REPRODUCTIVE STRATEGY OF *EQUISETUM ARVENSE* L.

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Summary. The rhizome of elongation of *Equisetum arvense* L. started soon after the growth of shoots, but the formation of tuber followed two months later than rhizome elongation. The greater part of dry matter production was partitioned into rhizome and tuber, and 75% of dry matter partitioning ratio to rhizomes and tubers was observed in the maturing growth stage. Rhizomes were more tolerant against drought or high temperature stress than tubers. The growth of rhizome originating from tuber was more rapid than that from rhizome.

INTRODUCTION

Equisetum arvense L. is one of the most common perennial weeds in Japan and is difficult to control. It is growing on eighty percent of agricultural area in Japan (2), and it has been enhanced by recent extension of minimum- or no-tillage conservation. Problems of this weed are more serious in cool agricultural zones, i.e. northern part of Japan, especially in pasture. Because *E. arvense* contains thiaminase enzyme, animals eating this weed become deficient of vitamin B_1 (1).

E. arvense propagates both by sexual reproduction (spores) and by asexual reproduction (rhizomes and tubers). Ecological features of their propagative organs are not characterised well. Some experiments were carried out to enable to design the reasonable control method of this weed.

METHODS

1. Germination and establishment of spores. The fertile cones of *E. arvense* were collected from fields in Tsukuba for the materials in the experiment. The spores produced in sporangium in a desiccator were put on MS medium or volcanic ash soil. The effects of some environmental conditions on the germination and establishment of spores were examined by various treatments as follows: (i) pH of MS medium: pH 3.7, 4.5, 5.7, 6.8, 7.4; (ii) Temperature: 5, 15, 20, 25, 30°C; (iii) Soil moisture: pF 1.0, 1.5, 2.0, 2.7, 4.0; and (iv) Gas condition: 100% N_2 gas, air with sealed or ventilated condition.

2. Reproduction of rhizomes and tubers. Three tubers were planted into 1/5000 a Wagner pot filled with volcanic ash soil on 7 June 1988 without any fertiliser, and were placed outside. Dry weight of each organ was measured monthly. Five tubers or two rhizomes with three nodes were also planted into 1/5000 a Wagner pot filled with volcanic ash soil. These were set up in a water bath controlled at 15, 20, 25 and 30°C. The amount of reproduction of newly formed tubers or rhizomes were examined six months after planting.

3. Tolerance of rhizome and tuber against environmental stress. Responses to some kinds of stress were compared between rhizome and tuber. Tubers and rhizomes cut into segments with three nodes were subjected to experiments as follows:

(i) Low temperature: The segments were put into soil with 66% soil moisture condition, and incubated at -1, -3 and -5°C for 1, 2, 4 and 7 days.
(ii) High temperature: The segments set in grass tubes were put into the water bath controlled at 40, 45, 50, 55 and 60°C for 5, 10, 20, 30, 60 and 120 minutes.
(iii) Drought condition: The segments set in petri dish were put into drying incubator controlled at 25°C for 20, 45, 60, 90 and 180 minutes.

RESULTS AND DISCUSSION

1. Germination and establishment of spores. Responses of spore germination to some environmental factors were summarised as follows:

(i) pH: Range for normal germination: pH 4.5-6.5, Optimum: pH 5.7.
(ii) Temperature: Range for normal germination: 15-30°C, Optimum: 20°C.
(iii) Soil moisture: Spores could germinate at the soil moisture condition less than pF 2.7, but prothallium was produced less than pF 2.0 (Table 1).
(iv) Gas condition: Spores could germinate without O_2.

Table 1. Effect of soil moisture on germination of spores, development after germination and formation of prothallium

pF	Germination	Development	Prothallium
1.0	good	good	formed
1.5	good	good	formed
2.0	good	good	formed
2.7	medium	bad	no
4.0	bad	dead	no

It is known that the numerous spores are produced (1), but the results obtained here suggest that it is very difficult to establish the plants of *E. arvense* from spores under natural conditions.

2. Reproduction of rhizomes and tubers. The elongation of rhizomes started soon after the onset of shoot growth. The total length of new rhizomes reached about 50 cm/plant 4 months after planting. The formation of tubers followed two months later than rhizome elongation. Finally six tubers/plant were newly formed.

Fig. 1 shows changes in dry matter partitioning ratio to each organ during growing period. When the shoots started growth, the dry matter partitioning ratio to shoot was higher than 75%. During August dry matter partitioned into underground organs was increased. In September the dry matter partitioning ratio to rhizome and tuber reached 75%.

Temperatures affected the tuber formation from rhizome or tuber responded similarly. In both cases, optimum temperature for tuber formation was observed at 20°C, and tuber formation was decreased at 30°C.

On the other hand, temperatures affected rhizome elongation from tuber or rhizome differently. Total length of new rhizomes from tuber was longer than those from rhizome, except at high temperature (Fig. 2).

The partition of photosynthetic products to rhizomes and tubers starts from early growth stage and at maturing growth stage the greater part of photosynthates translocates to their under ground propagative organs.

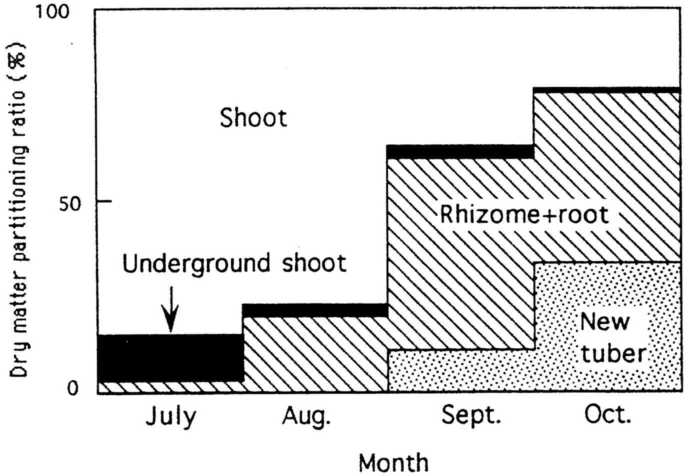

Figure 1. Changes in dry matter partitioning ratio into each organ during growth season.

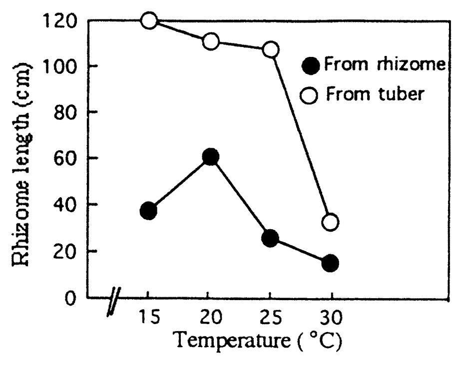

Figure 2. Difference in response of rhizome elongation to temperature between rhizome from rhizomes and that from tubers.

3. Tolerance of rhizome and tuber against environmental stress. The ratio of emergence of tubers and rhizomes was decreased by the treatment of -3 or -5°C for a day. Treatments of -3 or

-5°C longer than 2 days killed all buds on tubers and rhizomes. Treatment of -1°C did not influence the emergence even for 7 days.

Buds of tubers were killed by treatment at 45°C for 60 minutes, or 50°C for 10 minutes. Those of rhizomes were not killed by treatment at 45°C for 120 minutes but killed by treatment at 50°C for 30 minutes.

The emergence of buds of rhizome was decreased when moisture loss of rhizome reached 40%, and all buds of rhizomes were killed when the moisture loss reached 62%. Emergence of buds of tubers was decreased when the moisture loss of tubers reached 10%, and all buds of tubers were killed when the moisture loss reached 25% (Fig. 3).

These results indicate that the emergence ability of rhizomes is more tolerant against high temperature and drought stress than that of tubers.

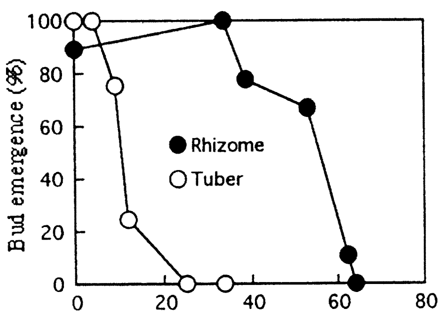

Figure 3. Difference in tolerance of germinating ability to water stress between rhizomes and tubers.

Conclusion. Rhizomes are more tolerant against severe environmental condition than tubers. On the other hand, the growth of rhizomes originated from tuners is more rapid than those from rhizomes. The vigorous reproductive ability of *E. arvense* depends on different characteristics of tubers and rhizomes in the propagative strategy.

REFERENCES

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