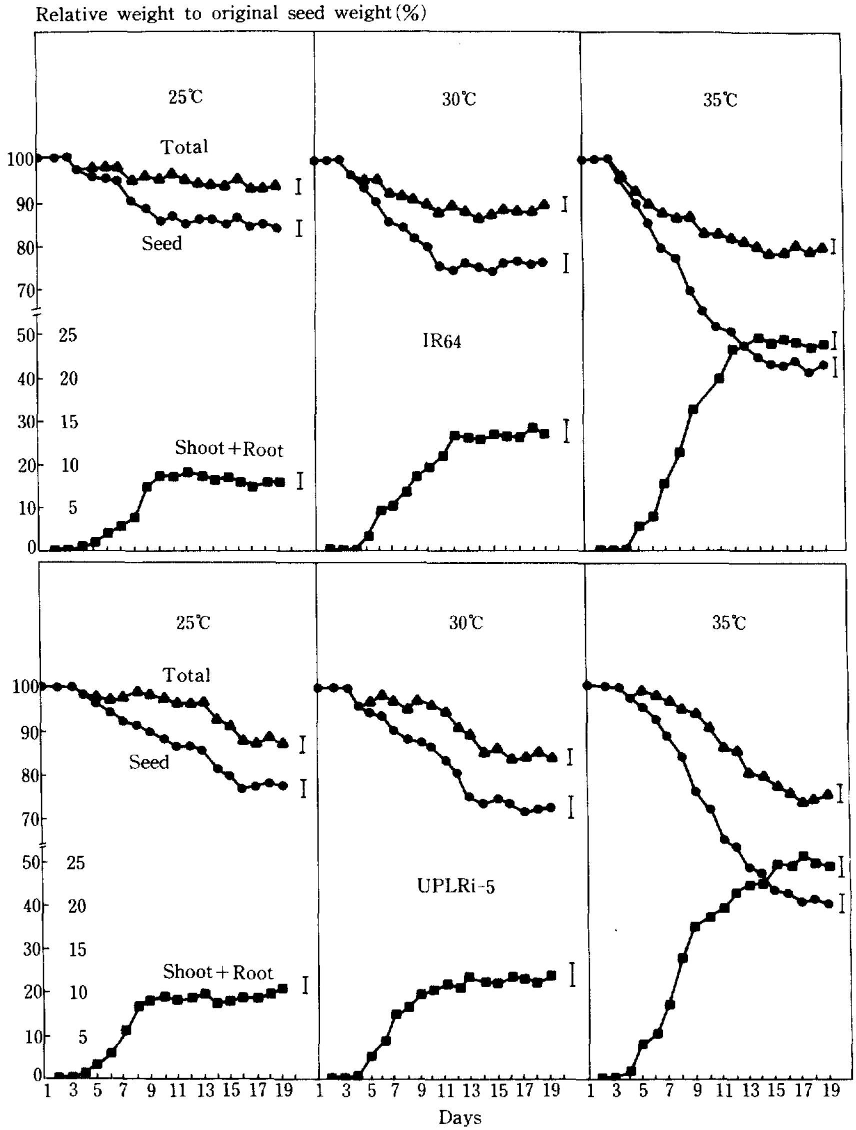

Fig. 3. Changes in relative weights of seed, shoot and root to original seed weight of rice at three different temperatures. Vertical bars represent LSD (0.05).

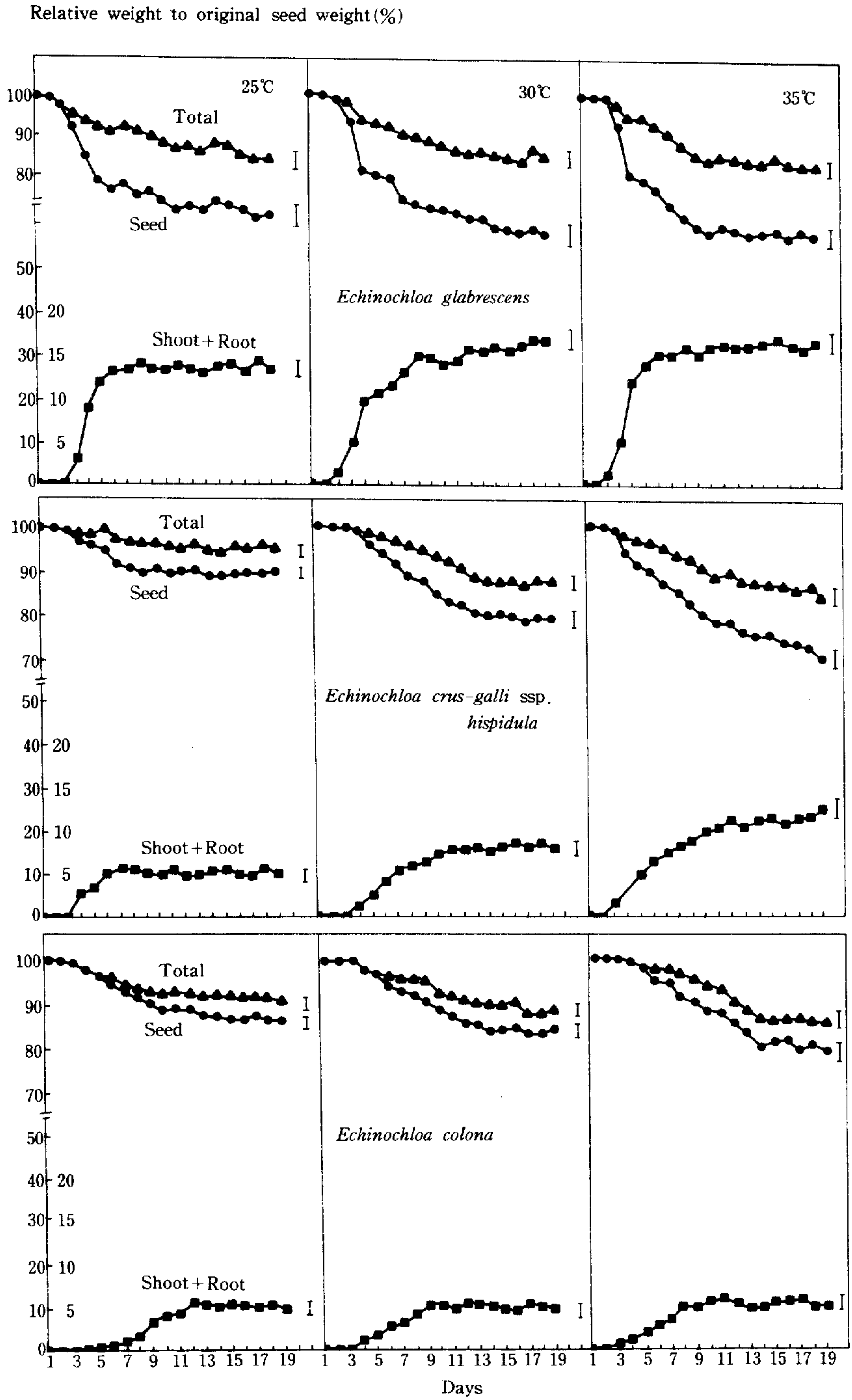

Fig. 4. Changes in relative weight of seed, shoot and root to original seed weight of *Echinochloa* species at three different temperatures. Vertical bars represent LSD(0.05).

The trend for *Echinochloa* species was similar to that of rice even though the effect of temperature was not as great (Fig. 4). Among *Echinochloa* species *E. glabrescens* had the greatest relative root and shoot growth. Again, the growth of the root and shoot could not compensate for the loss of stored carbohydrate.

A typical rice leaf is composed of the sheath, the blade, the ligule, and the auricles(Yoshida, 1981). The sheath is an elongated, ribbonshaped leaf base rolled into a cylinder that encloses all the younger parts of the shoot. The blade is narrow, flat, and longer than the sheath in all leaves except the second. The ligule is a small, white, triangular scale that looks like a continuation of the sheath, there is a white band called the collar. A pair of hairy and sickle-shaped auricles are located at the junction between the collar and the sheath. The presence of well-developed auricles and ligules is a good guide for differentiating rice from *Echinochloa* species which lack auricles and ligules. Some rice cultivars, however, lack the ligule and auricles(Yoshida, 1981).

Seedling development of *Echinochloa* species differed from rice. For both species, germination was observed on the third day after soaking (Fig. 5). On the fourth day, both species started to produce roots. The root of *E. glabrescens* grew from the seed on the opposite side of the shoot while for IR64 they grew from the same side of the seed as the root. The length of the shoot and the root of *E. glabrescens* reached about 1cm while for rice it was less than 0.2cm. On the fifth day *E. glabrescens* produced the first leaf with a length of about 2cm while IR64 still remained in the coleoptile stage having a length of less than 1 cm. On the sixth day, the first leaf of *E. glabrescens* expaned and chlorophyll was observed while IR64 had no expaned leaf and no chlorophyll in its first leaf.

The mesocotyl became apparent on the seventh day for *E. glabrescens* but not for IR64. Several crown roots came from the mesocotyl for *E.*

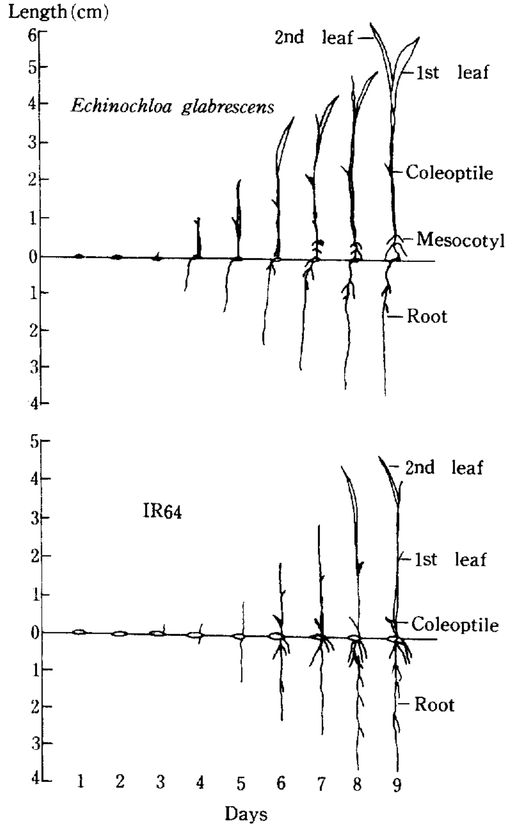

Fig. 5. Comparison of seedling devlopment between *Echinochloa glabrescens* and IR64. Average of nine replications.

glabrescens while for IR64 seminal roots still came from the base of the seed. On the eighth day, the second expanded leaf which contained chlorophyll appeared for both rice and *E. glabrescens*.

These results indicate three important physiological and morphological differences between rice and *E. glabrescens*. 1. existence of chlorophyll in the first leaf of *E. glabrescens* 2. presence of an expanded leaf blade for the first leaf of *E. glabrescens* 3. earlier crown root appearance for *E. glabrescens*. Based on the above factors, *E. glabrescens* could possibly start independent growth from the sixth day while this was possible only after 10 days for IR64. Considering the headstart advantage, *E. glabrescens* had the potential to be. ecologically more aggressive and more competitive than rice from the beginning.

The results in this experiment indicate that *Echinochloa* species, as a strong competitor to rice, have a significant advantage during seedling establishment. *Echinochloa* species emerge faster than rice and perpetuate independent growth earlier having chlorophyll at the leaf blade-like expanded first leaf while rice had an incomplete first leaf that had no leaf blade and no chlorophyll. This will be one of the important strategy to adaptation or to compete with rice.

摘 要

1987年 國際米作硏究所(IRRI)에서 水稻品種 IR64, 陸稻品種 UPLRi-5와 필리핀產 피 3種類를 供試하여 種子發芽性과 幼苗發達 樣相을 比較하기 위해 窒酸 0.1N 溶液으로 休眠打破 시킨후 25℃, 30℃, 35℃ 暗狀態에서 發芽試驗을 實施하였다.

· 벼品種은 試驗된 溫度範圍에서는 溫度間 差異가 없이 90% 以上의 높은 發芽率을 보인데 反해 피는 種類에 따라 10~80% 發芽率을 보였다. 3種類의 피中에서 *Echinochloa crus-galli* ssp. *hispidula*(물피 일종)는 가장 낮은 發芽率을 보였으며 25℃에서 約 45%, 그 以上의 溫度에서는 20% 以下의 發芽率을 보였다. 다른 두피는 70% 以上의 發芽率을 보였고 溫度別로는 *E. glabressens*(강피일종)는 高溫(35℃)에서 發芽가 약간 抑制되었고 *E. colona*(돌피일종)는 溫度間 差異는 없었다.

· 벼와 피 다같이 幼芽와 幼根 發達이 經過되면서 種子의 무게는 漸次 減少되었으나 幼芽와 幼根의 發達은 種子무게 減少를 完全 補償하지는 못하였다.

· 피의 幼根은 幼芽의 反對 部位에서 發達하였으나 벼는 幼根과 幼芽가 같은 部位에서 發達하였다.

· 벼의 第1葉은 不完全葉으로 葉身과 葉綠素가 없으나 피의 第1葉은 葉身과 葉鞘의 뚜렷한 區分은 없으나 葉綠素를 가진 葉身모양의 잎을 가지고 있었다. 發芽速度와 第1葉의 生理, 生態的 特性으로 볼때 幼苗의 獨立 生長을 營爲해 나갈수 있는 最少限의 期間이 피가 벼보다 2~3日 빨랐다.

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