STUDY ON RICE ROOT CHARACTERISTICS IN SEEDLING STAGE [1)]

Soemartono [2)]

RINGKASAN

Untuk mengetahui apakah tekanan air pada fase perkecambahan dapat digunakan untuk menilai toleransi terhadap kekeringan, dibuat simulasi tekanan air (moisturestrees) dengan menggunakan larutan Poly Ethylene glycole (Carbo wax 6000).

Dalam penelitian ini diuji 8 varietas padi yang mewakili berbagai tingkatan toleransi terhadap kekeringan.

Dua puluh lima butir padi untuk tiap varietas dikecambahkan pada gulungan "blotter paper" dan diletakkan tegak dengan sudut $\pm 60^{o}$ pada cawan-cawan petri yang telah diisi larutan polyethylen glycol dengan tekanan osmose −2,8 bars dan air suling. Kemudian cawan-cawan petri ini diletakkan dalam "germinator" pada suhu 32^{o} C. Dalam penelitian ini digunakan pola "Randomized Complete Block" dengan 4 ulangan.

Hasil-hasil penelitian adalah sebagai berikut :

1. Ada hubungan antara penilaian toleransi terhadap kekeringan yang berdasarkan kekeringan daun, dan yang berdasarkan drajat penggulungan daun, kekeringan daun dan hambatan pertumbuhan.
2. Ada hubungan yang lebih erat antara sifat perakaran dengan nilai toleransi kekeringan berdasar kekeringan daun, drajat penggulungan dan hambatan pertumbuhan daripada nilai toleransi yang hanya berdasar kekeringan daun.
3. Dalam waktu 10 hari sesudah perkecambahan, perbedaan sifat perakaran antar varietas dapat diamati lebih jelas di bawah kondisi air suling daripada di bawah kondisi tekanan terhadap air.
4. Dalam waktu 10 hari sesudah perkecambahan, makin lambat pengamatan, makin jelas dapat dilihat adanya perbedaan sifat perakaran antar varietas.

SUMMARY

To study whether moisture strees condition in germination stage could be used to determine drought tolerance of rice varieties, a simulation of moisture strees was applied by using Poly Ethylene Glycol solution (Carbowax 6000).

In this study, 8 varieties rice representing different level of drought tolerance were used.

Twenty five seeds of each variety were germinated by putting seed in between rolled blotter paper and placed on the petridishes filled with distilled water and poly ethylene glycole solution respectively.

---

1) An appendix of the major research entlited "Pulling force and its relationship with root characteristics of the rice plant in seedling stage" in Agric. Sci. 2 (2) 1977.

2) Dept. of Agronomy, Fac. of Agriculture Gadjah Mada University Yogyakarta.

Rolled blotter papers were placed on the petridishes at about 60^{o} angle and kept in the germinator at $32^{o}C$.

Randomized Complete Block Design with 4 replications were used in the experiment.

The following are the results of the experiment :

1. There was a relationship between field drought tolerance rating based on desiccation evaluation and rating based on leafrolling and unfolding, dead of leaf and degree of stunted growth.
2. There was closer relationship between root characteristics in the early seedling stage with field drought tolerance rating based on leaf rolling and unfolding, dead leaf and degree of stunted growth than rating based on leaf desiccation.
3. Within 10 days after germination, differences of root characteristics among of the varieties could be detected more clearly under distilled water condition than under simulated strees condition.
4. Within 10 days after germination, later in conducting measurement, more helpful in detecting the differences of root characteristics among of the varieties.

Introduction

Many research workers consider that upland rice is very important recently. This statement is supported by the fact that there was appointed in the International Rice Research Institute at Los Banos, Philippines, the largest Rice Research Institute in the world, a genetic evaluation and utilization drought resistance team who will be responsible for the improvement of upland rice yield in this Institute.

Many research workers also realize that breeding for the drought resistance are not easy. Some research workers might be skeptic in fasing this problem. This statement is supported by the paper of E.A. Hurd entitled "Can we breed for drought resistance.?, Fortunately, that he answers his own question with "Yes".

One of the major problems in drought resistance breeding is the scarcity of simple screening method for that character.

The objective of this study is try to solve the problem by studying the relationship between field drought tolerance rating and root characteristics in the early seedling stage.

This experiment is an appendix of the major experiment conducted at the International Rice Research Institute by the author, during his stay in this Institute under the supervision of Dr. J.C. O'Toole. Assosiate Agronomist at the Agronomi Department of this Institute.

For his invaluable guidance, the author wishes to express his sincere gratitude and appreciation to him.

Literature Review

Thin stands in the field can generally be attributed to adverse soil moisture conditions during germination and early seedling stages. Establisment may be related to the ability of the seeds to germinate under a given moisture strees (Dotzenko and Dean, 1951).

Kaul (1966) stated that theoretically water strees can be induced by interfering with water uptake, even when water is abundant by increasing the osmotic pressure of nutrient solution like mannitol, sugar, and salt. But most of them have serious disadvantages because they are subject to microbiological decomposition and affect plant metabolism.

Recently, P.E.G. (Poly Ethylene Glycol) as osmotic agent under the name carbowax is much better than substances mentioned earlier because of its inert, stable, is taken up in small amount by plant.

Kaul's statement was supported by Copeland (1976) and said that high osmotic pressure of the germination solution make inhibition more difficult, and retard germination and the ability of seed to germinate under high osmotic pressures differ with variety as well as with species.

The last statement also agrees with fryxell, who said that osmotic value of mature plant is genetic trait and external factor affect this characteristic (Fryxell, 1954).

Levitt (1972) stated that the ability of seed to germinate under high osmotic concentration, or low osmotic potential sometimes related, but some resent attempt proves that there is no relation with drought resistance. This statement agrees with the result of Wiggans and Gardner's experiment. In their experiment using glucose, sucrose, Na Cl, D. mannitol and P.V.C., they concluded that radish germination was almost identical to the best of the sorghum varieties they used in the experiment, even though differences between sorghum and radish with respect to drought resistance in the field was obvious (Wiggans & Gardner, 1951).

On the other hand, Parmar and More (1966) reported that aqueous solution of Poly Ethylene Glycol at 8 and 10 atm osmotic pressure were beneficial in studying the effects of simulated drought condition.

If the ability to germinated at high osmotic pressure is heritable, and heritability is high and closely associated with drought tolerance, a simple method of screening large number of breeding lines is available.

So there are still too many more experiments conducted, to study whether there is a relationship between the ability to germinate and grow under high osmotic pressure and drought tolerance (William et al., 1967; Rodger et al., 1957; Prisco & O'Leary, 1970; Sharma, 1976).

This experiment is to study whether there are significant difference among varieties on root characteristics in early seedling stage, both under distilled water and high osmotic pressure solution.

Materials and Methods

The following 8 varieties probably vary in drought tolerance were used in the experiment (Pls. see attached table, p. 209).

Seedling stage in this study means period from initial embryo germination up to the stored food reserve of the seed have been depleted. In rice, this stage is about the first 14 days after germination.

Two experiments conducted in this study, i.e. germination under distilled water and under about -2.8 bars osmotic potencial of Polyethylene glycole (Carbowax 6000) solution.

Twenty five seeds of each variety were germinated by putting seed in between rolling blotter paper, and plased on the petridishes which were filled with distilled water, and poly ethylene glycole solution, respectively.

Rolled blotter papers were placed on the petridishes at about 60^{o} angle and kept in the germinator at 32^{o} C. At possition like this, the root will grow straight down and are easy to measure.

To avoid fungi contamination, captex (copper fungicide) was used in the solution at rate 2 gram per 200 ml of distilled water, and PEG solution.

Randomized complete block design with 4 replications was used. Varieties were randomized within each block (location in the germination i.e. upper inside, upper outside, below inside, and below outside). Because of many seeds did not germinate at location below inside, this location/replication was dropped from the experiment.

Origin and parents of varieties used in the experiment and their drought tolerance rating.

Variety	Parents/Origing	Drought tolerance rating	
		Plant Breeding*	Agronomy*
Palawan	Lokal upland rice from the Philippines	2	5
IR 20	IR 262/24/3 x TKM 6	4	7
IR 1529/680/3	IR 24/Sigadis[2]/TNI	3	6
IR 1529/430/3	Ibid	4	6
OS 4	Lokal upland from Afrika	1	5
C 22	Improved upland rice from the UPLB	3	6
IR 26	IR 24 x TKM 6	3	4

* 1–2, R; 3–4, MR; 5, I; 6–7, MS; 8–9, S; Source of data : Dr. J.C. O'Toole

** Average of −2, −4, and −10 bars strees; 1 = none to slight effect of strees; 9 = all plants apparently dead; Source of data : Pablo Vicencio.

Each observation was average of 4 seedling measurement.
Observation was conducted at 5 days and 10 days after germination. Observation was done only twice because many seedlings were yellowing already at 11 days after germination.

Data to be collected were root length, root number, root weight, root to shoot ratio, and root branching.

Objectives of the study were as follows :

1. To determine whether there are assosiation between field drought tolerance rating and root characteristics in the early seedling stage. To answer this question, correlation coefficients between drought tolerance rating done by both Agronomy Department and Plant Breeding Department of IRRI, and root characteristics at the first observation and the second observation as well were computed.

2. To determine which one is the best between the two dates of observation, to measure root characteristics, in order to detect differences among the varieties most clear. To answer this question, coefficient of variation and varietal variance to total variance ratio were computed far each date of observation.

3. To determine the effect af strees upon root characteristics. To answer this question, analysis of variance were computed also far two experiments and two dates of observation separately. To compare the 2 conditions, i.e. under distilled water and osmotic strees, tests were used based on the average over 3 replications and 8 varieties.

RESULTS AND DISCUSSION

1. Correlation between field drought tolerance rating and root characteristics

From Tables 1. 2. 3. and 4. it was observed that there was agreement between rating done by Agronomy and Plant Breeding Departments of IRRI, even not significant (r were .459 and .522 for the first and the second experiments, respectively).

There were not significant correlation between root characteristics and field drought tolerance rating done by Agronomy Department, both under distilled water condition, and under osmotic strees at the first observation as well as at the second observation, while correlation coefficient between Plant Breeding's rating in relation with root characteristics might be caused by different concept. Agronomy's rating was based on desiccation evaluation only, Plant Breeding's rating was based on several symtoms as leaf rolling and unfolding, dead leaf, and degree of stunted growth.

Correlation between field drought tolerance rating done by Plant Breeding's Department and root characteristics, were most significant at the second observation than the first observation, under both strees condition and distilled water condition, and more significant correlation under distilled water condition than under strees condition, at both the first and the second observations. At the second observation, a all of root characteristics showed significant correlation with Plant Breeding's rating under distilled water condition, while under strees condition only 2 of 5 root characteristics showed significant correlation.

It seems that within 10 days after germination was not enough time for the drought tolerance variety to adjust its growth under stress condition, so what was happening within 10 days after germination under stress was only irregularity in growth for both drought tolerance and susceptible varieties. And the result was that, the differences in root characteristics which could be detected clearly under distilled water condition, could not be detected under stress condition, as reflected by the number of significant correlation under stress was lower than under distilled water condition.

The conclusion was, in clearly germination stage, in this case, within 10 days after germination, distilled water condition or normal condition of germination, can detect differences in root characteristics more clear than under stress condition.

2. Coefficient of variation and varietal variance to total variance ratio

The coefficient of variation and varietal variance to total variance ratio were used as criteria to determine between two dates of observation which one was the best time to detect the differences of root characteristics among the varieties.

From Table 5 and 6, it can be observed that under distilled water condition, increasing of varietal variance to total variance ratio and decreasing of coefficient of variation from the first observation to the second observation, more regular than under stress condition.

Again this result showed that what was happening within 10 days after germination under stress condition was irregularity in growth.

Most of the lowest coefficient of variation and most of the largest varietal variance to total variance ratio under distilled water condition were located at the second observation, or 10 days after germination. It means that within 10 days after germination, the second observation is better than the first observation in detecting differences in root characteristics more clear.

3. Effects of the stress condition upon root characteristics

Effect of the stress condition upon root characteristics, specificaly in clearly seedling stage can be observed in Tables 7 dan 8.

It was observed from Table 7 that all of root characteristics were significantly different under distilled water condition at the second observation, while under stress condition were only two significant difference. Again this fact reflects under distilled water/normal condition within 10 days after germination, the differences in root characteristics among the varieties can be detected more clearly than under stress condition.

From Table 8, it can be observed that root length was stimulated by the stress, while root number, root branching, and root weight were retarded by the stress.

Even though root weight was lower under stress (it is probably caused by lower in branding and number), the root to shoot ratio was higher under stress. It means that the root growth was more retarded than root growth under stress.

CONCLUSION

1. There was a relationship between field drought tolerance rating based on desiccation evaluation (Agronomy Department) and rating based on leaf rolling and unfolding, dead leaf and degree of stunted growth (Plant Breeding Department).
2. There was more close relationship between root characteristics in the early seedling stage with field drought tolerance rating done by Plant Breeding Department than by Agronomy Department.
3. Within 10 days after germination, differences of root characteristics could be detected more clearly under distilled water condition than under simulated stress condition.
4. Within ten days after germination, later inconducting measurement, more helpful in detecting the differences of root characteristics among the varieties.

ACKNOWLEDGEMENTS

This research was done at IRRI and sponsored by the Gadjah Mada – Rockefeller Foundation staff development project.

The author wishes to express his sincere gratitute and appreciation to above mentioned Institutes, and to his adviser, Dr. J.C. O'Toole, associate Agronomist of IRRI for his invaluable guidance during the course of training at IRRI.

LITERATURE CITIED

Dotzenko, A.D. and Dean, J.G. (1951) Germination of six alfalfa varieties at three levels of osmotic pressure. Agron. J. 51 : 308 – 309.

Copeland, L.O. (1976) Principles of seeds science and technology. Burgess Publishing Co., Minneapolis, Minn. 369 p.

Fryxell, P.A. (1954) A prosedure of possible value in Plant Breeding. A Agronomy. 46 : 433 – 434.

Kaul, R. (1966) Relative growth rates of spring wheat, oats and barley under polyethylene glycol induced water stress. Can. J. Pl. Sci. 46 : 611 – 617.

Levitt, J. (1972) Responses of plant to environmental stress. Academic Press, London.

Parmar, M.T. and More, R.P. (1966) Effect of simulated drought by polyethylene glycol solution on corn. Agron. J. 58 : 391 – 392.

Prisco, J.T. and O'Leary, J.W. (1970) Effect of salt and water stress on protein syntesizing capacity of embryo axis of germinating *Phaseulus vulgaris* L. seeds. Rey. Brazil Biol. 30 (2) : 317–321.

Rodger, et al. (1976) A rapid method for determining winter hardiness in alfalfa. Agron. J. 49 : 88–92.

Sharma, H.L. (1976) Interaction of water potential and temperature effects on germination of three semi-arid plant species. Agron. J. 68 : 390 – 394.

Wiggans, S.C. and Gardner, F.P. (1959) Effectiveness of various solution for simulating drought conditions as measured by germination and seedling growth. Agron. J. 51 : –.

William, T.V. et al. (1976) Method in measuring drought tolerance in corn. Crop Sci. 7 : 179–182.

Table 1. Correlation matrix between drought tolerance rating and root characteristics under distilled water condition at the first observation.

	FR–PB 1	R/S 2	RW 3	RL 4	RN 5	RB 6	FR–AG 7
FR–PB	–	–.725*	+.448	–.403	+.807*	+.321	+.459
R/S		–	–.024	+.372	–.377	–.171	–.426
RW			–	–.335	+.673	+.697	+.008
RL				–	–.717*	–.753*	–.587
RN					–	+.714*	+.483
RB						–	+.078
FR–AG							–

Table 2. Correlation matrix between field drought tolerance rating and root characteristics under distilled water condition at the second observation.

	FR–PB 1	R/S 2	RW 3	RL 4	RN 5	RB 6	FR–AG 7
FR–PB	–	–.744*	–.905*	+.924**	–.931**	–.891**	+.459
R/S		–	+.527	+.573	–.671	+.665	–.359
RW			–	+.941**	–.858**	+.921**	–.351
RL				–	–.854**	+.908**	–.543
RN					–	–.883**	+.470
RB						–	–.323
FR–AG							–

FR–PB : Field rating by Plant Breeding Dept.
R/S : Root-to-shoot ratio
RW : Root weight
RL : Root length
RN : Root number
RB : Root branching
FR–AG : Field rating by Agronomy Dept.

Table 3. Correlation matrix between field drought tolerance rating and root characteristics under stress condition at the first observation

	FR–PB 1	R/S 2	RW 3	RL 4	RN 5	RB 6	FR–AG 7
FR–PB	–	+.109	–.076	–.780*	+.319	+.142	+.459
R/S		–	–.207	+.222	–.032	+.002	+.342
RW			–	+.255	–.008	+.442	+.138
RL				–	+.148	+.360	–.133
RB					–	+.816*	+.234
RN						–	+.192
FR–AG							–

r.. 05 (6 df) : .707 r .01 (6 df) : .834

Table 4. Correlation matrix between field drought tolerance rating and root characteristics under stress condition at the second observation.

	FR–PB 1	R/S 2	RW 3	RL 4	RN 5	RB 6	FR–AG 7
FR–PB	–	–.674	–.483	–.833	+.774*	–.281	+.522
R/S		–	+.121	+.420	–.671	+.033	–.189
RW			–	+.780*	+.144	+.888**	–.086
RL				–	–.410	+.599	–.300
RN					–	+.327	+.584
RB						–	–.055
FR–AG							–

Table 5. Coefficient of variation and varietal variance to total variance ratio of root characteristics under distilled water condition.

Root Characteristics	C.V. (%)		σ_v^2 / σ^2 Total (%)	
	1st Obs.	2nd Obs.	1st Obs.	2nd Obs.
Root to shoot ratio	*7.3*	10.4	*52*	46
Root length	16.7	*14.4*	0	*45*
Root number	21.9	*14.9*	66	*68*
Root branching	15.2	15.0	43	51
Root weight	14.4	*8.0*	15	*70*

Table 6. Coefficient of variation and varietal variance to total variance ratio of root characteristics under stress.

Root Characteristics	C.V. (%)		σ_v^2 / σ^2 Total (%)	
	1st Obs.	2nd Obs.	1st Obs.	2nd Obs.
Root to shoot ratio	42.9	53.7	13	22
Root length	7.1	13.5	86	62
Root number	25.1	31.9	54	31
Root branching	31.5	25.6	37	33
Root weight	62.8	23.3	0	45

Table 7. F calculated of treatment/variety of root characteristics at the first and second observation under distilled water and under stress condition.

Root Characteristics	Under distilled water		Under stress	
	1st Obs.	2nd Obs.	1st Obs.	2nd Obs.
Root to shoot ratio	4.31**	3.60*	1.44^{ns}	1.84^{ns}
Root weight	1.46^{ns}	7.84**	1.00^{ns}	3.50*
Root length	0.95^{ns}	3.44*	19.74**	5.86**
Root number	6.85**	7.52**	4.59**	2.32^{ns}
Root branching	3.26*	4.16*	2.72^{ns}	2.51^{ns}

F .05 (14 df) : 2.77 F 0.01 (14 df) : 4.28

Table 8. Differences in root characteristics under both distilled water and stress condition***.

Root Characteristics	Under distilled water	Under stress	Difference
	1st Observation		
Root to shoot ratio	910.5	2188.0	1277.5**
Root length (cm)	4.5	6.0	1.5**
Root number	5.0	2.0	– 3.0**
Root branching	2.8	1.5	– 1.3**
Root weight	0.0023	0.0015	– .0008**
	2nd Observation		
Root to shoot ratio	799.1	1904.0	1104.9**
Root length (cm)	6.2	7.7	1.5
Root number	7.0	3.7	– 3.3**
Root branching	3.6	3.0	– .6^{ns}
Root weight	0.004	0.0033	– .0007*

*** Averaged over 3 replications and 8 varieties.