Effect of Depth of Tuber Burial, Soil Temperature, and Soil Moisture on Tuber Sprouting of *Eleocharis Kuroguwai* Ohwi

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올방개 塊莖의 萌芽에 미치는 埋沒深, 土壤溫度 및 水分條件의 影響

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ABSTRACT

A study was conducted to determine the effect of depth of burial, soil temperature and/or moisture on tuber sprouting of *E. kuroguwai*. Tubers were evenly distributed in the upper 30cm of soil. Tuber weight increased as depth of tuber formed increased. No dormancy in newly formed tubers was found, whereas mature tubers were dormant. When new tubers were subjected both to continuous 5℃ and to gradual decreasing temperatures regimes ranged from 20 to 1℃ for 30 days, the tubers remained non-dormant. Viability of tubers was reduced when buried at 5cm depth in dry and moist soil conditions, but no reduction was obtained when buried at 25cm depth, regardless of soil moisture conditions employed. Percent sprouting of tubers buried at 25cm depth increased with increasing duration of burial in three soil moisture conditions studied, wherease in dry and moist conditions percent sprouting of tubers buried at 5cm depth increased by 60-day burial and thereafter decreased. In submerged condition, tuber sprouting was greater when buried at 5cm depth than when buried at 25cm depth, and increased as duration of burial increased at the both depths.

Key word : *Eleocharis kuroguwai*, tuber burial, temperature, moisture

INTRODUCTION

E. kuroguwai, a member of Cyperaceae, is a herbaceous perennial weed that is reportedly confined to Korea and Japan[6] and occurs in transplanted lowland rice(*Oryza sativa* L.) fields. This weed is capable of causing serious yield reductions of rice. It has become the most troublesome weed since various herbicides effective to annual weeds have been widely used in most areas of the rice culture[1,9]. Control with herbicides is often unsatisfactory. In addition, the weed remains green in the fall and poses harvesting problem.

Tubers of *E. Kuroguwai* are recognized as the primary dispersal unit[4,7,10]. In the fall *E. kuroguwai* rhizomes differentiate into tubers as daylength shortens[10] and the tubers are most dormant at the end of the season they were produced. Ueki et al.[10] reported that low temperature treatment was not effective to break the dormancy.

Ryang et al.[7] and Kusanagi[4] found that tubers of *E. kuroguwai* were usually distributed with

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the top 30cm of soil. At different soil depths the tubers are exposed to different environmental conditions for over-wintering period, resulting in different depths of dormancy. Studies have shown large influences of temperature and moisture on tuber sprouting of perennial weeds[2,8]. Therefore, the present study was initiated to determine effect of soil temperature and/or moisture on tuber dormancy of *E. kuroguwai* at different soil depths.

MATERIALS AND METHODS

Tuber Collection and Tuber Maturity: *E. kuroguwai* tubers were obtained from the University lowland field in the late October 1991. At collection time, soil depth that the tubers were situated was recorded and fresh weight of the tubers was measured after rinsing with tap water several times to remove soil and drying with blotting paper.

From the the freshly collected tubers immature and mature tubers were selected on the basis of tuber color. Tubers that were white in color was considered immature, whereas dark brown tubers were chosen as mature tuber.

Tuber Sprouting: Ten uniform tubers were placed on a Whatman No. 1 filter paper in a petri dish (9cm diameter) moistened with 10ml distilled water. The petri dish was kept in a growth chamber maintained at 29+2℃. The tuber was considered sprouted when one or more of buds on the tuber was 5mm long. There were four replications.

Soil Temperature and Moisture: Relation between soil temperature and moisture and tuber sprouting was observed in closed-plastic pots (33×27×42cm) installed in paddy field. The pots were buried at the same height with soil surface. After 16 replicates of ten mature tubers were placed in 5 and 25cm deep on November 7, 1991, the pots were filled with the paddy soil and imposed with different moisture conditions; dry, moist, and submerged. For dry condition, no water was allowed to enter to the pots during the experimental period, whereas moist condition was maintained to pF 2.0 (Tension Meter, Takemura Electric Works, Ltd., Japan) by watering. To keep submerged condition, standing water was always controlled to be 1cm high. Change in soil temperature at the buried depths of the tubers was recorded at 0900 hour at six-day intervals starting from November 13, 1991 for four months. At one-month intervals, four replicates were selected at random to determine tuber viability and sprouting. Out of ten tubers selected half was used to determine percent sprouting as described above. The rest was used to observe tuber viability using 2, 3, 5-triphenyl-2H-tertazolium chloride (TTC). Approximately 300mg of tuber fragments was placed in a test tube containing 5ml of 0.1% TTC solution prepared in 0.1 M phosphate buffer (pH 7.0). After 3h storage in the dark at 30℃, the tuber fragments were rinsed with distilled water and ground in a mortar with 12ml of ethyl acetate. The extract was then filtered through a Whatman No. 1 filter paper, and light absorbance of the filtrate was determined in a colorimeter as a wavelength of 585nm. If the absorbance was greater than 0.05, the tuber was considered viable.

Temperature Regime: Temperature affecting tuber sprouting was controlled by Refrigerated Constant Temperature Circulator (Model 9100 Polyscience, U.S.A.). Temperature regime employed ranged from 20 to 1℃ using liquid medium of a mixture of ethylene glycol and water (90/10 v/v). After freshly harvested tubers and/or mature tubers were placed in 300ml beakers covered with aluminum foil, the beakers were kept in the liquid medium for an appropriate period depending on the experimental conditions. On completing the temperature treatments four replicates of ten tubers were selected at random from the beakers, washed, and used for sprouting test as described above.

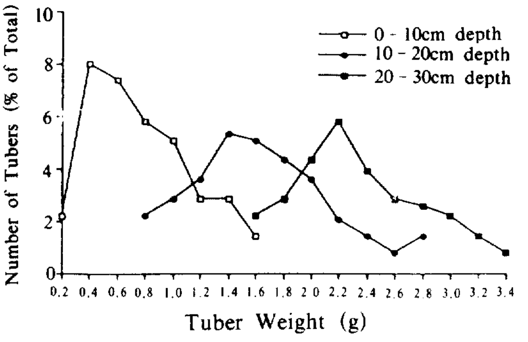

Fig. 1. Percent distribution of *Eleocharis kuroguwai* tubers with respect to the tuber weights at different soil depths.

RESULTS AND DISCUSSION

Distribution of Tubers in Soil : More than 95% *E. kuroguwai* tubers were formed within 30cm soil depths. The tubers were distributed evenly at the soil depth, but the tuber size as determined by weight was variable(Fig. 1). About 36% of the total tubers that weighed less than 1.6g occurred in the upper 10cm of soil. In the second 10cm of soil, however, about 35% tubers weighed 0.8 to 2.8g. The rest whose weight was between 1.6 and 3.4g was found in the third 10cm of soil. This indicated that the tuber size was a function of tuber depth in the soil ; tuber weight increased as its depth in the soil increased. A similar trend was also obtained by Matsubara and Nakamura[5] and Ryang et al.[7].

Formation of large tubers in deeper soils may have an ecological attribute of *E. kuroguwai*. At sprouting tubers situated at deeper soil would take more time to reach the soil surface, resulting in requirement of more food as compared with those situated near soil surface. Large tuber would supply more food to establish the seedling. Tuber size is positively correlated with seedling vigour. This fact was confirmed with tubers of *Sagittaria pygmaea* Miq. by Chun and Shin[3].

Effect of Temperature : As tuber formation proceeds, tuber color changes from white to brown and finally to dark brown, depending on tuber maturity. When the new tubers were allowed to sprout, percent sprouting varied with the maturity(Table 1). At 10 days after planting (DAP) white to brown tuber sprouted by 50% and the percent sprouting increased with time. However, only 10% of dark brown tubers sprouted at 80 DAP. This was due probably to dorman-

Table 1. Percent sprouting of freshly harvested tubers of *Eleocharis kuroguwai*.

Tuber color	Accumulative percent sprouting[1)]				
	Days after planting				
	10	20	40	60	80
Dark brown	0 b	0 b	0 b	10 b	10 b
White to brown	50 a	80 a	85 a	85 a	85 a

1) Means in a column followed by a common letter are not significantly different at 5% level by Duncan's multiple range test.

Table 2. Tuber sprouting of freshly harvested tubers stored at two temperature regimes.

Tuber Maturity	Temperature regime (℃)	Accumulative percent sprouting[1)]			
		Days after planting			
		5	10	30	60
Mature	5	0 c	30 b	45 b	45 b
	20	0 c	10 c	10 c	10 c
Immature	5	50 a	88 a	100 a	100 a
	20	10 b	33 b	33 b	33 b

1) Means in a column followed by a common letter are not significantly different at 5% level by Duncan's multiple range test.

cy difference between the tubers. The dormancy seems to be developed as the tuber matures.

Effect of temperatures on tuber sprouting revealed that dormancy of new tubers was greatly affected by temperature to which the tubers were exposed. Non-dormant new tubers were able to sprout after subjecting them to 5 for 30 days, whereas percent sprouting decreased by about 30% when subjected to 20 (Table 2). On the other hand, dormancy of matured tubers lasted under the temperature regime of 20℃. Slight dormancy break for the matured tubers was obtained when treated with 5℃ for 30 days. This result clearly indicated that at 20℃ freshly matured tuber remained non-dormant, dormancy of the matured tuber was slightly broken. Low temperature appeared to play an important role in dormancy characteristic of *E. kuroguwai* tubers.

Effect of low temperature on dormancy of white to brown tuber was confirmed under gradual decreasing temperature conditions (Table 3). When the white to brown tuber was subjected to 20℃, percent sprouting reached 20% at 20 DAP. With decreasing the temperature to 15℃ or lower the sprouting was accelerated and increased. Further decrease to 1℃ resulted in complete sprouting even at 5 DAP. In contrast, lowering the temperature did not affect dormancy breaking of matured tuber (data not presented).

Effect of Soil Moisture and Depth of Burial: In the field, tubers formed in the soil are exposed to different soil environmental conditions. When tubers were subjected to different soil moisture conditions, viability of tubers buried at different depths varied (Table 4). In dry or moist soil condition viability of tubers buried at

Table 3. Percent sprouting of freshly harvested white to brown tubers as affected by simulated temperature regimes.

Temperature regime (℃)[1]	Accumulative percent sprouting[2]			
	Days after planting			
	5	10	15	20
20	0 d	0 d	20 d	20 d
20-15	0 d	5 d	45 c	58 c
20-15-12	0 d	35 c	80 b	80 b
20-15-12-10	10 c	78 b	80 b	80 b
20-15-12-10-5	55 b	100 a	100 a	100 a
20-15-12-10-5-1	100 a	100 a	100 a	100 a

[1] Respective temperature regime lasted for 5 dasy.
[2] Means in a column followed by a common letter are not significantly different at 5% level by Duncan's multiple range test.

Table 4. Viability of freshly harvested dark brown tubers buried at different soil depths as affected by soil moisture conditions.

Moisture condition	Depth of burial (cm)	Percent survival[1]			
		Days after burial			
		30	60	90	120
Dry	5	100 a	75 c	10 c	10 c
	25	100 a	100 a	100 a	100 a
Moist	5	100 a	88 b	75 b	75 b
	25	100 a	100 a	100 a	100 a
Submerged	5	100 a	100 a	100 a	100 a
	25	100 a	100 a	100 a	100 a

[1] Means in a column followed by a common letter are not significantly different at 5% level by Duncan's multiple range test.

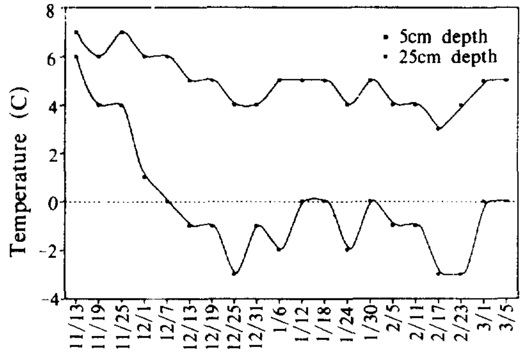

Fig. 2. Change in soil temperature at 5 and 25cm soil depths in dry soil condition between November 1991 and March 1992.

25cm depth was not affected, but when buried at 5cm depth tuber viability was reduced as days after tuber burial increased. The reduction was greater in dry soil condition than in moist. However, no reduction occurred in submerged soil condition, regardless of depths of burial employed. The result indicated that tuber viability was influenced by both soil moisture condition and depth of burial. This influence would be affected by soil temperature fluctuation as shown in Fig. 2. Soil temperature at 25cm depth in dry soil condition was ranged from 3 to 7℃, whereas at 5cm deep the temperature sharply decreased to 0℃ on December 7 and thereafter fluctuated between 0 and -3℃. Tubers near at soil surface would be susceptible to winterkill due to the effect of frozen surface soil. Under a simulated temperature condition, about 62% and 91% of the tubers were killed at -3 and -5℃, respectively, when exposed for 48h (unpublished data). In submerged soil condition, however, tubers even at 5cm depth were escaped from freezing due probably to the insulating effect of frozen standing water. Although the standing water was frozen during the experimental period, soils below the soil surface were hardly frozen.

Tuber dormancy was also affected by soil moisture and depth of burial (Table 5). Percent sprouting of tubers buried at 25cm depth increased with increasing duration of burial, regardless of soil moisture conditions employed, whereas in dry and moist soil conditions percent sprouting of tubers buried at 5cm depth increased by 60-day burial and thereafter decreased. The decrease in percent sprouting was greater in dry soil condition than in moist. This was attributed to different influences of soil temperature either on dormancy breaking or tuber viability or both. In submerged condition tubers at 5cm depth sprouted significantly greater percentage than tubers at 25cm depth during the experimental period, indicating great dormancy breaking of tubers at the upper soil layer.

The results indicate that edaphic factors such as temperature, moisture, and depth of tuber burial markedly affect dormancy and viability of *E. kuroguwai* tubers. Tuber sprouting test with newly formed tubers revealed that tuber dormancy was obtained during the maturing process right after formation of tubers. Once mature

Table 5. Percent sprouting of freshly harvested dark brown tubers buried at different soil depths as affected by soil moisture conditions.

Moisture condition	Depth of burial (cm)	Percent sprouting[1) Days after burial] 30	60	90	120
Dry	5	48 a	73 a	8 c	5 d
	25	10 c	38 b	60 b	73 b
Moist	5	40 a	75 a	60 b	58 b
	25	10 c	18 c	58 b	68 bc
Submerged	5	43 a	65 a	83 a	88 a
	25	20 b	40 b	53 b	63 bc

[1)] Means in a column followed by a common letter are not significantly different at 5% level by Duncan's multiple range test.

tuber became dormant, the tubers were not easily sprouted under a favorable environmental condition. In addition, the fact that white to brown tubers remained non-dormant when subjected to low temperature suggested that induction of dormancy would not be related with exposure to low temperature.

After tubers of *E. kuroguwai* are formed in the upper 30cm of soil in the fall they are exposed to different soil temperature and/or moisture during the subsequent winter. Tubers situated near the soil surface were more influenced by soil moisture conditions than those situated at lower level of soil, so that less viable tubers and percent sprouting in the former. This effect appeared to be related with differences in soil temperature at different soil dephts. For example, in dry soil condition temperature was lower and more fluctuate near the soil surface than at lower level. Considering the susceptible response of tubers situated near the soil surface to soil temperature and/or moisture, tillage operations in early winter followed by keeping the soil dry would bring the tubers to the soil surface and winterkill the tubers.

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摘　要

올방개 塊莖 形成과 休眠 覺醒에 미치는 埋沒深, 土壤溫度 및 水分條件의 影響을 調査하였다. 새로 形成되는 塊莖은 土壤表層으로 부터 30cm 以內에 고루 分布하였다. 塊莖의 크기는 形成深度가 깊어질수록 커지는 傾向이었다. 새로 形成되는 塊莖은 休眠性이 없지만, 成熟 塊莖은 休眠性을 보였다. 新塊莖을 5℃ 定溫 또는 20℃로부터 1℃로 下降되는 變溫條件에서 30일간 處理할 때는 非休眠性이 維持되었다. 塊莖의 生存力은 乾燥 및 濕潤 土壤條件에서 5cm 깊이로 埋沒시키면 減少되었지만, 25cm 埋沒深에서는 土壤 水分條件에 관계없이 減少되지 않았다. 25cm 깊이로 埋沒시킨 塊莖의 萌芽率은 土壤水分條件에 관계없이 埋沒 期間이 길어질수록 增加한 반면, 乾燥 및 濕潤 條件의 5cm 埋沒에서는 60일 동안

萌芽率이 增加하다가 그 以後부터 減少되었다. 湛水條件에서의 萌芽率은 25cm 보다 5cm 埋沒深에서 높았으며, 두 埋沒深 모두 埋沒 期間이 길어지면 增加되는 傾向이었다.