

Root Morphological Characters at Several Distances from Irrigated Trench in Rice Varieties Grown under Rain-fed Conditioned Plots

by Reinaldi 06

FILE	ROOT MORPHOLOGICAL CHARACTERS AT SEVERAL DISTANCES FROM IRRIGATED TRENCH IN RICE VARIETIES GROWN UNDER RAIN-FED CONDITIONED PLOTS .PDF (349.26K)	WORD COUNT	3433
TIME SUBMITTED	07-APR-2019 06:11PM (UTC+0700)	CHARACTER COUNT	17102
SUBMISSION ID	1107362696		

Root Morphological Characters at Several Distances from Irrigated Trench in Rice Varieties Grown under Rain-fed Conditioned Plots

Asia Arifin¹, Rinaldi Sjahril^{2*}, Muhammad Riadi², Naoya Arita³, Akira Miyazaki⁴

¹ Master Degree Student, Agro-technology Study Program, Faculty of Agriculture, Hasanuddin University, Makassar, Indonesia

² Department of Agronomy, Faculty of Agriculture, Hasanuddin University, Makassar, Indonesia

³ Master Degree Student, Agricultural Science, Graduate School of Integrated Arts and Sciences, Kochi University, Kochi Prefecture, Japan

⁴ Faculty of Agriculture and Marine Science, Kochi University, Kochi University, Japan

* Corresponding author's E-mail: rinaldi.sjahril@gmail.com

How to Cite: Arifin, A., Sjahril, R., Riadi, M., Arita, N., and Miyazaki, A. (2018). Root Morphological Characters at Several Distances from Irrigated Trench in Rice Varieties Grown under Rain-fed Conditioned Plots. *Int. J. Agr. Syst.* 6(1): 82-88

ABSTRACT

In rain-fed area, water deficit or drought stress is a serious limiting factor to rice production and yield stability, and root system with deep roots is one of the most important characters. This study aimed to identify which root morphological characters induce the advantage of the deep rooting between varieties. Six varieties consisting of two groups of ecosystems, upland: NERICA1, NERICA4, NERICA7, Yumenohatamochi, and lowland: Hinohikari and Koshihikari were grown under the rain-fed condition in the field of Kochi University. The results suggested the adaptability of NERICA varieties to the upland rainfed conditions, due to the development of roots into the deep soil layer. NERICA7 had lowest soil moisture content and had a higher root weight, root surface area, root length and the number of root branching in the deep soil layer at heading stage. NERICA7 also had higher value on dry weight, surface area and thickness in total amount of root morphological characters. Varietal difference of root surface area in the deep soil layer was related to both root length and thickness, and root length was involved with root branches. On the other hand, the varietal difference of total amount of root surface area was related not to the root length, but to the root thickness. This result suggested that the emergence of the thick roots (probably primary crown roots) allowed the roots to penetrate into the deep soil layer. Therefore, it is considered that the emergence of thick roots is an important trait for the deep rooting character.

Copyright © 2018 IJAS. All rights reserved.

Keywords:

rice; irrigated-trench; root morphological characters; rain-fed

1. Introduction

The main obstacles to cultivation in rain-fed land are very low water availability and large fluctuations in groundwater content. This has an impact on stunted growth and development of plants, both physiological and morphological and biochemical processes so that crop production also decreases.

Macleán *et al.*, (2002) estimated that about one-third of the world's rice production area is a lowland rain-fed area and most are prone to drought. Addressing this issue should be an important part of a breeding program aimed at crop improvement. The adaptive mechanisms of plants in response to drought have been reported by several scientists (Fukai and Cooper, 1995; Nguyen *et al.*, 1997; Chaj and Sinha, 1998; Ndjiondjop *et al.*, 2010; Abdallah *et al.*, 2016). The rooting system is one of the important components of drought resistance. Among the root morphological characters, root length and root thickness are important characters associated with drought resistance in upland conditions (Ganapathy *et al.*, 2010).

Increasing the thickness of the roots can increase the resistance to drought because the roots can increase root length density, root surface area, and water uptake by producing more and larger root branches. In lowland rain-fed conditions, long root densities greater than 20 cm and rapid root responses to alter soil moisture levels in soil layers 10-20 and 20-30 cm are common root characters for drought resistant genotypes (Ingram *et al.*, 1994). However, roots are usually distributed in shallow soil layers in lowland rain-fed areas, possibly due to the presence of a hard and watertight soil layer that inhibits deep rooting. The groundwater extraction is confined to the soil layer where root penetration occurs. Thus, in lowland rain-fed with the presence of hard and watertight soil layers, the development of a root system above the coating is important for water absorption by plants (Kameoka-Nakata *et al.*, 2013).

The root development has been evaluated under different soil moisture conditions in sloping system (Kameoka *et al.*, 2015) and sprinkler system (Kameoka *et al.*, 2016). In this study, we used furrow irrigation system to compare rice varieties under different soil moisture conditions.

Based on the description, we have conducted a set of research on root morphological change at several distances from irrigated-trench in six different rice varieties grown on rain-fed conditioned plots.

2. Materials and Methods

Six rice varieties consisting of two groups of ecosystems. The upland ecosystem consisted of the NERICA1 (N1), NERICA4 (N4), NERICA7 (N7), Yumenohatamochi (YH) rice varieties, and Hinohikari (HH) and Koshihikari (KH) rice varieties for the low land ecosystem. They were grown in plots under rain-fed condition in the experimental field of Kochi University, Monobe Campus, Kochi Prefecture, Japan.

Seeds were sown directly on May 23, 2016 at a rate of 5 seeds per hill (Bhowmik *et al.*, 2012), with a spacing of 30 x 10 cm on a plot measuring 2.6 m x 4.1 m. Fertilizer (N:P:K = 14:14:14, 40 kg ha⁻¹) was applied at 29 days after sowing (DAS). The irrigation systems were made by a small dugout trench (5 cm wide, 15 cm deep) in the center of the plots, and were manually implemented by giving water to the trench once every two days, starting from 43 - 116 DAS, except for rainy days. Shoot samples were collected at heading and maturity periods with distance of 20, 40, 60 cm from the center trench and separated into each organ. In addition, at heading stage, the remaining roots for each hill were extracted using a soil core (11.5 cm in diameter, 15 cm in height) separated for each 5 cm in depth. Root length, root surface area and root branching was determined using software (WinRHIZO, Regent). All the separated parts were dried in the oven at 80°C for three days, and then the constant dry weight was measured. Soil moisture content with distance of 20, 40, 90 cm from the center

trench was measured using soil moisture meter (TDR-100, FieldScout). An analysis of variance (ANOVA) and Tukey's honest significant difference (HSD) procedure using JMP for windows version 7.0 was performed to determine the response of variety and distance.

3. Results and Discussion

Soil moisture content was significantly higher in 20 cm than in 40 and 90 cm distance from trench crossing in the middle of each plots. There was a significant difference in soil moisture between varieties, and N7 had the lowest soil moisture content between varieties (Figure 1). This results suggested that water uptake of N7 was higher than another varieties. As Trillana *et al.* (2001) reported, lower soil moisture shown higher water uptake of IRAT13.

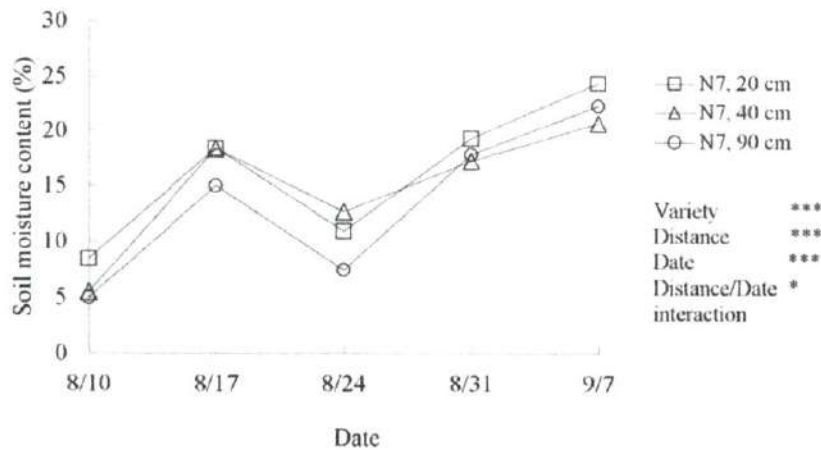


Figure 1. Soil moisture content condition at 20, 40 and 90 cm distance from NERICA7 (N7) plants. The symbols * and *** indicates significance at $P < 0.05$ and $P < 0.001$

Significant differences between varieties were shown in root morphological characters of the deep soil layer at heading stage, and upland rice varieties (N7, N4, N1, and YH) had a higher root weight, root surface area, root length and the number of root branching than those in lowland varieties (HH and KH) (Table 1). However, the effect of distance on root morphological characters was not significant. There was a significant interaction between the variety and distance on root weight, root surface area, root length and root branching, but not in root thickness and deep root length ratio. This suggests that the effect of the distance was different between varieties. Kono (1993) explains that the roots tend to penetrate deeply with a decrease in soil water content. The tendency to penetrate to the soil layer by nodal roots is known as the deep-rooted characteristics, which are governed by genetic factors. However, changes can occur in these characteristics, depending on soil factors, especially water conditions, even on the same cultivar. Nazirah (2008) also reported that the growth of each variety varies under the same environmental conditions because each variety has a different genetic ability to respond to its environmental conditions.

Table 1. Root morphological characters (plant⁻¹) in the deepest soil layer only (10 - 15 cm deep)

Treatment	Dry weight (g)	Surface area (cm ²)	Length (cm)	Branch	Thickness (mm)	Deep root length ratio (%)	
Variety (V)	HH	0.06 c	57.4 c	990 bc	8226 bc	0.19bc	16.2 ab
	KH	0.03 c	29.5 c	553 c	4750 c	0.17 c	10.8 b
	N4	0.15 b	109.7 b	1642 b	15433 b	0.22ab	23.9 ab
	N1	0.17 b	116.6 b	1596 b	13432 bc	0.24 a	17.4 ab
	N7	0.30 a	196.8 a	2745 a	27371 a	0.24 a	29.6 a
YH	0.10 bc	72.8 bc	1154 bc	11142 bc	0.20abc	22.6 ab	
Distance (D) (cm)	20	0.13 a	87.4 a	1212 a	10737 a	0.22 a	18.5 a
	40	0.14 a	102.1 a	1559 a	14736 a	0.20 a	21.2 a
	60	0.14 a	101.9 a	1569 a	14705 a	0.20 a	20.6 a
Variety	***	***	***	***	***	*	
Distance	ns	ns	ns	ns	ns	ns	
V x D	*	**	**	**	ns	ns	

Deep root length ratio was calculated as the ratio of root length in 10-15 cm soil depth to total root length. Value with same letter indicates no significant difference at 0.05 level. ns indicates not significant. *, ** and *** indicates significance at P<0.05, P<0.01 and P<0.001.

Table 2. Total amount of root morphological characters (plant⁻¹) for the three layers observed (0 - 15 cm deep)

Treatment	Dry weight (g)	Surface area (cm ²)	Length (cm)	Branch	Thickness (mm)	
Variety (V)	HH	0.60b	408 bc	6306 a	55841a	0.21 b
	KH	0.51b	319 c	5136 a	49282a	0.20 b
	N4	0.96ab	534 abc	6889 a	61167a	0.25 a
	N1	1.35a	748 ab	9332 a	77607a	0.26 a
	N7	1.40a	760 a	9406 a	84111a	0.26 a
	YH	0.79b	447 abc	5685 a	52416a	0.25 a
Distance (D) (cm)	20	0.92a	508 a	6346 a	54066a	0.25 a
	40	0.96a	538 a	7568 a	68787a	0.23 b
	60	0.93a	543 a	7463 a	67358a	0.23 b
Variety	***	**	*	ns	***	
Distance	ns	ns	ns	ns	*	
V x D	ns	ns	ns	ns	ns	

Value with same letter indicates no significant difference at 0.05 level. ns indicates not significant. *, ** and *** indicates significance at P<0.05, P<0.01 and P<0.001.

Similarly, the significant difference between varieties in total amount of root morphological characters was observed, and upland varieties had higher value on dry weight, surface area and thickness than lowland varieties (Table 2). The effect of distance was significant only on thickness, and the root thickness in 20 cm was significantly higher than that in 40 and 60 cm. This result indicates that soil condition in 20 cm from the irrigated-trench suitable for the root development, especially for root diameter (thickness), and variety with thicker root was drought tolerance. Trillana *et al.* (2001) explained that root length density (RLD) and root diameter (thickness) are often used to characterize root system development of rice cultivar and under rainfed lowland condition, RLD in the 10-30 cm layer and the dynamic shedding of roots and root elongation were associated with drought tolerance.

Figure 2 showed root surface area sampled from the deep soil layer was significantly correlated with total root surface area. Root surface area plays an important role in

water and nutrient uptake to support plant growth. Teo (1995) reported that an increase in root length also resulted in an increase in root surface area, thus providing a more open area for nutrient uptake. Gowda *et al.* (2011) also explained that the surface area is the size of the contact with the soil, the main determinant for water and nutrient uptake as the whole root system.

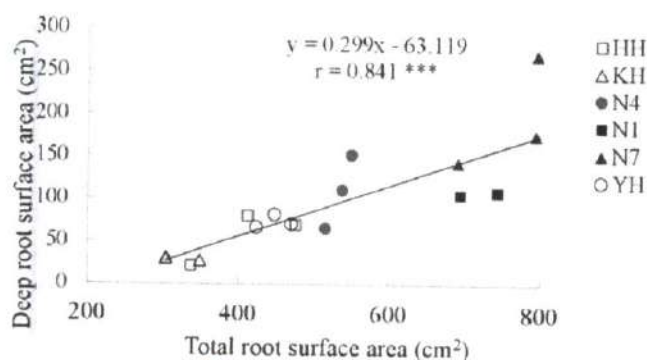


Figure 2. Relationship between total root surface area and deep root surface area at heading stage. The symbol *** indicates significance at $P < 0.001$

Total shoot dry weight was not affected by the variety and distance at the heading stage (Table 3). However, the shoot dry weight in maturity stage was significantly different with varieties, and N4 showed a higher value than KH. This result suggests that N4 was a high-yielding genotype that expressed root plasticity. As stated by Menge *et al.* (2016) under moderate drought soil conditions where roots could penetrate into the deep soil layer, deep root development was greater in NERICA 4 than in NERICA 1, which contributed to maintaining dry matter production.

Table 3. Shoot dry weight (g plant^{-1}) at heading and maturity stage of seven rice varieties planted at three distances from its irrigated trench

Treatments		Shoot dry weight (g plant^{-1})	
		Heading	Maturity
Variety (V)	HH	13.4 a	20.0 ab
	KH	11.6 a	14.4 b
	N4	12.5 a	28.2 a
	N1	13.6 a	20.7 ab
	N7	12.5 a	19.6 ab
	YH	14.1 a	23.1 ab
	20	13.9 a	19.2 a
Distance (D) (cm)	40	13.2 a	21.6 a
	60	17.23 a	22.2 a
	Variety	ns	ns
Distance	ns	ns	
V x D	ns	ns	

Value with same letter indicates no significant difference at 0.05 level. ns indicates not significant.

* indicates significance at $P < 0.05$.

Kameoka *et al.* (2015) also conclude that the genotype that expressed root plasticity with root system developing in the soil portion where more soil moisture was available

showed larger shoot dry weight than a genotype that showed root plasticity in the soil layer where soil moisture was less available. Similar response were also reported, the high-yielding cultivars whose shoot biomass at maturity in aerobic culture was greater than in flooded culture (Katsura *et al.*, 2010).

4. Conclusion

From the results, it can be concluded that NERICA varieties had the adaptability to the upland rainfed conditions, due to the development of roots into the deep soil layer. Varietal difference of root surface area in the deep soil layer was related to both root length and thickness, and root length was involved with root branches. On the other hand, the varietal difference of total amount of root surface area was related not to the root length, but to the root thickness. This result suggested that the emergence of the thick roots (probably primary crown roots) allowed the roots to penetrate into the deep soil layer. Therefore, it is considered that the emergence of thick roots is an important trait for the deep rooting character.

Acknowledgement

We thank all members of Crop Science Laboratory, Kochi University for their valuable help in this research, especially in root sampling. Thanks are also conveyed to SUIJI (Six University Initiative Japan Indonesia: Hasanuddin University, Bogor Agriculture University, Gadjah Mada University, Kochi University, Ehime University, Kagawa University), where through its joint degree program the author has the opportunity to do the research.

References

- Abdallah, E.H., Y. Musa, M. Mustafa, R. Sjahril and M. Riadi. (2016). Comparison between hydro- and osmo-priming to determine period needed for priming indicator and its effect on germination percentage of aerobic rice cultivars (*Oryza sativa* L.). AGRIVITA Journal of Agricultural Science. 38(3): 222-230. DOI: <http://doi.org/10.17503/agrivita.v38i3>.
- Bhowmik, S.K., M.A.R. Sarkar and F. Zaman. (2012). Effect of Spacing and Number of Seedlings Per Hill on The Performance of Aus Rice cv. NERICA 1 under Dry Direct Seeded Rice (DDSR) System of Cultivation. J. Bangladesh Agril. Univ. 10(2): 191-195.
- Chapra, R.K. and S.K. Sinha. (1998). Prospects of Success of Biotechnological Approaches for Improving Tolerance to Drought Stress in Crop Plants. Current Science. 74(1): 25-34.
- Fukai, S. and M. Cooper. (1995). Development of Drought Resistance Cultivars Using Physio-Morphological Traits in Rice. Field Crops Research. 40: 67-86.
- Ganapathy, S., S.K. Ganesh, P. Shanmugasundaram and R.C. Babu. (2010). Studies on Root Traits for Drought Tolerance in Rice (*Oryza sativa* L.) under Controlled (PVC Pipes) Condition. Electronic Journal of Plant Breeding. 1(4): 1016-20.
- Gowda, V.R.P., A. Henry, A. Yamauchi, H.E. Shashidhar and R. Serraj. (2011). Root biology and genetic improvement for drought avoidance in rice. Field Crops Research, 122, 1-13.

- Ingram, K. T., F.D. Bueno, O.S. Namuco, E.B. Yamboo and C.A. Beyrouly. (1994). Rice Root Traits for Drought Resistance and Their Genetic Variation. In: Rice Roots: Nutrient and Water Use. G.J.D. Krik (ed.), IRRI, Philippines, pp: 67-70.
- Kameoka, E., R.R. Suralta, S. Mitsuya and A. Yamauchi. (2015). Matching the expression of root plasticity with soil moisture availability maximizes production of rice plants grown in an experimental sloping bed with soil moisture gradients. *Plant Production Science*, 18(3): 267-276.
- Kameoka, E., R.R. Suralta, S. Mitsuya and A. Yamauchi. (2016). Developmental Plasticity of Rice Root System Grown under Mild Drought Stress Condition with Shallow Soil Depth; Comparison between Nodal and Lateral roots, *Plant Production Science*.19(3): 411-419. DOI: 10.1080/1343943X.2015.1128094.
- Kano-Nakata, M., V.R.P. Gowda, A. Henry, R. Serraj, Y. Inukai, D. Fujita, N. Kobayashi, R.R. Suralta and A. Yamauchi. (2013). Functional Roles of the Plasticity of Root System Development in Biomass Production and Water Uptake under Rainfed Lowland Conditions. *Field Crops Research*. 144: 288-296.
- Katsura, K., M. Okami, H. Mizunuma and Y. Kato. (2010). Radiation use efficiency, N accumulation and biomass production of high-yielding rice in aerobic culture. *Field Crop. Res.* 117: 81-89.
- Kono, Y. (1993). Soil Factor and Root Morphology, Morphological Responses to the Environment. In *Science of The Rice Plant: Morphology*. Eds., T. Matsuo and K. Hoshikawa, Tokyo: Food and Agriculture Policy Research Center, pp: 507-525
- Maclean, J.L., D.C. Dawe, B. Hardy and G.P. Hettel. (2002). *Rice Almanac*. Third Edition. Los Banos (Philippines): International Rice Research Institute, Bouaké (Côte d'Ivoire): West Africa Rice Development Association, Cali (Colombia): International Center for Tropical Agriculture, Rome (Italy): Food and Agriculture Organization. 253 p.
- Menge, D.M., E. Kameoka, M. Kano-Nakata, A. Yamauchi, S. Asanuma, H. Asai, M. Kikuta, R.R. Suralta, T. Koyama, T.T. Tran, J.D.L.C. Siopongco, S. Mitsuya, Y. Inukai and D. Makihara. (2016): Drought-induced root plasticity of two upland NERICA varieties under conditions with contrasting soil depth characteristics, *Plant Production Science*, DOI: 10.1080/1343943X.2016.1146908
- Nazirah, L. (2008). Response Some Upland Rice Varieties to Water Distribution Intervals and Levels. Master Thesis, Graduate School of University of North Sumatera, Medan. (*in Indonesian*)
- Ndjiondjop, Marie-Noelle, F. Cisse, K. Futakuchi, M. Lorieux, B. Manneh, R. Bocco and B. Fatondji. (2010). Effect of Drought on Rice (*Oryza spp.*) Genotypes According to Their Drought Tolerance Level. Second Africa Rice Congress, Bamako, Mali, 22-26 March 2010: Innovation and Partnerships to Realize Africa's Rice Potential.
- Nguyen, H.T., R.C. Babu and A. Blum. (1997). Breeding for Drought Tolerance in Rice: Physiology and molecular genetics considerations. *Crop Science* 37, 1426-1434.
- Teo, Y.H., C.A. Beyrouly, R.J. Norman and E.E. Gbur, (1995). Nutrient Uptake Relationship to Root Characteristics of Rice. *Plant Soil* 171: 297-302. <https://doi.org/10.1007/BF00010285>
- Trillana, N., T. Inamura, R. Chaudhary and T. Horie, (2001). Root System Development in Two Rice Cultivars during Stress Recovery and Plant Traits. *Plant Prod. Sci* 4(3): 155-59.

Root Morphological Characters at Several Distances from Irrigated Trench in Rice Varieties Grown under Rain-fed Conditioned Plots

ORIGINALITY REPORT

% **24**
SIMILARITY INDEX

% **15**
INTERNET SOURCES

% **22**
PUBLICATIONS

% **2**
STUDENT PAPERS

PRIMARY SOURCES

- 1** Menge, Daniel Makori, Emi Kameoka, Mana Kano-Nakata, Akira Yamauchi, Shuichi Asanuma, Hidetoshi Asai, Mayumi Kikuta, Roel Rodriguez Suralta, Takuya Koyama, Thiem Thi Tran, Joel D. L. C. Siopongco, Shiro Mitsuya, Yoshiaki Inukai, and Daigo Makihara. "Drought-induced root plasticity of two upland NERICA varieties under conditions with contrasting soil depth characteristics", Plant Production Science, 2016.
Publication % **2**
- 2** krishikosh.egranth.ac.in
Internet Source % **2**
- 3** www.jstage.jst.go.jp
Internet Source % **1**
- 4** nagoya.repo.nii.ac.jp
Internet Source % **1**
- 5** Kameoka, Emi, Roel Rodriguezc Suralta, Shiro

Mitsuya, and Akira Yamauchi. "Matching the Expression of Root Plasticity with Soil Moisture Availability Maximizes Production of Rice Plants Grown in an Experimental Sloping Bed having Soil Moisture Gradients", Plant Production Science, 2015.

Publication

% 1

6 Emi Kameoka, Roel Rodriguez Suralta, Shiro Mitsuya, Akira Yamauchi. "Developmental Plasticity of Rice Root System Grown under Mild Drought Stress Condition with Shallow Soil Depth; Comparison between Nodal and Lateral roots", Plant Production Science, 2016

Publication

% 1

7 El Sayed Hasan Mohamed Fa, Saber Abdel Hamed El Mowafy, Mohamed Elbakry Saleh, Fares Soliman Mohame Salama. "Effect of Wheat (*Triticum aestivum* L.) Cultivars, Row Spacing and Weed Control Methods on Root Growth", Journal of Agronomy, 2018

Publication

% 1

8 docplayer.net
Internet Source

% 1

9 ejurnal.unisri.ac.id
Internet Source

% 1

10 Miransari, M.. "Using arbuscular mycorrhiza to reduce the stressful effects of soil compaction

% 1

on corn (*Zea mays* L.) growth", *Soil Biology and Biochemistry*, 200708

Publication

- 11 Samejima, Hiroaki, and Hiroshi Tsunematsu. "Genotypic variation in rice varieties screened for deep rooting under field conditions in West Africa", *Plant Production Science*, 2016. %1
Publication

- 12 Dinh Thi Ngoc Nguyen, Roel Rodriguez Suralta, Mana Kano-Nakata, Shiro Mitsuya, Stella Owusu-Nketia, Akira Yamauchi. "Genotypic variations in the plasticity of nodal root penetration through the hardpan during soil moisture fluctuations among four rice varieties", *Plant Production Science*, 2018 %1
Publication

- 13 Yong-Shu LIANG, Zhi-Qiang GAO, Xiao-Deng ZHAN, Yan-Li CHEN, Dai-Bo CHEN, Xi-Hong SHEN, Li-Yong CAO, Shi-Hua CHENG. "Phenotypic Correlation Among Root and Shoot Traits in an Elite Chinese Hybrid Rice Combination and Its Three Derived Populations", *Acta Agronomica Sinica*, 2011 %1
Publication

- 14 Ashiuchi, Makoto, Kenzo Fukushima, Haruna Oya, Toshihumi Hiraoki, Shigeo Shibatani, Nogiho Oka, Hirokazu Nishimura, Hirofumi %1

Hakuba, Masahiko Nakamori, and Masaru Kitagawa. "Development of Antimicrobial Thermoplastic Material from Archaeal Poly- γ -L-Glutamate and Its Nanofabrication", ACS Applied Materials & Interfaces, 2013.

Publication

15

Gowda, V.R.P.. "Root biology and genetic improvement for drought avoidance in rice", Field Crops Research, 20110428

Publication

% 1

16

mie-u.repo.nii.ac.jp

Internet Source

% 1

17

Henry Kesaulya, Baharuddin, Bandron Zakaria, Syatrianty A. Syaiful. "Isolation and Physiological Characterization of PGPR from Potato Plant Rhizosphere in Medium Land of Buru Island", Procedia Food Science, 2015

Publication

% 1

18

thescipub.com

Internet Source

% 1

19

academic.oup.com

Internet Source

<% 1

20

Kano-Nakata, Mana, Yoshiaki Inukai, Len J. Wade, Joel DLC. Siopongco, and Akira Yamauchi. "Root Development, Water Uptake, and Shoot Dry Matter Production under Water

<% 1

Deficit Conditions in Two CSSLs of Rice:
Functional Roles of Root Plasticity", Plant
Production Science, 2011.

Publication

-
- 21 www1.vnua.edu.vn <% 1
Internet Source
-
- 22 www.europeangrassland.org <% 1
Internet Source
-
- 23 Jie Huang, Tiesong Hu, Muhammad Yasir, Yun Gao, Can Chen, Rui Zhu, Xin Wang, Hongwei Yuan, Jiwei Yang. "Root growth dynamics and yield responses of rice (*Oryza sativa* L.) under drought–flood abrupt alternating conditions", *Environmental and Experimental Botany*, 2018
Publication <% 1
-
- 24 www.ijabpt.com <% 1
Internet Source
-
- 25 Yan Hock Teo. "Nutrient uptake relationship to root characteristics of rice", *Plant and Soil*, 04/1995
Publication <% 1
-
- 26 Suralta, R.R.. "Root growth, aerenchyma development, and oxygen transport in rice genotypes subjected to drought and waterlogging", *Environmental and Experimental Botany*, 200809
Publication <% 1

27

Hayat Ullah, Avishek Datta. "Root system response of selected lowland Thai rice varieties as affected by cultivation method and potassium rate under alternate wetting and drying irrigation", Archives of Agronomy and Soil Science, 2018

Publication

<% 1

28

Midori Okami, Yoichiro Kato, Nobuya Kobayashi, Junko Yamagishi. "Agronomic performance of an IR64 introgression line with large leaves derived from New Plant Type rice in aerobic culture", European Journal of Agronomy, 2014

Publication

<% 1

29

www.ijset.net

Internet Source

<% 1

30

Nguyen, Nghia Thi Ai, Cuong Van Pham, Dinh Thi Ngoc Nguyen, and Toshihiro Mochizuki. "Genotypic Variation in Morphological and Physiological Characteristics of Rice (*Oryza sativa* L.) under Aerobic Conditions", Plant Production Science, 2015.

Publication

<% 1

31

unesdoc.unesco.org

Internet Source

<% 1

32

www.aciar.gov.au

Internet Source

<% 1

33

Genomics and Breeding for Climate-Resilient
Crops, 2013.

Publication

<% 1

34

Jinmin Fu, Peter H. Dernoeden. "Creeping
Bentgrass Putting Green Turf Responses to
Two Summer Irrigation Practices: Rooting and
Soil Temperature", Crop Science, 2009

Publication

<% 1

EXCLUDE QUOTES ON

EXCLUDE
BIBLIOGRAPHY ON

EXCLUDE MATCHES < 5
WORDS