

**DROUGHT TOLERANCE OF SPECIAL QUALITY RICE
APPLIED WITH PACLOBUTRAZOL**

ROMMEL D. WAMIL

An Undergraduate Thesis Manuscript Submitted to the Faculty of the Department of
Crop Science College of Agriculture, Central Luzon State University,
Science City Muñoz, Nueva Ecija, Philippines
in Partial Fulfillment of the Requirements
for the Degree of

**BACHELOR OF SCIENCE IN AGRICULTURE
(Crop Science - Agronomy)**

JUNE 2019

BIOGRAPHICAL SKETCH

The author, Rommel Dacca Wamil lives at Palusapis Science City of Muñoz, Nueva Ecija. He was born on the 2nd day of July 1999. He is the eldest among four children of Mr. Romeo A. Wamil and Mrs. Yolanda D. Wamil.

He finished his elementary education at Palusapis Elementary School and secondary education at Central Luzon State University Laboratory High School – Palusapis.

He took up Bachelor of Science in Agriculture major in Crop Science with specialization in Agronomy at Central Luzon State University Located at Science City of Muñoz, Nueva Ecija.

He joined the Society of Crop Science Majors (SCSM) when he was in third year college.

ACKNOWLEDGEMENT

The author would like to express his heartfelt gratitude and deepest appreciation to the people who helped him to make this study possible and highest praise to our Almighty God who gives him a strength and courage to surpass all the struggles in life.

He would also like to express his gratitude and appreciation to his beloved parents, Mr. Romeo A. Wamil and Mrs. Yolanda D. Wamil, who give him all the support he needed not only financially but also emotionally and spiritually to boost his morale during the time when he feels down.

His adviser Mr. Ace Mugssy L. Agustin, for his patience, expertise, consistent guidance and consistent advices that helped him bring this study into success and also to his critic Prof. Pacifico T. Vizmonte Jr, for his constructive comments, suggestions, and critiquing for the improvement of the manuscript.

He would like to fully extend his heartfelt gratitude to Dr. Ernesto A. Martin, Dean of College of Agriculture, Dr. Rosemarie T. Tapic, Chairperson of Department of Crop Science and to all faculty members of Department of Crop Science for the suggestions and recommendations for the improvement of the study.

To Dr. Vicky Jardiollin-Villa of Vicente V. Bello Scholarship Program for giving him an opportunity as one of their scholars that give a full support in his college life.

To the SCSM family for giving a memorable times and physical support during the conduct of the study.

Thank you for being a motivation and inspiration. God bless all.

TABLE OF CONTENTS

	PAGE
LIST OF TABLES	vii
LIST OF FIGURES	viii
LIST OF APPENDICES	ix
LIST OF APPENDIX TABLES	x
LIST OF APPENDIX FIGURES	xiv
ABSTRACT	xv
INTRODUCTION	1
Statement of the Problem	2
Importance of the Study	2
Objectives of the Study	3
Time and Place of the Study	3
REVIEW OF RELATED LITERATURE	4
Rainfed Lowland Rice Ecosystem	4
Drought Resistance Mechanism	5
Drought Resistant Varieties	8
Paclobutrazol	9
METHODOLOGY	12
Experimental Lay out	12
Treatments	12
Plant Materials	13
Seedling Production	13
Preparation of Soil Medium	13
Transplanting	13
Nutrient Management	14
Paclobutrazol Application	14
Weeding	14
Harvesting	14
Data Gathered	15
Water Use	15
Root Parameters	15

Agronomic Parameters	15
Statistical Analysis	17
RESULTS AND DISCUSSION	18
Plant Height	18
Number of Tillers	20
Total Shoot Dry Weight	22
Total Root Dry Weight	24
Total Plant Dry Weight	25
Nodal Roots	26
Lateral Roots	27
Cumulative Use	28
Water Use efficiency	30
Agronomic Parameters at Maturity	31
Plant Height at Maturity	31
Number of Tillers at Maturity	31
Days to Flowering	32
Days to Maturity	32
Number of Panicle per Hill	33
Panicle Length (cm)	34
Number of Filled Grains	35
Number of Spikelet per Panicle	36
Percent Filled Grains	37
Harvest Index	37
1,000 Grain Weight	38
Grain Yield per Plant	39
SUMMARY AND CONCLUSION	41
LITERATURE CITED	43
APPENDICES	48

LIST OF TABLES

TABLE		PAGE
1	Cumulative water use (L) of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	29
2	Water use efficiency (g grain L ⁻¹) of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	30
3	Plant height (cm) of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	31
4	Number of tillers of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	32
5	Days to flowering of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	33
6	Days to maturity of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	33
7	Number of panicles per hill of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	34
8	Panicle length (cm) of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	35
9	Number of filled grains of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	35
10	Number of spikelets per panicle of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	36
11	Percent filled grains of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	37
12	Harvest index of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	38
13	1000-grain weight (g) of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	39
14	Grain yield per plant (g) of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	40

LIST OF FIGURES

FIGURE		PAGE
1	Plant height (cm) of NSIC Rc216 applied with Paclobutrazol at different water regimes.	18
2	Plant height (cm) of Dinorado applied with Paclobutrazol at different water regimes.	19
3	Number of tillers of NSIC Rc216 applied with Paclobutrazol at different water regimes.	21
4	Number of tillers of Dinorado applied with Paclobutrazol at different water regimes.	22
5	Total shoot dry weight (g) of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes.	23
6	Total root dry weight (g) of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes.	24
7	Total plant dry weight (g) of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes.	26
8	Number of nodal roots of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes.	27
9	Number of lateral roots of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes.	28

LIST OF APPENDIX TABLES

APPENDIX TABLE		PAGE
1	Analysis of variance on plant height at 14 DAT of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	49
2	Analysis of variance on plant height at 21 DAT of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	49
3	Analysis of variance on plant height at 28 DAT of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	50
4	Analysis of variance on plant height at 35 DAT of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	50
5	Analysis of variance on plant height at 42 DAT of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	51
6	Analysis of variance on plant height at 49 DAT of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	51
7	Analysis of variance on number of tillers at 14 DAT of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	52
8	Analysis of variance on number of tillers at 21 DAT of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	52
9	Analysis of variance on number of tillers at 28 DAT of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	53
10	Analysis of variance on number of tillers at 35 DAT of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	53

11	Analysis of variance on number of tillers at 42 DAT of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	54
12	Analysis of variance on number of tillers at 49 DAT of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	54
13	Analysis of variance on shoot dry weight at vegetative stage NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	55
14	Analysis of variance on shoot dry weight at reproductive stage NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	55
15	Analysis of variance on shoot dry weight at maturity stage NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	56
16	Analysis of variance on root dry weight at vegetative stage NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	56
17	Analysis of variance on root dry weight at reproductive stage NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	57
18	Analysis of variance on root dry weight at maturity stage NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	57
19	Analysis of variance on plant dry weight at vegetative stage NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	58
20	Analysis of variance on plant dry weight at reproductive stage NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	58
21	Analysis of variance on plant dry weight at maturity stage NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	59

22	Analysis of variance on number of nodal roots weight at vegetative stage NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	59
23	Analysis of variance on number of nodal roots weight at reproductive stage of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	60
24	Analysis of variance on number of nodal roots weight at maturity stage of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	60
25	Analysis of variance on number of lateral roots weight at vegetative stage of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	61
26	Analysis of variance on number of lateral roots weight at reproductive stage of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	61
27	Analysis of variance on number of lateral roots weight at maturity stage of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	62
28	Analysis of variance on plant height at maturity stage of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	62
29	Analysis of variance on tiller number at maturity stage of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	63
30	Analysis of variance on days to flowering of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	63
31	Analysis of variance on days to maturity of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	64

32	Analysis of variance on number of panicle per hill of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	64
33	Analysis of variance on panicle length of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	65
34	Analysis of variance on number of filled grains of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	65
35	Analysis of variance on number of spikelet per panicle of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	66
36	Analysis of variance on percent filled grains of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	66
37	Analysis of variance on harvest index of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	67
38	Analysis of variance on 1,000 grain weight of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	67
39	Analysis of variance on yield per pot of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	68
40	Analysis of variance on cumulative water use of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	68
41	Analysis of variance on water use efficiency of NSIC Rc216 and Dinorado applied with Paclobutrazol at different water regimes	69
42	Correlation analysis of agronomic parameters to water use efficiency	70

LIST OF APPENDIX FIGURES

APPENDIX FIGURE		PAGE
1	Planting of seeds	71
2	Uprooting of seedling	71
3	Sieving of soil	72
4	Sieved soil	72
5	Fertilizer application	73
6	Experimental lay-out	73
7	Weighing of plants	74
8	Water application	74
9	Harvesting at vegetative stage	75
10	Harvesting at reproductive stage	75
11	Harvesting at maturity	76
12	Cleaning of roots	76
13	Weighing of harvested plants	77
14	Weighing cleaned roots	77

ABSTRACT

WAMIL, ROMMEL D. Department of Crop Science, College of Agriculture, Central Luzon State University, Science City of Munoz, Nueva Ecija, Philippines, **June 2019, DROUGHT TOLERANCE OF SPECIAL QUALITY RICE APPLIED WITH PACLOBUTRAZOL**

Adviser: ACE MUGSSY L. AGUSTIN, M.Sc.

The study was conducted with the general objective of evaluating the effects of different concentrations of PBZ on the growth, water use and grain yield of two special quality rice varieties (NSIC Rc216 and Dinorado) under drought stress condition.

The result showed that PBZ generally improved tiller and panicle number which is supported by correlation analysis with moderate and strong relationships, respectively. Among root parameters evaluated, only lateral roots showed positive moderate relationship with PBZ indicating PBZ has the potential of improving this root parameter which is considered as key root trait under drought condition. Moreover, tiller number and root parameters showed weak to very weak relationships to grain yield and water use. Thus, the targeted parameters or traits (tiller number and root parameters) did not contribute to better performance of NSIC Rc216 and Dinorado under contrasting water regimes. Lastly, PBZ showed different effects on grain yield of two rice ecotypes wherein positive effects for newly released modern variety (NSIC Rc216) but negative effect on traditional variety (Dinorado). This indicates that different rice varieties require different levels of PBZ; thus, it is recommended to conduct another study using different traditional and modern rice varieties under field condition.

Keywords: Paclobutrazol, tiller number, lateral roots, grain yield

LITERATURE CITED

- Ali, Q., Ahsan, M., Tahir, M.H.N., Elahi, M., Farooq, J., and Wasem, M. (2011). Gene Expression and Functional Genomic Approach for abiotic stress tolerance in different crop species. *IJAVMS*, 5(2), 221-248
- Alpuerto, Vida-Lina, E.B., Norton, G.W., Alwang, J., and Ismail, A.M. (2009). "Economic Impact Analysis of Marker-Assisted Breeding for Tolerance to Salinity and Phosphorous Deficiency in Rice." *Applied Economic Perspectives and Policy*, 31(4):779-792.
- Araus, J.L., Slafer G.A., Reynolds M.P., Royo C. (2002). Plant breeding and drought in C3cereals: what should we breed for? *Ann. Bot.* 89, 925-940.
- Assuero, S. G., Lorenzo M., Pérez Ramírez N. M., Velázquez L.M., & Tognetti J.A., (2012). Tillering promotion by paclobutrazol in wheat and its relationship with plant carbohydrate status, *New Zealand Journal of Agricultural Research*, 55:4, 347-358, DOI: 10.1080/00288233.2012.706223.
- Bernier, J, A. Kumar, R., Venuprasad, D., Spaner, G.N. ATLIN. (2007). "A large-effect QTL for grain yield under reproductive stage drought stress in upland rice." *Crop Science*, 47(2):505-516.
- Blum, A., Shpiler, L., Golan, G. and Mayer, J. (1989). Yield stability and canopy temperature of wheat genotypes under drought stress. *Field Crop Res.* 22: 289-96.
- Blum, A., (2005). Drought resistance, water use efficiency, and yield potential – are they compatible, dissonant, or mutually exclusive? *Aust. J. Agric. Res.*, 56: 1159-1168.
- Chaney, W.R., (2005). Growth retardants: A promising tool for managing urban trees. Purdue Extension document FNR-252-W. Accessed on May 11, 2011 at: <http://www.extension.purdue.edu/extmedia/FNR/FNR-252-W.pdf>.
- Collard, Bertrand C.Y., Mackill, David J. (2008). "Marker-assisted selection: An approach for precision plant breeding in the twenty-first century." *Philosophical Transactions of the Royal Society*, 363(1491): 557-572.
- Chu, G., Wang Z. Q., Zhang H., Yang J.C., Zhang J.H., (2016). Agronomic and physiological performance of rice under integrative management. *Agronomy Journal*, 108, 117-128.

- Diaz, L., Ferrer C., Newingham, Ma. C., Roel R., Gabriel R. (2014). Phenotypic Diversity of Farmers' Traditional Rice Varieties in the Philippines. Philippine Rice Research Institute.
- Dixit, S., Singh, A., Kumar, A. (2014). Rice Breeding for High Grain Yield under Drought: A Strategic Solution to a Complex Problem. International Rice Research Institute.
- Fang, T. and Zhao, W. (2005). Chemical control of the overgrowing seedlings in the Continuous cropping of late rice. Effect of MET on the growth and tillering of rice seedling and the yield of rice grain. Retrieved on September 12, 2010. <http://en.cnki.com.cn/Articleen/CJFDTOTAL-XBZW198802000.htm>.
- Fletcher, R., Gilley A., Saklan, N., Davis, T.D., (2000). Triazoles as Plant Growth Regulators and Stress Protectants. *Hortic. Rev.* 2: 55-138.
- Frantz, J., Pincock D., Klassen S., Bugbee B., (2004). Characterizing the Environmental response of a gibberellic acid-deficient rice for use as a model crop. *Agronomy Journal* 96: 1172-1181.
- Gall, H.L., Philippe F., Domon J.M., Gillet F., Pelloux J. and Rayon, C. (2015). Cell wall metabolism in response to abiotic stress. *Plants*, 4: 112-166.
- Huang, B. (2006). *Plant Environment Interactions*. 3rd Edition: CRC Press/Taylor and Francis. Boca Raton FL, USA.
- Ju, C.X., Buresh, R.j., Wang, Z.Q., Zhang H., Liu, L.J., Yang J.C., Zhang J.H., (2015). Root and shoot traits of rice varieties with higher grain yield and nitrogen rates application. *Field Crops Research*, 175, 47-59.
- Kavar, T., Maras M., Kidric M., Sustar-Vozlic J., Meglic V. (2007). Identification of genes involved in the response of leaves of *Phaseolus vulgaris* to drought stress, *Mol. Breed.* 21, 159–172.
- Kramer, P.J. and Boyer, J.S. (1995). *Water Relations of Plants and Soils*. Academic Press, San Diego, CA. 495 p.
- Kumar, A., Bernier, J., Verulkar, Satish, Lafitte, H.R., and Atlin, G.N. (2008). Breeding for drought tolerance: direct selection for yield, response to selection and use of drought-tolerant donors in upland and lowland-adapted populations. *Field Crops Research*, 107(3): 221-231.

- Li, J., Wang, X.Q., Watson, M.B., and Assmann, S.M. (2000). Regulation of abscisic acid-induced stomatal closure and anion channels by guard cell AAPK kinase. *Science*. 287, 300-303.
- Li, Z. K. & Xu, J. L. (2007). Breeding for drought and salt tolerant rice (*Oryza sativa* L.): progress and perspective. In M. A. Jenks, P. M. Hasegawa and S. M. Jain (eds), *Advances in Molecular Breeding Towards Salinity and Drought Tolerance*. Springer, Netherland, pp. 531-64.
- Mackill, David J., Ismail A.M., Pamplona, A.M., Sanchez, D.L., Carandang, J.J., Septiningsih, E.M. (2010). "Stress-Tolerant Rice Varieties for Adaptation to a Changing Climate". *Crop, Environment & Bioinformatics*, 7:250-259. Online: [www.tari.gov.tw/csam/CEB/member/publication/7\(4\)/004.pdf](http://www.tari.gov.tw/csam/CEB/member/publication/7(4)/004.pdf), accessed on November 20, 2011.
- Mactal, A., and Canare, J. JR. (2015). Lodging Resistance and Agro-morphological Characteristics of Elon-elon and Palawan Red Sprayed with Paclobutrazol. *Journal of Agricultural Technology* 11 (7): 1649-1667.
- Magtalas, P.M., (2018). Rainfed Performance of Different Rice Ecotypes Applied with Paclobutrazol.
- Mitra, J. (2001). Genetics and genetic improvement of drought resistance in crop plants. *Curr. Sci.* 80: 758-62.
- Morgan, P.W., Miller, F.R., and Quinby, J.R. (1977). Manipulation of sorghum growth and development with gibberellic acid. *Agronomy Journal* 69: 789-793.
- Nilsen, E. and Orcutt, D. (1996). *The Physiology of Plants under Stress: Abiotic Factors*. New York, John Wiley and Sons, Inc.
- Ocha. 2016. *Humanitarian Bulletin Philippines: El Niño brings drought to 40 percent of the Philippines*. Issue 4.
- O'toole, J.C., Baladia, E.P. (1981). Water deficit and Mineral Uptake in Rice. *Crop Science* 6: 1144-1150.
- O'toole, J.C. (1982). Adaptation of Rice to Drought Prone Environments. In: *Drought Resistance in Crops with Emphasis on Rice*. Los Baños, Philippines, 195-123.
- Olszewski, N., Sun T.P., Gubler F., (2002). Gibberellin signaling: biosynthesis, catabolism, and response pathways. *The Plant Cell* 14 (supplement): S61-S80.

- Pan S., Zhao J., Khan A., Yadav N. S., Batushansky A., Barak S., Rewald B., Fait A., Lazarovitch N., & Rachmilevitch S., (2016). Paclobutrazol induces tolerance in tomato to deficit irrigation through diversified effects on plant morphology, physiology.
- Pantuwan, G., Fukai, S., Cooper, M., Rajatasereekul, S. and O'toole, J.C. (2002). Yield response of rice (*Oryza sativa* L.) genotypes to drought under rainfed lowlands. Selection of drought resistant genotypes. *Field Crop Res.*, 73: 169–80.
- Qi W. Z., Hui H.L., Peng L., Shu T.D., Bing Q. Z., Hwat B. S., Geng L., Heng D. L., Ji W. Z., Bin Z., (2012). Morphological and physiological characteristics of corn (*Zea mays* L.) roots from cultivars with different yield potential. *European Journal Agronomic*, 38, 54-63.
- Ramaiah, V., Dalid, C.O., Del Valle, M., Zhao D., Espiritu, M., Sta Cruz, M.T., Amante, M., Kumar, A and Atlin, G.A. (2009). "Identification and characterization of large effect quantitative trait loci for grain yield under lowland drought stress in rice using bulk segregant analysis." *Theoretical and Applied Genetics*, 120 (1): 177-190.
- Serraj, R., Kumar, A., McNally, K.L., Slamet-Loedin, I., Bruskiewich, R., Mauleon, R., Cairns, J., Hijmans, R.J. (2009). "Improvement of drought resistance in rice." *Advances in Agronomy*. 103: 41-99.
- Singh, S., Pradhan, S., Singh, A. and Singh, O. (2012). Marker validation in recombinant inbred lines and random varieties of rice for drought tolerance. *Australian J. of Crop Sci.* 6: 606–12.
- Sullivan, C. Y. and Ross, W. M. (1979), *Stress Physiology in Crop Plants*. Wiley, New York, 263–81.
- Tesfahun, W., & Menzir, A. (2018). Effects of rates and time of paclobutrazol application on growth, lodging, yield and yield components of tef [*Ergostis tef* (Zucc.) Teotter] in Ada district, East Shewa Ethopia. *Journal of Biology, Agriculture and Healthcare* 8(3), 104-117.
- Tekalign T., (2007). Growth photosynthetic efficiency, rate of transpiration, lodging and grain yield tef [*Ergostis tef* (Zucc.) Teotter] as influenced by atsgc and rate of paclobutrazol application. *East African Journal of Sciences*.
- Turner, N.C., Wright, G.C. and Siddique, K.H.M. (2001). Adaptation of grain legumes (pulses) to water-limited environments, *Adv. Agron.* 71, 123–231.

- Wang, H., Inukai, Y., Yamauchi, A. (2006), Root development and nutrient uptake. *Crit. Rev. Plant Sci.* 25: 279–301.
- Warwick, R.A., (1975). Drought hazard in the United States: A research assessment: Boulder. University of Colorado, Institute of Behavioral Science, Colorado (Monograph no. NSF/RA/E-75/004, 199 p.).
- Wuthrich et al., (2016). Gibberellin Deficiency Confers Both Lodging and Drought Tolerance of Small Cereals. *1 Institute of Plant Sciences, University of Bern, Bern, Switzerland, 2 Institute of Biotechnology, Addis Ababa University, Addis Ababa, Ethiopia.*
- Xangsayasane, P., Jongdee, B., Pantuwan, G., Fukai, S., and Mitchell, J.H. (2014). Genotypic performance under intermittent and terminal drought screening in rainfed lowland rice. *Field Crops Res* 156: 281-292.