Physical Quality of Rice Seedlings Required for Mechanical Transplanting

By TOSHIHIKO NISHIO*

Central Agricultural Experiment Station
(Konosu-shi, Saitama, 365 Japan)

Mechanical transplanting of rice accounted for 72% of the total lowland rice area of Japan in 1976, and is showing an increasing trend. Rice seedlings to be used for mechanical transplanting must have adaptability to mechanical planting, in addition to good physiological property. Principal factor of the adaptability is regarded to be physical quality of seedlings, but studies on this aspect are extremely few.

The present study was carried out to make clear the physical quality, and conditions required for growing seedlings adapted to mechanical planting, i.e. seedlings with superior physical quality as well as superior physiological properties, with an aim of knowing how to grow good seedlings for mechanical transplanting.

Physical characters measured

To know the physical quality of seedlings, more than ten different physical characters were measured. However, fairly high correlations were found to exist among several physical characters. As a result, buckling moment which expresses buckling intensity at the basal portion of top of seedlings, buckling stress and compressive modulus both expressing physical rigidity of the basal portion, section modulus expressing thickness of the basal portion, plant height and height of gravity-center, buckling index expressing resistance to buckling of whole seedling and natural deflection ratio expressing bending resistance of whole seedling were taken as major physical characters, as shown in Table 1. In addition, fresh wieght of tops was taken into consideration sometimes.

Planting accuracy, seedling establishment and initial growth as related to physical quality of seedlings

What kind of trouble may occur when the physical quality is not good is given in Table 1. It shows that 6 physical characters exert strong influences on planting accuracy, and rooting as well as initial growth of seedlings after planting while the effect of fresh weight of tops is not so apparent. Namely, the occurrence of seedling damage (abrasion, buckling and cutting) was closely related to the rigidity (buckling stress) of the basal portion of tops, buckling angle, plant height, as well as buckling resistance (buckling index) and bending resistance (natural deflection ratio), both shown by the seedling as a whole.

Attitude of planted seedling (planting angle) was closely related to buckling intensity (buckling moment) at the basal portion of tops, plant height, and buckling resistance as well as bending resistance, both shown by seedling as a whole.

It was also found that the lodging of normally transplanted seedlings occurred by muddy water flow caused by the running transplanter was closely related to buckling intensity of the basal portion of tops, and buckling resistance of whole seedling.

Effects of physical quality on seedling es-

* Present address: Agriculture, Forestry and Fisheries Research Council Secretariat, Ministry of Agriculture, Forestry and Fisheries
(Kasumigaseki, Tokyo, 100 Japan)

Table 1. Planting accuracy and initial growth after planting as related to physical quality of seedlings

	Physical quality	Damage of leaf sheath	Attitude of planted seedlings	Lodging by muddy water flow	Recovery from lodging	Establishment of seedlings artificially compressed
Basal portion of tops	Buckling intensity (buckling moment)	×	○	○	○	—
	Rigidity (buckling stress, compressive modulus)	◎	—	—	—	○
	Thickness (section modulus)	◎	—	—	—	—
Seedlings as a whole	Plant height or height of gravity-center	○	◎	×	×	—
	Fresh weight of top	×	×	×	○	—
	Buckling resistance (buckling index)	○	◎	○	○	—
	Bending resistance (natural deflection ratio)	◎	◎	—	—	—

◎: Close relation observed, ○: Relation observed, ×: No relation observed, —: Relation not confirmed.

tablishment and initial growth were observed as follows: As to the rising-up (recovery) of lodged seedlings, it was found that seedlings with small, light tops well balanced to the basal portion, which is well developed with increased buckling intensity, i.e., higher buckling resistance of seedling as a whole, showed better recovery.

Difference in the degree of damage caused by artificial compression was derived from the difference in physical quality of seedlings: seedlings with rigid (higher compressive modulus) basal portion showed less damage and better establishment and initial growth.

Based on the above relationships observed between physical quality of seedlings and planting accuracy, seedling establishment and initial growth after planting, desirable physical quality required for mechanical transplanting can be listed as follows:

1) Increased buckling intensity of the basal portion of tops.
2) Rigid basal portion of tops, that causes 1).
3) Well-thickened basal portion.
4) Small plant height or low gravity-centre.
5) Well-balanced proportion between the top and the basal portion of top, with small top in contrast to well-developed basal portion, and high buckling resistance of seedling as a whole.
6) Erect leaves, rigid tops which are difficult to bend due to high bending resistance of seedling as a whole.

Method and condition to grow seedlings with good physical quality

A large number of different conditions for growing seedlings were tested and their effects on physical quality of seedlings are summarized in Table 2.

Conditions tested and ranges of treatments are shown in the second and third columns from the left in the Table. The forth column indicates specific treatments at which seedlings grown were judged to be best in physical quality within the given ranges of treatments. The criteria used for the judgement are shown in the fifth and sixth columns.

Based on the results shown in the fifth and sixth columns, all the seedling-raising conditions can be classified into 3 types (in the 1st column). In general, the buckling intensity of basal portion of seedling tops is determined by two factors: thickness and rigidity of that portion. However, there is a negative correlation

Table 2. Nursery conditions which improved physical quality of seedlings and their comparison with conditions effective to improve physiological property

Type	Condition	Range of treatment	Treatment which improved physical quality	Basal portion of top			Seedling as a whole			Condition effective to improve physiological property
				Rig.(1)	Thic.(2)	Bu.I.(3)	Pl(4)	Bu.R.(5)	Be.R.(6)	
Growth retarding	Kinds of nursery	Upland vs. lowland	Upland	○	×	△	○	○	○	Upland nursery[8]
	N application rate	0–20 g/m² 0–2 g/box(9)	No N	○	×	×	○	○	○	2–3 g/box to grow 4-leaf age seedlings
	N application method	Basal vs split	Split(11)	○	×	×	○	○	○	Split application[7]
	K application rate	0–4 g/box	No K	○	×	△	△	○	○	2–3% content[5]
	Air temperature(7)	15–30°C (day time)[10]	15°C(10)	○	×	×	○	○	○	Air temp. 21–31°C[1–3] water temp. 16°C
	Soil moisture	pF 2.8–submerged	< pF 2.8	○	×	×	○	○	○	< pF 2.2
Thickening promotion	Variety	16 var.	Lodging-resistant var.	×	○	○	○	○	○	—
	Seeding rate	90–720 g/m²	90 g/m²	×	○	○	×	○	○	Low rate[4,6]
	Nursery period	17–45 days	45 days	○	○	○	×	○	○	Mature seedlings of 40–50 days
	Light intensity	0–65% shading	No shading	×	○	○	△	○	○	No shading
	Air temperature(8)	18–30°C (daytime)	24°C (daytime)	△	○	○	△	△	○	Air temp. 21–31°C[1–3] water temp. 16°C
Artificial hardening	RH-531 treatment	0–200 ppm	200 ppm	○	△	○	○	○	○	< 100 ppm
	Wind treatment	0–2 m/sec	2 m/sec	○	△	○	○	○	△	1 m/sec

(1) Rig.=rigid, (2) Thic=well thickened, (3) Bu.I.=buckling intensity increased, (4) Pl=small plant height and low gravity-centre, (5) Bu.R.=buckling resistance increased, (6) Be.R.=bending resistance increased, (7) Samples were taken after the same nursery period, (8) Samples were taken at the same leaf age, (9) Box=seedling box, (10) Night temperature was kept 15°C, (11) Split application with emphasis on basal dressing

○: Postive effect (improved physical character) observed

×: Negative effect observed

△: No effect observed

Figures in parenthesis in the rightmost column indicate reference number

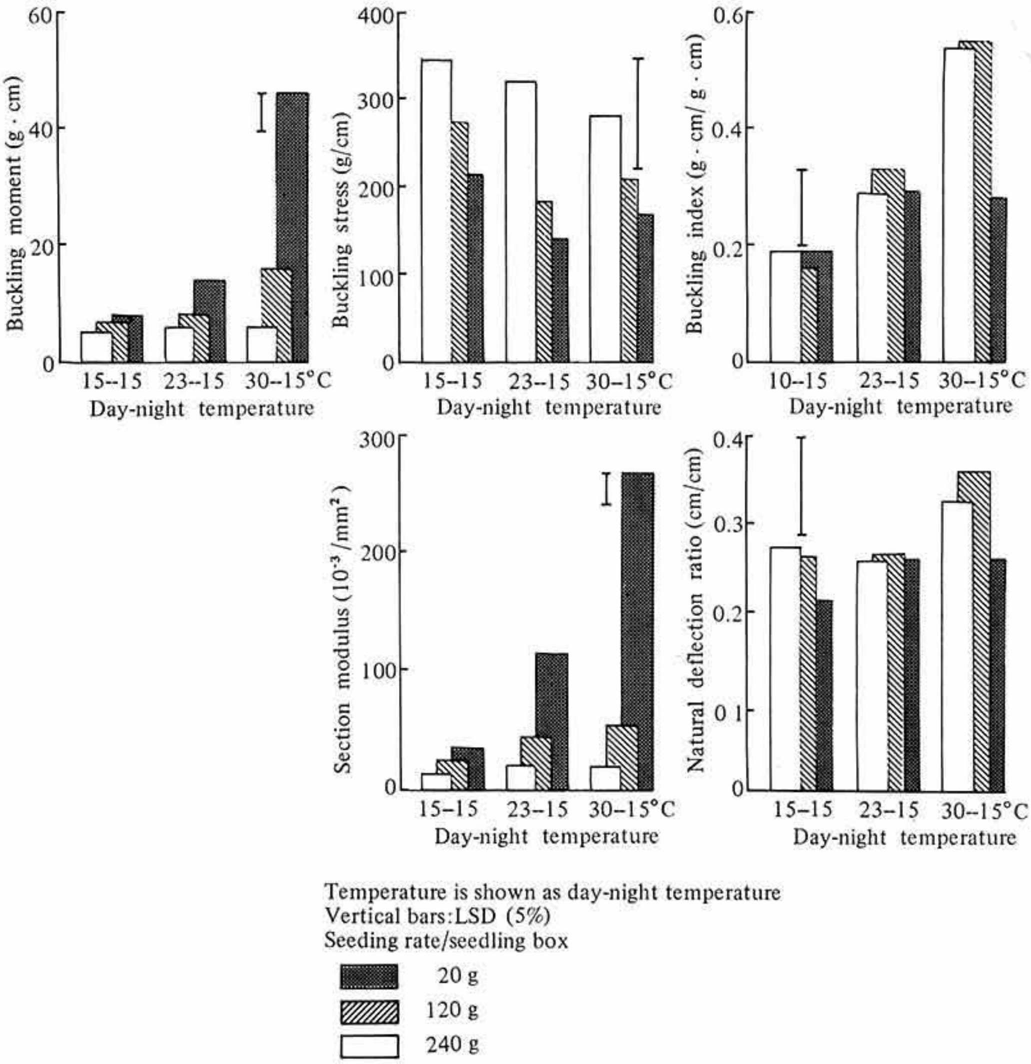

Fig. 1. Effect of air temperature on physical characters of seedling (sampled after the same nursery period)

between these two factors: e.g. the thicker the basal portion, the less rigid it is. To increase the buckling intensity, treatments of the growth retarding type placed emphasis on increasing the rigidity, those of the thickening promotion type on increasing the thickness, and the artificial hardening type attempted to break the negative correlation by artificial treatments.

1) Growth retarding type

By retarding seedling growth, the basal portion of tops was made to be more rigid, and buckling resistance and bending resistance of whole seedling were increased. Upland nursery (nursery without submerging irrigation), split application of reduced amount of nitrogen fertilizer, reduced rate of potassium application, decreased air temperature (Fig. 1) and dry soil are the conditions belonging to this type. However, in all these cases, buckling intensity of the basal portion of tops was rather decreased,* although buckling resistance of seedling as a whole was consistently increased.

* As already mentioned, rigidity is not the only factor contributing buckling intensity.

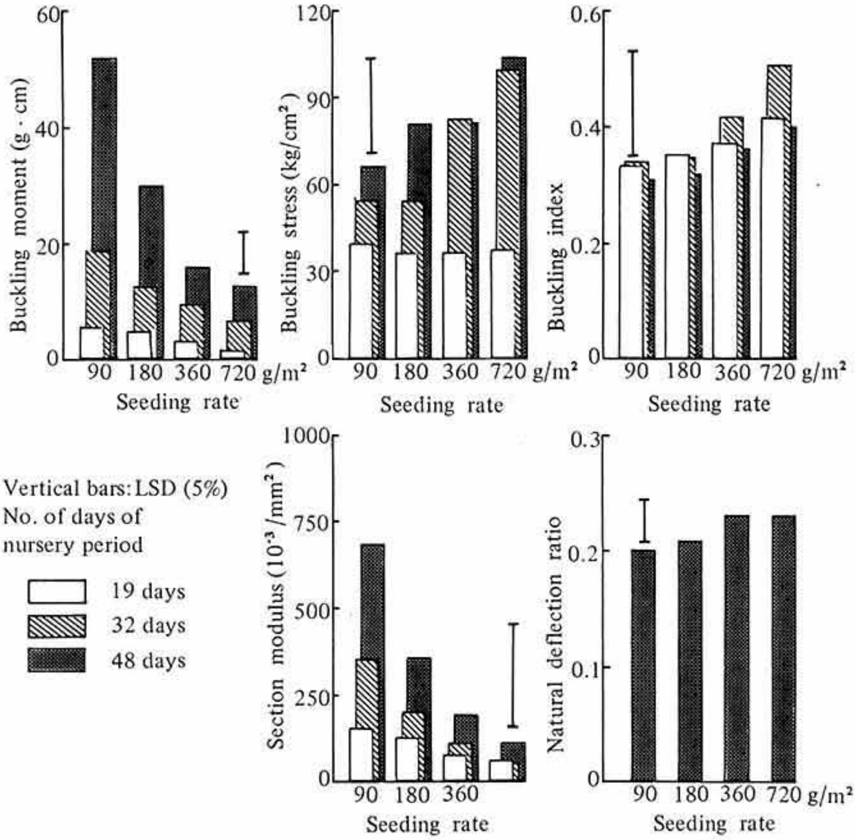

Fig. 2. Effect of seed rate on physical characters of seedlings

2) Thickening promotion type

In this type, the thickening of basal portion of tops was positively promoted by increasing dry matter production, and hence buckling intensity of the basal portion of tops was increased, resulting in the increased buckling resistance and bending resistance of seedling as a whole. Use of lodging-resistant varieties, low seeding rate (Fig. 2), longer nursery period, use of natural sunlight for nursery, and air temperature of 24°C for daytime and 18°C for night time are all the conditions belonging to this type. However, in some cases, the basal portion of tops becames to be less rigid.

3) Artificial hardening type

In this type, rigidity and buckling intensity of the basal portion of tops were increased by some artificial treatments such as the use of growth regulator, RH-531 (Fig. 3), or the treatment with strong wind. As a result, buckling resistance and bending resistance of seedling as a whole were increased. This type is different from the growth retarding type in that the thickening of the basal portion was not retarded, although the rigidity was increased. In the latter type, rigidity of the basal portion was increased, but the thickening of that portion was not enough.

Thus, the specific conditions effective in improving physical quality of seedlings were made clear. Then, these conditions were compared with the specific conditions effective in improving physiological property of seedling. The latter is shown in the last column of Table 2, in which results obtained by the present study or reported by other workers are listed. The comparison shows that the latter coincides approximately to the former. However, it

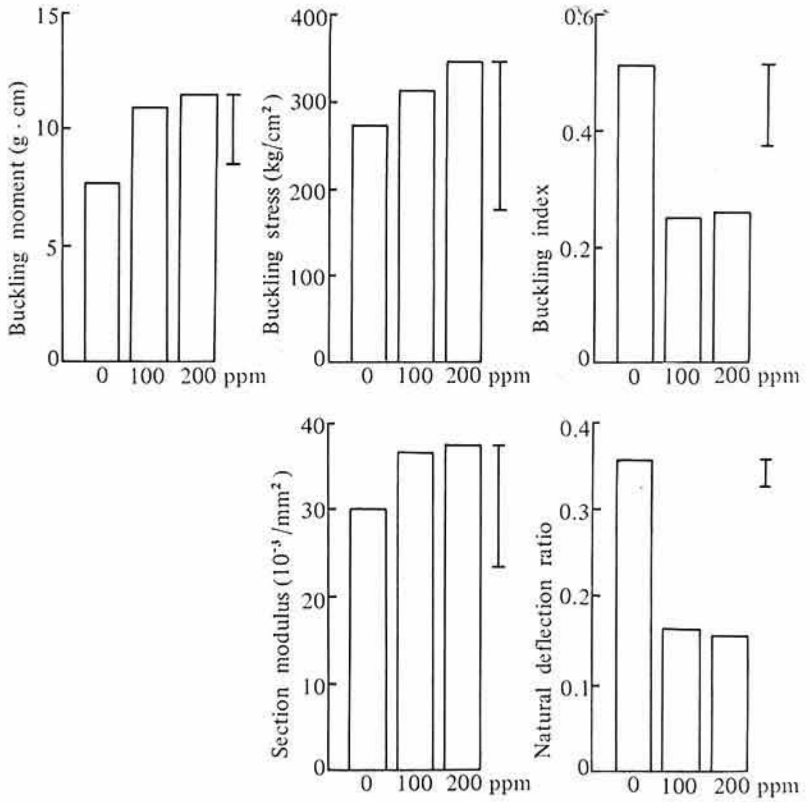

Fig. 3. Effect of plant growth regulator, RH-531, on physical characters of seedlings

seems that the conditions effective in improving physiological property of seedlings are obtained at more or less moderate treatments as compared with the conditions effective in improving physical quality of seedlings in case of the treatments of artificial hardening type and growth retarding type. For example, slightly less growth retardation was appropriate as the condition for improving physiological property than for improving physical quality in the growth retarding type of treatments.

Namely, it can be said that the conditions of growing seedling for better physical quality are generally the ones for better physiological property. However, severe growth retardation by the treatments of growth retarding type, or too much intensive treatments of the artificial hardening tends to cause poor physiological property.

Based on the results of this study, it can be concluded that the combination of treatments of the thickening promotion type, taken as the major factors, is most effective as the method of growing seedlings which have both superior physical quality and superior physiological property. If necessary, some treatments of the growth retarding type may be added.

References

1) Hoshino, M. et al.: Analysis of yield-determining process and its application to yield-prediction and culture improvement of lowland rice. LXXXVIII. Combined effects of air temperature and water temperature in seedling periods on the characteristics of seedlings of rice plants. *Proc. Crop. Sci. Soc. Japan*, **38**, 273–278 (1969) [In Japanese with English summary].

2) Hoshino, M. et al.: Analysis of yield-determining process and its application to yield-prediction and culture improvement of lowland rice. LXXXIX. Rooting activity of seedlings grown under the conditions of various combinations of air temperatures and water temperatures when they are transplanted under the conditions of various combinations of air temperatures and water-tempera-

tures (2). *Proc. Crop Sci. Soc. Japan*, **38**, 279–286 (1969) [In Japanese with English summary].

3) Hoshino, M. et al.: Analysis of yield-determining process and its application to yield-prediction and culture improvement of lowland rice. XCIII. Effects of different temperature conditions and fertilizing conditions during a nursery period on the growth and characteristics of rice seedlings. *Proc. Crop Sci. Soc. Japan*, **40**, 197–203 (1971) [In Japanese with English summary].
4) Kondo, Y.: Performance of rice seedlings grown at low seeding rate. *Nogyo oyobi Engei*, **19**, 513–517 (1944) [In Japanese].
5) Miyake, S., Ogawa, A. & Omura, H.: On the application of fertilizers to young seedlings of rice plant. *Bull. Tochigi Agr. Exp. Sta.*, **15**, 21–28 (1971) [In Japanese].
6) Sato, K.: Studies on rooting activity of rice plant. *J. Agr. Lab. Central Res. Inst. Electric Power Industry, Japan*, **3**, 1–74 (1962) [In Japanese with English summary].
7) Hirasawa, N. et al.: On the use of the 4-leaf stage seedlings on late-planting culture of paddy rice. *Bull. Ibaragi Agr. Exp. Sta.*, **16**, 1–20 (1975) [In Japanese].
8) Yamada, N. & Ota, Y.: Physiological quality of rice seedlings. 1. Seedlings grown in upland- and lowland-nurseries. *Nogyo-gijutsu*, **12**, 13–15 (1957) [In Japanese].

(Received for publication, October 14, 1980)