MORPHOMETRIC PROFILE OF ROOT SYSTEM DISTRIBUTION OF PHILIPPINE RICE GERMPLASM

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ABSTRACT

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Traditional rice varieties are likely source of potentially adaptable traits to a wide range of abiotic and biotic stresses, characterization of this rice germplasm is essential for ensuring the future generations of available materials needed to build better rice plants. In this study, 52 traditional rice varieties conserved at PhilRice were characterized to assess their root phenotypic characteristics. Correlation analysis among root trait showed a high positive correlation in some traits such as total root number and shoot length. Cluster analysis divided the different varieties into 3 various group. Analysis of result showed highly significance among in major phenotypic trait based on root system architecture. Generally, Luzon has 26 deep rooting and 12 shallow varieties whereas Visayas has 4 classified as deep rooting and 1 shallow rooted. Lastly, Mindanao has 8 deep rooting varieties and 1 shallow rooting. Specifically, among 52 selected traditional rice varieties there was 39 classified as deep rooting and 13 verified as shallow rooted. Future collection and characterization would further enrich the genetic resource of Philippine traditional rice varieties.

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LITERATURE CITED

Ahmadi, N., Audebert, A., Bennett, M., Bishop, A., Oliveira, A., Courtois, B., Diedhiou, A., Dievart, A., Gantet, P., Ghesquière, A., Guiderdoni, E., Henry, A., Inukai, Y., Kochian, L., Laplaze, L., Lucas, M., Luu, D., Manneh, B., Mo, X., Muthurajan, R., Perin, C., Price, A., Robin, S., Sentenac, H., Bassirou, S., Uga, Y., Wissuwa, M., Ping, W. & Xu, J. (2014). The roots of future rice harvests. *The Rice Journal*, 7(29), 1–9.

Arai-sanoh, Y., Takai, T., Yoshinaga, S., Nakano, H., Kojima, M., Sakakibara, H. & Uga, Y. (2014). Deep rooting conferred by deeper rooting 1 enhances rice yield in paddy fields. *Scientific Reports*, 4(5563), 1–6.

Araki, H., Morita, S., Tatsumi, J. & Iijima, M., (2002). Physio-morphological analysis on axile root growth in upland rice. *Plant Production Science*, 5(4), 286–293.

Aroca, R., Porcel, R. & Ruiz-lozano, J. M. (2012). Regulation of root water uptake under abiotic stress conditions. *Journal of Experimental Botany*, 63(1), 43–57.

Arsenault, J. E., Yakes, E. A., Hossain, M. B., Islam, M. M., Ahmed, T., Hotz, C. & Brown, K. H. (2010). The current high prevalence of dietary zinc inadequacy among children and women in rural Bangladesh could be substantially ameliorated by zinc biofortification of rice. *The Journal of Nutrition*, 140(9), 1683–1690.

Barroga, R., Bordey, F., Desamero, N., Duldulao, J., Javier, L., Juliano, L., Manalo IV, J., Orge, H., Relado, R., Romero, R. & Zagado, R., (2017). Roadmap for impact: The PhilRice strategic plan retrieved from https://dbmp.philrice.gov.ph/dms_records/docs/PhilRice_Issuances/13081CES.pdf.

Bengough, A. G., Bransby, M. F., Hans, J., Mckenna, S. J., Roberts, T. J. & Valentine, T. A. (2006). Root responses to soil physical conditions ; growth dynamics from field to cell. *Journal of Experimental Botany*, 57(2), 437–447.

Chapman, N., Miller, A. J., Lindsey, K. & Whalley, W. R. (2012). Roots, water, and nutrient acquisition : let's get physical. *Trends in Plant Science*, 17(12), 701–710.

Choudhury, B., Khan, M. L. & Dayanandan, S. (2013). Genetic structure and diversity of indigenous rice (*Oryza sativa* L.) varieties in the Eastern Himalayan region of Northeast India, *Springer Plus*, 2(228), 1-10.

Clark, R. T., Maccurdy, R. B., Jung, J. K., Shaff, J. E., Mccouch, S. R., Aneshansley, D. J., & Kochian, L. V. (2011). Three-dimensional root phenotyping with a novel imaging and software platform. *Plant Physiology*, 156(6), 455-465.

Comas, L. H., Becker, S. R., Cruz, V. M. V, Byrne, P. F., & Dierig, D. A. (2013). Root traits contributing to plant productivity under drought. *Frontiers in Plant Science*, 4(11), 1–16.

Cortaga, Cris & Bartolome A. Duldulao, Joy & Perez, Loida. (2014). Grain quality of some Philippine traditional rice varieties retrieved from https://www.researchgate.net/publication/313875510_Grain_quality_of_some_Philippine_traditional_rice_varieties/citation/download.

De Dorlodot, S., Price, A., Tuberosa, R. & Forster, B. (2007). Root system architecture : opportunities and constraints for genetic improvement of crops. *Trends in Plant Science*, 12(10), 1-8.

Diagne, A., Alia, D. Y., Wopereis, M. C. S., Saito, K., Nakelse, T. & Seck, P. A. (2013). Impact of rice research on income, poverty and food security in Africa : An Ex-ante analysis 1. *Realizing Africa's Rice Promise*, 390(4), 423-457.

Dusschoten, D. Van, Metzner, R., Kochs, J., Postma, J. A., Daniel, P., Bühler, J. & Germany, D. D. (2016). Quantitative 3D analysis of plant roots growing in soil using magnetic resonance imaging 1. *American Society of Plant Biologists*, 170(3), 1176–1188.

Fageria, N. K. & Moreira, A. (2011). The role of mineral nutrition on root growth of crop plants. *Advances in Agronomy*, 110(5), 252-318.

Gelderen, K. Van, Kang, C. & Pierik, R. (2018). Light signaling, root development, and plasticity. *American Society of Plant Biologists*, 176(6), 1049–1060.

Giehl, R. F. H., Gruber, B. D. & Wirén, N. Von. (2014). It's time to make changes : modulation of root system architecture by nutrient signals. *Journal of Experimental Botany*, 65(3), 769-778.

Gowda, V. R. P., Henry, A., Vadez, V., Shashidhar, H. E., & Serraj, R. (2012). Water uptake dynamics under progressive drought stress in diverse accessions of the OryzaSNP panel of rice (*Oryza sativa*). *Functional Plant Biology*, 35(9) 401-411.

Gu D, Zhen F, Hannaway DB, Zhu Y, Liu L, Cao W, et al. (2017) Quantitative classification of rice (*Oryza sativa L.*) root length and diameter using image analysis. *Plos One*, 12(1), 1-14.

Hanzawa, E., Sasaki, K., Nagai, S., Obara, M., Fukuta, Y., Uga, Y. & Sato, T. (2013). Isolation of a novel mutant gene for soil-surface rooting in rice (*Oryza sativa* L.). *The Rice Journal*, 6(30), 1-11.

Haque, M., Pramanik, H. R., Biswas, J. K., Iftekharuddaula, K. M., & Hasanuzzaman, M. (2015). Comparative performance of hybrid and elite inbred rice varieties with

respect to their source-sink relationship. *The Scientific World Journal*, 2015(4), 1–12.

Henry, A., Gowda, V. R. P., Torres, R. O., Mcnally, K. L., & Serraj, R. (2011). Field crops research variation in root system architecture and drought response in rice (*Oryza sativa*): Phenotyping of the OryzaSNP panel in rainfed lowland fields. *Field Crops Research*, 120(2), 205–214.

Kondo, M., Aguilar, A., Abe, J., Morita, S., Kondo, M., Aguilar, A., Morita, S. (2015). Anatomy of nodal roots in tropical upland and lowland rice varieties anatomy of nodal roots in tropical upland and lowland rice varieties. *Plant Production Science*, 3(4), 437-445.

Laborte, A., Paguirigan, N., Moya, P., Nelson, A., Sparks, A. & Gregorio, G. B. (2015). Farmers preference for rice traits : Insights from farm surveys in Central Luzon. *Plos One*, 8(10), 1–18.

Lin, C. & Sauter, M. (2017). Control of adventitious root architecture in rice by darkness, light and gravity. *American Society of Plant Biologists*, 176(2), 1352-1364.

Long, S. P., Marshall-colon, A. & Zhu, X. (2015). Review meeting the global food demand of the future by engineering crop photosynthesis and yield potential. *Cell*, 161(1), 56–66.

Lou, Q., Chen, L., Mei, H., Xu, K., Wei, H. & Feng, F. (2017). Root transcriptomic analysis revealing the importance of energy metabolism to the development of deep roots in rice (*Oryza sativa* L.). *Frontiers in Plant Science*, 1314(8), 1–13.

Mishra, A., & Salokhe, V. M. (2011). Rice root growth and physiological responses to SRI water management and implications for crop productivity. *Paddy Water Environment*, 2011(9), 41–52.

Moriwaki, T., Miyazawa, Y., Kobayashi, A., Uchida, M. & Watanabe, C. (2011). Hormonal regulation of lateral root development in arabidopsis modulated by MIZ1 and requirement of GNOM activity of *MIZ1* function. *American Society of Plant Biologists*, 157(3), 1209–1220.

Niones, J. M., Inukai, Y., Suralta, R. R. & Yamauchi, A. (2015). QTL associated with lateral root plasticity in response to soil moisture fluctuation stress in rice. *Plant Soil*, 2015(391), 63-75.

Niones, J. M., Suralta, R. R., Inukai, Y., & Yamauchi, A. (2015). Roles of root aerenchyma development and Its associated QTL in dry matter production under transient moisture stress in rice. *Plant Production Science*. 16(3), 205-216.

Nurliani, K. & Rosada, I. (2016). Rice-field conversion and its impact on food availability. *Agriculture and Agricultural Science Procedia*, (153)9, 40–46.

Obara, M. & Tamura, W. (2010). Fine-mapping of qRL6. 1, a major QTL for root length of rice seedlings grown under a wide range of $NH4^+$ concentrations in hydroponic conditions. *Theoretical and Applied Genetics*, 123(3), 535–547.

Omori, F. & Mano, Y. (2007). QTL mapping of root angle in F 2 populations from maize "B73" x teosinte "*Zea luxurians*". *Plant Root*, (147)1, 57–65.

Onyegbula, C. B. (2017). Rice farmer's perception of effects of climate change on rice development stages in Niger State. *Journal of Agricultural Extension and Rural Development*, 9(2), 14-19.

Price, A. H., Steele, K. A., Gorham, J., Bridges, J. M., Moore, B. J., Evans, J. L., Jones, R. G. W. (2002). Upland rice grown in soil-filled chambers and exposed to contrasting water-deficit regimes. *Field Crop Research*, 76, 11–24.

Rabara, R. C., Ferrer, M. C., Calayugan, M. I. C. & Duldulao, M. D. (2015). Conservation of Rice Genetic Resources for Food Security. *Advances in Food Technology and Nutritional Sciences*, (176)1, 51-56.

Ramalingam, P., Kamoshita, A., Deshmukh, V. & Uga, Y. (2017). Association between root growth angle and root length density of a near-isogenic line of IR64 rice with deeper rooting 1 under different levels of soil compaction. *Plant Production Science*, 20(2), 162-175.

Rekha, T., Martin, K. P., Sreekumar, V. B. & Madassery, J. (2011). Genetic diversity assessment of rarely cultivated traditional indica rice (*Oryza sativa* L.) varieties. *Biotechnology Research International*, 11(4), 1-7.

Rich, S. M. & Watt, M. (2013). Soil conditions and cereal root system architecture : review and considerations for linking Darwin and Weaver. *Journal of Experimental Botany*, 64(5), 1193-1208.

Rohman, A., Helmiyati, S., Hapsari, M. & Setyaningrum, D. L. (2014). Rice in health and nutrition. *International Food Research Journal*, 21(1), 13–24.

Santos-Madelliin, C., Edwards, J., Liechty, Z., Nguyen B. & Sundaresan V. (2017). Drought stress results in a compartment specific restructuring of the rice root associated micribiomes. *American Society for Microbiology*, 8(4), 1–15.

Sariam, O. (2009). Effect of irrigation practices on root growth and yield of rice. *Journal of Tropical Agriculture and Food Science*, 37(1), 1–8.

Shahzad, Z. & Amtmann, A. (2017). Science direct food for thought : How nutrients regulate root system architecture. *Current Opinion in Plant Biology*, 39(6), 80–87.

Smith, S. & Smet, I. D. (2012). Root system architecture : Insights from arabidopsis and cereal crops. *Philosophical Transactions of the Royal Society*, 367(7), 1441–1452.

Suralta, R. R. & Yamauchi, A. (2008). Root growth, aerenchyma development, and oxygen transport in rice genotypes subjected to drought and waterlogging. *Environmental and Experimental Botany*, 64(8), 75–82.

Suralta, R. R., Niones, J. M., Kano-nakata, M., & Tran, T. T. (2018). Plasticity in nodal root elongation through the hardpan triggered by rewatering during soil moisture fluctuation stress in rice. *Scientific Reports*, 2017(7), 1–11.

Tang, G., Qin, J., Dolnikowski, G. G., Russell, R. M. & Grusak, M. A. (2009). Golden Rice is an effective source of vitamin A. *The America Journal of Clinical Nutrition*, 89(3), 1776–1783.

Tomas, Mervalyn, M. (2014). Variety what it where? Retrieved from https://www.philrice.gov.ph/wp-content/uploads/2015/01/2014_3Q_opt.pdf.

Trachsel, S., Kaeppler, S. M., Brown, K. M. & Lynch, J. P. (2013). Field crops research maize root growth angles become steeper under low N conditions. *Field Crops Research*, 140(9), 18–31.

Tron, S., Bodner, G., Laio, F., Ridolfi, L. & Leither, D. (2015). Can diversity in root architecture explain plant water use efficiency. *Ecological Modelling*, 312(15) 200-210.

Trontin, C. (2011). What does arabidopsis natural variation teach us about adaptation in plants?. *Plant Biology*, 14(4), 225–231.

Uga, Y., Assaranurak, I., Kitomi, Y., Larson, B. G., Craft, E. J., Shaff, J. E., Kochian, L. V. (2018). Genomic regions responsible for seminal and crown root lengths identified by 2D & 3D root system image analysis. *BMC Genomics*, 19(273), 1–12.

Uga, Y., Ebana, K., Abe, J., Morita, S., Okuno, K. & Yano, M. (2009). Variation in root morphology and anatomy among accessions of cultivated rice (*Oryza sativa* L.) with different genetic backgrounds. *National Institute of Agrobiological Sciences*, 93(5), 87–93.

Uga, Y., Hanzawa, E. & Nagai, S. (2012). Identification of qSOR1, a major rice QTL involved in soil-surface rooting in paddy fields. *Theoretical and Applied Genetics*, 124(1), 75–86.

Uga, Y., Kitomi, Y., Ishikawa, S. & Yano, M. (2015). Genetic improvement for root growth angle to enhance crop production. *Breeding Science*, 119(7), 111–119.

Uga, Y., Okuno, K. & Yano, M. (2011). Dro1, a major QTL involved in deep rooting of rice under upland field conditions. *Journal of Experimental Botany*, 62(8), 2485–2494.

Uga, Y., Sugimoto, K., Ogawa, S., Rane, J., Ishitani, M., Hara, N. & Yano, M. (2013). Control of root system architecture by deeper rooting 1 increases rice yield under drought conditions. *Nature Publishing Group*, 45(9), 1097–1102.

Uga, Y., Yamamoto, E., Kanno, N., Kawai, S., Mizubayashi, T. & Fukuoka, S. (2013). A major QTL controlling deep rooting on rice chromosome 4. *Scientific Reports*, 3040(3), 1-6.

Wassmann, R., Jagadish, S. V. K., Heuer, S., Ismail, A. & Sumfleth, K. (2009). Climate change affecting rice production: The physiological and agronomic basis for possible adaptation strategies. *Advances in Agronomy*, 101(9), 59-122.

Xiao-hua, S. H. I. & Rui-fa, H. U. (2017). Rice variety improvement and the contribution of foreign germplasms in China. *Journal of Integrative Agriculture*, 16(10), 2337–2345.

Zibaee, A. (2013). Rice Research : Open access rice : Importance and Future. *Journal of Rice Research*, 1(2), 102.