Studies on the Seedling Emergence in Crops

Effects of soil moisture content, cultural temperature and seed size on the strength of plumule-elongation in naked barley plants

JUN INOUE, HIDEFUMI SEKO** and Kenji Iro
(Faculty of Agriculture, Kyushu University, Fukuoka)

Barley is generally considered more sensitive to deep seeding than either oats or wheats. In barley plants, seedling emergence of uzu variety (semi brachytic character) easily affected by soil physical conditions than that of normal variety. Therefore, it is often hard to get proper stands of uzu variety. This reason may be explained by lack of good coleoptile length to emerge under varying field conditions. That is, coleoptile length has been received considerable attention in relation to emergence. ALLAN et al. established a positive relationship between coleoptile length and emergence in winter wheats^{1,2,3)}. However, plumule of long coleoptile does not always result in good seedling emergence.

Recently, KOLP et al. revealed from the experiment of winter wheats under compacted soil condition that cell diameter of coleoptile was positively correlated to coleoptile sheath thickness, coleoptile total diameter, and coleoptile strength, and indirectly correlated to coleoptile length.⁹⁾

Considering the results obtained by this time, we proposed in previous paper that the seedling emergence ability (EA) in cereals was as follows⁵⁾:

$$EA = R \cdot St \cdot Sp$$

R : Coefficient of resistance elimination at the time of emergence (shape of plumule, length of coleoptile and physiological nature of plumule, etc.).

St : Strength of plumule-elongation (mecha-

nical strength of plumule to push a thing up with the tip of it measured with unbonded gauge type transducer).

Sp : Speed of plumule elongation in darkness.

Hereupon, in the early growing stage of plumule (short plumule), it is thought that both R and Sp are almost all the same in barley varieties. Accordingly, under the condition of thin layer of covering soil, it may be said that the more St is strong, the better emergence is obtained. Under the condition of thick layer of covering soil, on the other hand, it is thought that both R and Sp change with growing of plumule, so that both R and Sp of fairly elongated plumule (long plumule) may be varied among varieties. However, St may be the most requirement for successful stands of barley under varying field conditions.

An attempt to examine the strength of germinating seedling to push a thing up with the tip of it was tried by WILLIAMS in four species of Leguminosae¹²⁾. His measuring method was thus; Germinating seedlings were subjected to vertical force of weighted glass rods while being restrained laterally by glass tubing. Substantial movement of the rods was recorded as evidence that the seedling exerted a force equal to the weight of the rod. In wheat plumules, However, EVANS used this measuring method unsuccessfully in an attempt to measure the strength of coleoptile elongation.⁹⁾

In this experiment, effects of soil moisture content, cultural temperature and seed size on the strength of plumule-elongation in naked barley varieties were examined with unbonded

* Received for publication on March 27, 1969.

** Present address : Shikoku Agricultural Experiment Station.

gauge type transducer in darkness.

MATERIALS AND METHODS

The strength of plumule-elongation, strength of plumule to push a thing up with the tip of it, was examined with unbonded gauge type transducer (UL 1 kg of Shinko) in darkness for about 48 hours in each plumule. The measuring method of the strength was same as that in previous paper.⁴⁾

Materials were Kagoshimahadaka (uzu), Kai-monhadaka (uzu) and Futsu No. 1 (normal) in winter naked barley varieties.

After incubation on moistened filter paper in petri dish at 25°C for 24 hours in darkness, a seed was placed on the seed bed in each pot of glass tube, 25×80 mm. Seed bed was made from sand which was filtered with 12 mesh sieve. The seed was then covered with 10 mesh granulated sandy loam.

Unless otherwise mentioned, well matured seeds of medium size were used in each variety, and soil moisture content was about 11 per cent in both seed bed and covering soil.

Each experimental lot consisted of six or more number of plumules.

RESULTS AND DISCUSSION

1) Effect of soil moisture content on the strength of plumule-elongation.

Well matured seeds of medium size were selected in Kagoshimahadaka (uzu) and Futsu No. 1 (normal) barley varieties. After incubation at 25°C for 24 hours, germinating seeds were sown in each pot. And then, about 3 cm thick of covering soil was made. Thereafter, the pots were transferred to 20°C in darkness. When plumules grew to about 3 cm long, strength of plumule-elongation was measured at 20°C in darkness for about 48 hours. Soil moisture content of seed bed and covering soil was 5, 8, 10, 15, 20, 22, 25 and 27 per cent. Under the soil moisture conditions of 5 and 27 per cent, none of the plumules could grow. The results are shown in fig. 1.

As shown in fig. 1, the effect of soil moisture

content on the strength of plumule-elongation was little under the conditions ranging from 8 to 15 per cent of moisture content in both two barley varieties. It decreased with increasing of soil moisture content. At the condition of 25 per cent, the strength was about 1/2 in uzu variety and about 3/5 in normal one as compared with each maximum strength.

2) Change of the strength of plumule-elongation as growing

Under the condition of warm temperature, it is reported that the strength of plumule-elongation of uzu barley varieties decreased with growing of plumules.⁴⁾

After sowing of Kagoshimahadaka (uzu), Kai-monhadaka (uzu) and Futsu No. 1 (normal) barley seeds, the seeds were covered with 2-7 cm thick of soil. Thereafter, the pots were transferred to 20°C in darkness. When the plumules grew to 0.6, 1.5, 3.0, 4.0, 5.0 and 7.0 cm long, the strength of plumule-elongation was examined at 20°C in darkness. The results are given in table 1.

The strength of plumule-elongation in uzu varieties was maximum in early growing stage of plumules (0.6~3.0 cm long), and it decreased with growing of plumules. In particular, the strength decreased strikingly at the plumules of about 5 cm long. On the other hand, the strength of plumule-elongation in normal variety increased with growing of plumules, and it was maximum in the plumules of 3.0 cm long. Then, the strength decreased with growing of plumules, gradually.

In uzu variety the 1st leaf had emerged from coleoptile in the plumules of about 4.5 cm long. In the plumules of normal variety, however, the 1st leaf did not emerged from coleoptile even in the plumules of 7.0 cm long.

Above difference of the strength between uzu barley variety and normal one may be attributed to total length of coleoptile.¹¹⁾

3) Effect of culture temperature on the strength of plumule-elongation

After sowing, 2~4 cm thick of covering soil

was made. Thereafter, the plumules were cultured under the temperatures of 10°, 15°, 20°, 25° and 30°C in darkness. When the plumules grew to 1.2~1.5 cm and 3.7~4.0 cm long, the strength of plumule-elongation was examined at each cultural temperature in darkness. Barley varieties were Kagoshimahadaka, Kaimonhadaka and Futsu No. 1. The results are shown in table 2.

In these three barley varieties, the strength of plumule-elongation was stronger at cool temperature conditions than that of warm temperature conditions in both growing stages of plumules. At cool temperature conditions of 10°, 15° and 20°C, both strength of short plumules (1.2-1.5 cm long) and long plumules (3.7-4.0 cm long) were almost the same in each variety. At 25°C, the strength of plumule-elongation was weaker than that of 20°C in both growing stages of plumules. And the weakness was more obvious in uzu varieties than that in normal one. At 30°C, on the other hand, the strength of short plumules was weaker about 15 g in uzu varieties, and about 35 g in normal one than that of 25°C. The strength of long plumules was weaker about 50 g than that of 25°C in normal variety, and none of the plumules could grow to about 4 cm long in uzu varieties.

In these naked barley varieties, it is likely that optimal temperature for the strength of plumule-elongation is slightly lower than that for germination and elongation of plumules.

4) Effect of seed size on the strength of plumule-elongation

Recently it was reported that a significant difference was found between seed size and coleoptile length in barley varieties. However, the effect of seed size on emergence was considered of minor importance.^{6,7,8)}

a) The following test was carried out to see the effect of seed size on the strength of plumule-elongation. Seeds of Kaimonhadaka (uzu) were classified into 5 groups by a seed weight, i.e., 19~21, 24~26, 29~31, 34~36 and 39~41 mg. After incubation at 25°C for 24 hours, germinating seeds were sown in each pot. And then, about 2 or 4 cm thick of covering soil was made. Thereafter, the pots were transferred to 10°, 15°, 20°, 25° and 30°C in darkness. When the plumules grew to 1.2~1.5 cm or 3.7~4.0 cm long, the strength of plumule-elongation was measured at each cultural temperature in darkness. The results are shown in fig. 3.

As shown in fig. 3, relation between seed size and the strength of plumule-elongation in this uzu variety was almost the same in all temperature conditions. The effect of seed size on the strength was more obvious in short plumules (1.2~1.5 cm long) than that in long plumules (3.7~4.0 cm long), i.e., the strength increased about 7 g in short plumules and about 6 g in long plumules with every 5 mg increasing of a seed weight, on an average. At 30°C, none of the plumules could grow to about 4 cm long.

b) Seeds of Kagoshimahadaka, Kaimonhadaka and Futsu No. 1 were classified into 5 or 6 groups by a seed weight, i.e., 14~16, 19~21,

Table 1. Change of the strength of plumule-elongation as growing at 20°C (soil moisture content; about 11%).

Length of plumule (cm.)	Varieties					
	Kagoshimahadaka		Kaimonhadaka		Futsu No. 1	
	No. of plumules	Strength (g)	No. of plumules	Strength (g)	No. of plumules	Strength (g)
0.6	6	114±13.6	10	106±15.3	21	78±12.9
1.5	7	119±11.9	9	106±11.4	8	95±15.9
3.0	11	104±14.4	8	108±13.4	9	104±14.3
4.0	6	63±12.1	6	79±12.7	6	76±12.6
5.0	6	37±8.1	6	37±7.4	6	54±9.0
7.0	6	23±2.1	6	23±3.0	6	47±14.0

Fig. 1 Effect of soil moisture content on the strength of plumule-elongation at 20°C.

○; Kagoshimahadaka, ●; Futsu No. 1.

Fig. 2 Variation of seed size in using barley varieties (500 grains, moisture content in seeds; about 11%).

○; Kagoshimahadaka, ●; Kaimonhadaka, ×; Futsu No. 1.

Fig. 3 Effect of seed size on the strength of plumule-elongation in Kaimonhadaka (soil moisture content; about 11%).

○; 10°C, ●; 15°C, △; 20°C, ▲; 25°C, ×; 30°C.

Table 2. Effect of cultural temperature on the strength of plumule-elongation (soil moisture content; about 11%).

Length of plumule (cm.)	Temperature (°C)	Varieties					
		Kagoshimahadaka		Kaimonhadaka		Futsu No. 1	
		No. of plumules	Strength (g)	No. of plumules	Strength (g)	No. of plumules	Strength (g)
1.2 }	10	6	123±13.8	6	105±11.3	12	84±14.5
	15	7	122±7.1	7	104±13.9	11	83±9.8
	20	7	119±11.9	9	106±11.4	11	84±11.9
	25	8	86±7.3	14	92±10.6	15	78±11.8
	30	7	74±6.9	6	76±11.4	6	40±11.9
3.7 }	10	10	66±7.8	7	74±15.7	7	73±5.5
	15	14	64±8.1	8	76±11.5	6	75±13.8
	20	6	63±12.1	6	79±12.7	6	76±12.6
	25	15	56±11.2	11	54±10.0	7	69±9.4
	30	-*		-*		6	21±5.8

* None of the plumules could grow to this stage.

Table 3. Effect of seed size on the strength of plumule-elongation at 20°C (plumule length; 3.7–4.0 cm, soil moisture content; about 11%).

A seed weight (mg)	Varieties					
	Kagoshimahadaka		Kaimonhadaka		Futsu No. 1	
	No. of plumules	Strength (g)	No. of plumules	Strength (g)	No. of plumules	Strength (g)
14~16	7	42±12.5	0		0	
19~21	11	45± 8.6	12	49± 7.5	10	48±11.7
24~26	11	58± 7.8	12	54± 8.0	6	60±14.9
29~31	13	70±10.5	11	57±11.1	6	64±11.3
34~36	7	72±16.4	9	63±14.2	6	76±18.0
39~41	8	73±12.3	10	69± 8.8	8	92±17.9
44~46	0		0		9	99±16.3

24~26, 29~31, 34~36, 39~41 and 44~46 mg.

After sowing of the germinating seeds, the seeds were covered with about 4 cm thick of soil. Thereafter, the plumules were cultured under the temperature of 20°C in darkness. When the plumules grew to 3.7~4.0 cm long, the strength of the plumule-elongation was examined at 20°C in darkness. The results are presented in table 3.

In each naked barley variety, positive correlation was observed between the strength of plumule-elongation and a seed weight. That is, the more seed size was large, the more strength of plumule-elongation was vigorous. And, it was more obvious in normal variety than that in uzu varieties, i.e., the strength increased about 10 g in normal variety and about 5 or 7 g in uzu varieties with every 5 mg increasing of a seed weight, on an average.

SUMMARY

Using unbonded gauge type transducer, effects of soil moisture content, cultural temperature and seed size on the strength of plumule-elongation were examined in two "uzu" and a "normal" naked barley varieties. This strength was mechanical vigour of plumule to push a thing up with the tip of it. The results are as follows:

1. Effect of soil moisture content on the strength was little in the soil moisture condition ranging from 8 to 15 per cent. And it decreased with increasing of moisture content.

2. The strength was maximum in early growing stage of plumules (0.6~3.0 cm long), and

it decreased with growing of plumules. This was more obvious in uzu varieties than that in normal one.

3. The strength was more vigorous in the plumules which were cultured under cool temperature conditions (10~20°C) than those under warm conditions (25, 30°C). It is thought that optimal temperature for the strength is more cooler than that for germination and elongation of plumules.

4. Effect of seed size on the strength was observed at all temperature conditions (10~30°C). The strength increased about 10 g in normal variety and about 5~7 g in uzu varieties with every 5 mg of a seed weight, on an average.

REFERENCES

1. ALLAN, R.E., O.A. VOGEL, J.R. BURLEIGH and C.J. Jr. PETERSON 1961. Inheritance of coleoptile length and its association with culm length in four winter wheat crosses. *Crop Sci.* 1: 328–332.
2. ALLAN, R.E., O.A. VOGEL and C.J. Jr. PETERSON 1962. Seedling emergence rate of fall-sown wheat and its association with plant height and coleoptile length. *Agron. J.* 54: 347–350.
3. ALLAN, R.E., O.A. VOGEL, T.S. RUSSELL and C.J. Jr. PETERSON 1965. Relation of seed and seedling characteristics to stand establishment of semi-dwarf wheat selections. *Crop Sci.* 5: 5–8.
4. INOUE, J. and K. ITO 1968. Studies on the

- seedling emergence in crops (Japanese, with English tables and summary). Proc. Crop Sci. Soc. Japan 37 : 352~358.
5. INOUE, J. and K. ITO 1969. Studies on the seedling emergence in crops (Japanese, with English tables and summary). Proc. Crop Sci. Soc. Japan 38 : 39—42
 6. KAUFMAN, M. L. and A. D. MCFADDEN 1963. The influence of seed size on results of barley yield trials. Can. J. Plant Sci. 43 : 51—58.
 7. KAUFMANN, M. L. and A. A. CUITARD 1967. The effect of seed size on early plant development in barley. Can. J. Plant Sci. 47 : 73—78.
 8. KAUFMANN, M. L. 1968. Coleoptile length and emergence in varieties of barley, oats, and wheat. Can. J. Plant Sci. 48 : 357—361.
 9. KOLP, B. J., D. G. MILLER, G. A. PRATT and SHOU-JEN HWANG 1967. Relation of coleoptile structure to coleoptile strength and seedling emergence under compacted soil conditions in six varieties of winter wheat. Crop Sci. 7 : 413—417.
 10. PECH, W. 1937. Neue Methode zur Bestimmung der Standfestigkeit des Getreides. Zeitschrift für Pflanzenzuchtung 21 : 46~58.
 11. TAKAHASHI, R. 1946. Studies on the classification and the geographical distribution of the barley varieties. I (in Japanese). Proc. Crop Sci. Soc. Japan 15 : 217—223.
 12. WILLIAMS, W. A. 1956. Evaluation of the emergence force exerted by seedlings of small seeds legumes using probit analysis. Agron. J. 48 : 273—274.

[和 文 摘 要]

作物の出芽に関する研究

——裸麦の幼芽の抽出力におよぼす土壌水分、温度および種子の大きさについて——

井之上 準・瀬古秀文*・伊藤健次

(九州大学農学部 *農林省四国農業試験場)

ストレーンゲージ荷重変換器 (UL 1 kg) を応用して、裸麦の幼芽の抽出力におよぼす土壌水分、温度および種子の大きさについて実験した。供試材料は渦性の鹿児島裸、カイモンハダカおよび並性の仏1号であつた。結果の概要はつぎの通りであつた。

(1) 土壌水分 8~15% の範囲内では (乾重比)、幼芽の抽出力にはほとんど差はみられなかつたが、土壌水分が 15% 以上になると幼芽の抽出力は弱くなつた (fig. 1)。

(2) 並性品種では、抽出力は幼芽が伸長するにつれて強くなり、幼芽長 3 cm で最高に達し、その後は幼芽の伸長につれて漸次弱くなつた。ところが渦性品種では、伸長初期の幼芽 (0.6~3.0 cm) ではほぼ同じ強さであつたが、その後は伸長につれて急激に弱くなつた (table 1)。

(3) 幼芽の抽出力は、10°~20°C で育成された幼芽において、25°~30°C で育成された幼芽よりも強かつた。このことは、裸麦の幼芽の抽出力の適温は、発芽および幼芽の伸長の適温よりもやや低いことを示していると思われる (table 2)。

(4) 種子の大きさは大きいほど、幼芽の抽出力は強かつた。すなわち、種子 1 粒重が約 5 mg 重ければ渦性品種では 5~7 g、並性品種では約 10 g 強くなつた。なお、この関係は、温度の影響をほとんど受けないようであつた (fig. 3, table 3)。