PAWEES 2012

International Conference on

"Challenges of Water & Environmental Management in Monsoon Asia"

27–29 November 2012

Xujati Kambhu Convention Hall & NEWMASIP Training Center, Royal Irrigation Department (Pakkred), Thailand

Aims

The objective is to provide a platform for researchers, scientists, practitioners, and policy makers to share and present new advances, research findings, perspectives, and experiences in Paddy and Water Environment and related disciplines. Special attentions will be given to developing certain skills or competence, or general upgrading of performance ability for climate change adaptation, participatory irrigation and environmental management, and sustainable development in irrigation and drainage in the monsoon Asia. The conference will bring together leading researchers, engineers, scientists, and officials in the domain of interest from around the world

Scope

Session A Climate Change and Uncertainty
Session B Participatory Management for Irrigation Projects
Session C Emerging Technologies in Water Management
Session D Environmental Sustainability in Paddy Irrigation and Drainage

Tuesday, November 27 th

08.30 AM- 04.30 PM

Keynote Speech:

Mr. Lertviroj Kowattana, Director General of Royal Irrigation Department

Mr. Hiroyuki Konuma, Assistant Director General of FAO

Featured Speech:

Session A Climate Change and Uncertainty

Dr. Chan-Yong Sung, President of KSAE, Korea

Assoc. Prof. Chaiyuth Suksri, Chulalongkorn University, Thailand

Session B Participatory Management for Irrigation

Mr. Va-Son Boonkird, Royal Irrigation Department

Session C Emerging Technologies in Water Management

Mr. Wei-Fuu Yang, President of TAES, Taiwan

Prof. Fi-John Chang, National Taiwan University, Taiwan

Session D Environmental Sustainability in Paddy Irrigation and Drain

Dr. Sho Shiozawa, President of JSIDE, Japan

Plenary Session Presentation (about 76 papers)

Wednesday, November 28 th

08.30 AM- 04.30 PM

Plenary Session Presentation(cont.)
Award ceremony
Agenda I- PWE publication
Agenda II- Management of PAWEES
Agenda III- International cooperation opportunities among member countries

Thursday, November 29 th

Technical tour to Irrigation project and industrial estate (Optional)

Registration fee

US $200 for International participants
US $100 for Thai national participants
US $ 50 for Students
registration fee can be paid at the Conference

Organizing Committee

Faculty of Engineering, Chulalongkorn University
Faculty of Engineering at Kamphangsaen, Kasertsart University
Royal Irrigation Department
PAWEES

Information and Contacts:

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Address:

Water Resources System Research Unit
Room 203, Bldg. 2 Faculty of Engineering,
Chulalongkorn University , Bangkok

http://project-wre.eng.chula.ac.th/watercu_eng/

Visit the website for more information and pre-registration (seating is limited)

International Society of Paddy and Water Environment Engineering (PAWEES)

Paddy and Water Environment Journal (PWE)

PAWEES 2022 FUKUOKA STATEMENT HOME MEMORIAL WRITING FOR DR. TETSU NAKAMURA ABOUT US

JOURNAL “PADDY AND WATER ENVIRONMENT” AWARDS NATIONAL SOCIETY MEMBERS HISTORY OF PAWEES

JOIN PAWEES CONTACT US MEMBER REGISTRATION

1st Announcement : PAWEES 2012-International Conference on “Challenges of Water & Environmental Management in Monsoon Asia”

ZD Scribd iPaper

By admin | January 1, 2012 | Uncategorized | No Comments |

← 21st International Congress on Irrigation & Drainage, 62nd IEC meeting, 8th International Micro Irrigation Congress

1st Announcement and Call for Papers : PAWEES 2013-The 12th Conference of International Society of Paddy and Water Environment Engineering →

Links of SWS and IDDC

IDDC
SWS Asia Chapter

THE RECORD OF 2016

Dr. Watanabe, a former President of PAWEES, was invited to the following conferences and gave a keynote speech. SWS Asia Chapter& International Dryland Development Comission(IDDC)

NATIONAL SOCIETY MEMBERS

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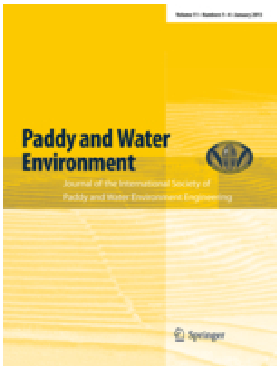
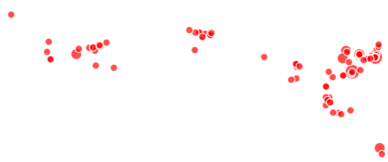
JOURNAL ‘PADDY AND WATER ENVIRONMENT’



PAWEES MEMBERSHIP REGISTRATION

VISITOR LOCATIONS

554 Pageviews
Mar. 04th - Apr. 04th



LINKS

American Society of Agricultural and Biological Engineers (ASABE)
European Society of Agricultural Engineers (EurAgEng)
Food and Agriculture Organization of the United Nations (FAO)
Indonesian Society of Agricultural Engineering (PERTETA)
International Commission of Agricultural and Biosystems Engineering (CIGR)
International Commission on Irrigation and Drainage (ICID)
International Rice Research Institute (IRRI)
International Union of Soil Sciences (IUSS)
International Water Management Institute (IWMI)
Korean Society of Agricultural Engineers (KSAE)
National Institute for Agro-Environmental Sciences (NIAES)
Taiwan Agricultural Engineers Society (TAES)
Thai Society of Agricultural Engineering (TSAE)
The Monsoon Asia Agro-Environmental Research Consortium (MARCO)
農業農村工学会 (JSIDRE – The Japanese Society of Irrigation, Drainage and Rural Engineering

3nd Announcement

PAWEES 2012International Conference on "Challenges of Water & Environmental Managementin Monsoon Asia"

27-29 November 2012, Thailand

International Society of Paddy and Water Environment Engineering (PAWEES)
Faculty of Engineering, Chulalongkorn University (CU)
Faculty of Engineering at Kamphaengsaen, Kasertsart University (KU)
Royal Irrigation Department (RID)

100th Anniversary of Chula Engineering 2013

Aims and Scope

The objective is to provide a platform for researchers, scientists, practitioners, and policy makers to share and present new advances, research findings, perspectives, and experiences in Paddy and Water Environment and related disciplines. Special attentions will be given to developing certain skills or competence, or general upgrading of performance ability for climate change adaptation, participatory irrigation and environmental management, and sustainable development in irrigation and drainage in the monsoon Asia.

The conference will bring together leading researchers, engineers, scientists, and officials in the domain of interest from around the world topics of the conference are:

- Climate Change and Uncertainty
- Participatory Management for Irrigation Projects
- Emerging Technologies in Water Management
- Environmental Sustainability in Paddy Irrigation and Drainage

Language

The official language of the conference will be English. All abstracts, papers and posters should be submitted in English.

Programs

DAY 1: PAWEES 2012 International Conference
DAY 2: PAWEES 2012 International Conference (cont.)
11th PAWEES Award Ceremony and Cultural events (Individual)
DAY 3: Technical tour to irrigation project and industrial estate (optional)

PAWEES 2012 International Conference

Date: 27 November 2012
Venue: XujatiKambhu Convention Hall & NEWMASIP Training Center

Time	Plenary Session			
08.30-09.00	**Registration**			
09.00- 10.10 (5 minutes for each remarks; 25 minutes for each keynote speech)	**Opening Ceremony and Opening Remarks** - Dr. BoonsomLerthirankul (Dean of Faculty of Engineering, CU) - Dr. PiromKamol-ratanakul (President of Chulalongkorn University) - Dr. VudtechaiKapilakanchana (President of Kasetsart University) - Dr. Tai-cheol Kim (President of PAWEES) Keynote Speech - Mr. LertvirojKowattana (Director General of RID) - Mr. Hiroyuki Konuma (Assistant Director General of FAO)			
10.10-10.30	**Coffee break**			
10.30- 12.10 (20 minutes for each keynote speech)	**Session A Climate Change and Uncertainty** - Keynote Speech Dr. Jin Soo Kim (President-elect of KSAE) **Session B Participatory Management for Irrigation Projects** - Keynote Speech Mr.Va-Son Boonkird (Royal Irrigation Department) **Session C Emerging Technologies in Water Management** - Keynote Speech Mr. Wei-Fuu Yang (President of TAES, Taiwan) Prof. Fi-John Chang (National Taiwan University) **Session D Environmental Sustainability in Paddy Irrigation and Drainage** - Keynote Speech Dr. ShoShiozawa (President of JSIDE)			
12.10- 13.00	**Lunch break**			
13.00- 15.00 (15 minutes for each presentation)	**Session A** Climate Change and Uncertainty	**Session B** Participatory Management for Irrigation Projects	**Session C** Emerging Technologies in Water Management	**Session D** Environmental Sustainability in Paddy Irrigation and Drainage
15.00- 15.30	**Coffee break**			
15.30- 16.30 (15 minutes for each presentation)	**Session A** Climate Change and Uncertainty	**Session C** Emerging Technologies in Water Management	**Session D** Environmental Sustainability in Paddy Irrigation and Drainage	**Session D** Environmental Sustainability in Paddy Irrigation and Drainage
18.00-20.00	**Reception Dinner**			

PAWEES 2012 International Conference (cont.)

Date: 28 November 2012

Venue: XujatiKambhu Convention Hall & NEWMASIP Training Center

Time	Plenary Session (Tentative)		
08.30-09.00	**Registration**		
09.00-10.00 (15 minutes for each presentation)	**Session A** Climate Change and Uncertainty	**Session C** Emerging Technologies in Water Management	**Session D** Environmental Sustainability in Paddy Irrigation and Drainage
10.00-10.30	**Coffee break**		
10.30-12.00 (15 minutes for each presentation)	**Session C** Emerging Technologies in Water Management	**Session C** Emerging Technologies in Water Management	**Session D** Environmental Sustainability in Paddy Irrigation and Drainage
12.00- 13.00	**Lunch break**		
13.00- 14.00	**Award ceremony** International Award Paper and Review Award		
14.00-15.00	**Agenda I-**PWE publication		
15.00- 15.30	**Coffee break**		
15.30-15.45	**Agenda II**- Management of PAWEES		
15.45-16.00	**Agenda III**- International cooperation opportunities among member countries		
16.00-16.20	**Bangkok Statement**		
16.20-16.30	**Closing Remarks**		
17.30	**Dinner with cultural events:** Loy Krathong		

Session A Climate Change and Uncertainty

(15 minutes for each presentation)

Invited paper: Farmers' responses to climate change adaptation in irrigation project (Thailand Case Study) by Assoc. Prof. Chaiyuth Suksri, Chulalongkorn University, Thailand.

A1. A review of land-use change scenarios by new climate change scenarios in Korea (Oh, Y.-G.*, S.-H. Yoo, D.K. Lee, J.-Y. Choi)

A2. Simulation of GHG emission from paddy by DNDC model for climate change impact in Korea (Shin, M., J. Jang, Y. Sung, J. Choi)

A3. Agricultural Infrastructure Database Establishment for Vulnerability Assessment According to Climate Change in Korea (Kim, S.M.*, S.M. Kim, M.W. Jang)

A4. Coping with uncertainties in climate change by stochastic storm rainfall simulation (Cheng, K.-S.*,Y.-C. Wu, Y.-F. Su, J.-J. Liou)

A5. The study to parameter sensitivity analysis of the Denitrification-Decomposition (DNDC) model (Vanichsan, D.*, and B. Kwanyuen)

D16. A Study on Nonpoint Pollution Management in Korea for Sustainable Water Resource (Lee, S.*, C. G. Yoon, S.-J. Lee, J.-h. Choi)

D17. Land use management and rice cropping pattern for sustainable solution to reduce flood risk at Chaophraya River Basin, Thaialnd (Kwanyuen, B. and N. Cherdchanpipat)

D18. Challenges in the decontamination of radioactive cesium of Fukushima: a rural planning perspective (Hashimoto, S.*, H. Arita, T. Yasutaka and Y. Iwasaki)

D19.Evaluation of effects of soil moisture content and wind condition on wind erosion in bare soil field (Yuge, K.*, M. Anan, and Y. Shinogi)

D20. Shift of Functional Roles of Irrigation Ponds in Agricultural Society- a Case Study in Taoyuan Tableland (Tan, C.-H.*, H.-Y. Hsu)

D21. Impacts of irrigation sources and practices on the nonpoint source pollution loadings from paddy fields (Cho, J., J.R. Jang, I. Song*, J.S. Kim, J.B. Lee, M.S. Kang, C.-G. Yoon, and J.S. Kim)

D22. Soil Macro Nutrient (N, P, K) during Growth Stages under Conventional and SRI (System of Rice Intensification) Practices in Tropical Soil (Ardiansyah*, Masrukhi, C. Arif, S.K. Saptomo, B.I. Setiawan)

D23. Effect of Cotton Mulch Sheets on Water Flow, EC, and Temperature Pattern in Masa (Loamy-sandy) Soil under Lettuce Crop Cultivation (Wijaya, K.*, H. Ueno, B.I. Setiawan, and Ardiansyah)

D24. A study of the reason why the reported yields of the System of Rice Intensification (SRI) are so widespread (Wakimoto, Y.*, E. Yamaji and S. Sato)

D25. Monitoring of Shallow Groundwater Infiltration of Pollutant Loads in Greenhouse and Conventional Farming Practices (Hong, E.M.*, J.-Y. Choi, M. S. Kang, S.-H. Yoo, J.-R. Jang)

K. Elant
PAKEES 2012
Secretar

SIGN

Organizing Committee

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1. Mr. Lertviroj Kowattana, Director General of Royal Irrigation Department

Co-Chairperson

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3. Mr. Vudtechai Kapilakanchana, President of Kasetsart University
4. Dr. Tai-cheol Kim, President of PAWEES, Vice-President of ICID

Advisor

5. Dr. Yohei Sato, Honorary President of PAWEES
6. Dr. Hiroyuki Konuma, Assistant Director General of FAO
7. Dr. ShoShiozawa, President of JSIDRE, Japan
8. Dr. Chan-Yong Sung, President of KSAE, Korea
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   Dean of Faculty of Engineering at Kamphaengsaen, Kasetsart University, Thailand

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19. Dr. Watchara Suidee, Royal Irrigation Department (RID), Thailand

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Faculty of Engineering at Kamphangsaen, Kasertsart University (KU)
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3. Dr. Bancha Kwanyuen, Kasetsart University, Thailand
4. Mr. Va-Son Boonkird, Royal Irrigation Department (RID),Thailand

Member

5. Dr. Thanet Aksorn, Royal Irrigation Department (RID), Thailand Member
6. Dr. Ekasit Kositsakulchai, Kasetsart University, Thailand
7. Dr. Yutaka Matsuno, Secretary General of PAWEES (Kinki University, Japan)

Secretary

8. Miss Mada Iaumsupanimit, Chulalongkorn University, Thailand

Pre-Registration

Participants or visitors must pre-register for the international conference on website: http://project-wre.eng.chula.ac.th/watercu_eng/ because seating is limited and pre-registration closes on November 23, 2012

1 (November 27, 2012) Plenary session presentation Venue: Learning Building 2

Session A Climate Change and Uncertainty
Venue: Lecture Room C11

ID	Chair: Assoc. Prof. Dr. Nuchanart Sriwongsitanon, KU
-	**Invited paper:** Farmers' responses to climate change adaptation in irrigation project (Thailand Case Study) Assoc. Prof. Chaiyuth Sukhsri, Chulalongkorn University, Thailand.
008	**Paper A1:** Simulation of GHG emission from paddy by DNDC model for climate change impact in Korea Shin, M., J. Jang, Y. Sung, J. Choi
025	**Paper A2:** Coping with uncertainties in climate change by stochastic storm rainfall simulation Cheng, K.-S.*,Y.-C. Wu, Y.-F. Su, J.-J. Liou
032	**Paper A3:** The study to parameter sensitivity analysis of the Denitrification-Decomposition (DNDC) model Vanichsan, D.*, and B. Kwanyuen
046	**Paper A4:** Climate Change Impact Assessment in Sukhothai Province: Intercomparison between Three Global Climate Models Hanittinan, P.*, S. Koontanakulvong

Session B Participatory Management for Irrigation Projects
Venue: Lecture Room C12

ID	Chair: Prof. Joongdae Choi , Korea
005	**Paper B1:** Relationship between irrigation water management by farmers' group and the levy system Uchimura, M.*, S. Sakata, T. Tomosho
033	**Paper B2:** Irrigation Vulnerable Duration Assessment using Distribution of Agricultural Water Supply and Demand Nam, W.-H.*, T. Kim, J.-Y. Choi, J.J. Lee
044	**Paper B3:** Assessment of Farmer Participation in Irrigation Management for Paddy Irrigation Development in Myanmar Naing, M.M.*, Z.M. Htut
071	**Paper B4:** Investigation of paddy field irrigation activities by farmers aiming for demand-oriented irrigation service Iida, T.*, M. Kimura, K. Yoshida, N. Kubo, T. Yokoi

Session C Emerging Technologies in Water Management
Venue: Lecture Room C14

ID	Chair: Dr. Aksara Putthividhya, CU
012	**Paper C1:** Assessing Flood Damages of Rice in the Chao Phraya Delta, Using MODIS Satellite Imageries Kotera, A.*, T. Nagano
015	**Paper C2:** Optimizing Non-Flooded Irrigation under System of Rice Intensification Crop Management using Genetic Algorithms Arif, C.*, M. Mizoguchi, B.I. Setiawan, R. Doi
018	**Paper C3:** Investigating the interactive recharge mechanisms between surface water and groundwater over the Jhuoshuei River Basin in Central Taiwan Chang, Fi-John et al.
023	**Paper C4:** A Bayesian Uncertainty Analysis of the Modelled Surface- and Ground-Water Flows in an Agricultural Watershed Imagawa, C.*, I. Hondoh
024	**Paper C5:** A Study on Drainage Efficiency of Shortcut Canal Project in the Lower Thachin River Intaboot, N.*, W. Taesombat

Coffee break

Session A Climate Change and Uncertainty
Venue: Lecture Room C11

ID	Chair: Prof. Chaiyuth Suksri, CU
049	**Paper A5:** Probability based assessment of Climate Change Impact on Irrigation Systems in Upper Chao Phraya Basin Koontanakulvong, S.*, C. Suthidhummajit
057	**Paper A6:** Mitigation Method of Irrigation Systems against Climate Change in the Chao Phraya Basin, Thailand Miyazato, T., K. Higuchi*, and H. Watanabe
075	**Paper A7:** Analysis Framework for Water Resource Policy Decision-Making under Effects of Climate Change N. Bongochgetsakul, P. Suttinon, K. Uemoto, S. Nasu
051*	**Poster presentation A8:** Assessment of Climate Change Impact on Agricultural Water Supply Capacity Using SWAT and MODSIM models Ahn, S.R.*, R. Ha, and S.J. Kim
052*	**Poster presentation A9:** Assessment of Climate Change Impact on Multi-purpose Dam based on RCP emission scenarios Using SLURP model Ha, R.*, S.R. Ahn, and S.-J. Kim

Session C Emerging Technologies in Water Management
Venue: Lecture Room C12

ID	Chair: Mr. Boonyong Piyasirinon , RID
031	**Paper C6:** Drought response model by farmers after decreasing water supply Tanji, H.*, H. Kiri and T. Nakaya
036	**Paper C7:** Development of Automated Irrigation System for Food Production Land Saptomo, S.K.*, B.I. Setiawan
047	**Paper C8:** Satellite Data Application for flood simulation Pakoksung, K.*, S. Koontanakulvong, A. Sriaiyawat
048	**Paper C9:** Statistical Forecasting of Rainfall and Runoff by ENSO index in Chao Phraya River Basin In Thailand Chaowiwat, W.*, S. Koontanakulvong
055	**Paper C10:** Estimation of Streamflow by SWAT Model in Sedone River Basin, LAO P D R Kimala, V.* and E. Kositsakuchai
059	**Paper C11:** Yoshino and Nan River Basins Development and Management Comparative Study Putthividhya, A.*, S. Koontanakulvong, and P. Hoisungwan

Session C Emerging Technologies in Water Management
Venue: Lecture Room C14

ID	Chair: Assoc. Prof. Dr. Suwattana Jittaladakorn, KU
061	**Paper C12:** System of Environment-Economic Accounting for Water in case of Thailand Suttinon, P.*, and S. Nasu
062	**Paper C13:** Application of Input-Output Table for future water resources management under policy and climate change in Thailand: Rayong Province Case study Jampanil, D.*, P. Suttinon, S. Nasu and S. Koontanakulvong
063	**Paper C14:** Water Footprint of Bioethanol Production in Thailand Sukumalchart, T.*, A. Pornprommin, S. Lipiwattanakarn
066	**Paper C15:** Development of a Float Type Optical Water Level Measurement by Image Processing Technique: Field Experiment Sirivitmitrie, C.*, V. Vudhivanich, P. Chuagula
077	**Paper C16:** Regional difference in the citizen's consciousness of water resources Uemoto, K.*, P. Suttinon, N. Bongochgetsakul, S. Nasu
073*	**Poster presentation C17:** Estimation of Optimum Planting Date of Cassava after Rice based on Real-time monitoring data using Field Monitoring System in Rain-fed upper paddy field in Northeast Thailand Srisutham, M., M. Mizoguchi, A. Polthanee, R. Doi

2 (November 28, 2012) Plenary session presentation Venue: Learning Building 2

ion D Environmental Sustainability in Paddy Irrigation and Drainage
Venue: Lecture Room C11

ID	Chair: Assoc. Prof. Dr. Kobkiat Pongput, KU
001	**Paper D1:** Can Asian Experience be transferred to Africa? -Lessons Learned from Drafting a Rice Production Manual in Africa Fujimoto, N.*, K. Osuga and C. Hirose
002	**Paper D2:** Water Quality Constituents Export from Paddy Field in Southern Korea Yoon, K.-S.*, D.H. Choi, J.W. Jung, W.J Choi, K.S. Lee, B.J. Lim
006	**Paper D3:** Evaluation of field Measurements and Estimated Rice Crop Water Requirement Maina M. M.*, M. S. M. Amin, W. Aimrun, A. Samsuzana
007	**Paper D4:** Effect of Rice Straw Mat Mulch and Soil Amendments on Runoff under Laboratory Rainfall Conditions Won, C., M. Shin, Y. Choi, J. Shin, W. Park, J. Choi*
009*	**Poster presentation D5:** Runoff and NPS Pollution Discharge Characteristics from Sloping Upland Fields in Korea Shin, J.Y., M. Shin, H. Yang, J. Choi

Session D Environmental Sustainability in Paddy Irrigation and Drainage
Venue: Lecture Room C12

ID	Chair: Prof. Seong-Joon Kim, Korea
013	**Paper D6:** Genetic diversities and population structures of small freshwater fishes in Mekong River basin Koizumi, N.*, S. Morioka, A. Mori, B. Vongvichith, K. Nishida, K. Watabe and T. Takemura
014	**Paper D7:** Characteristics of Drainage Water Quality and Loading from Paddy Field under Cyclic Irrigation and Its Management Options Kurihara, K.*, Y. Matsuno, and N. Hatcho
017	**Paper D8:** Estimating Regional Total Phosphate Concentration in a River Basin through the NARX network Chang, Fi-John et al.
021	**Paper D9:** Development of the World Atlas of Irrigated Agriculture for Sustainability Science Nagano, T.*, A. Kotera
022	**Paper D10:** Influential factors in determining the timing of transplanting lowland rice: case study in Lao PDR Ikeura, H.*, S. Inkhamseng, S. Vongphachanh, P. Xaypanya

Session D Environmental Sustainability in Paddy Irrigation and Drainage
Venue: Lecture Room C14

ID	Chair: Prof. Nobumasa Hatcho, Japan
027	**Paper D11:** Habitat potential maps of three frog species for paddy field areas of the middle Sakura River basin, Japan Watabe, K.*, A. Mori, N. Koizumi, T. Takemura and K. Nishida
040	**Paper D12:** Challenges in the decontamination of radioactive cesium of Fukushima: a rural planning perspective Hashimoto, S.*, H. Arita, T. Yasutaka and Y. Iwasaki
058	**Paper D13:** Soil Macro Nutrient (N, P, K) during Growth Stages under Conventional and SRI (System of Rice Intensification) Practices in Tropical Soil Ardiansyah*, Masrukhi, C. Arif, S.K. Saptomo, B.I. Setiawan
069	**Paper D14:** A study of the reason why the reported yields of the System of Rice Intensification (SRI) are so widespread Wakimoto, Y.*, E. Yamaji and S. Sato
072	**Paper D15:** Monitoring of Shallow Groundwater Infiltration of Pollutant Loads in Greenhouse and Conventional Farming Practices Hong, E.M.*, J.-Y. Choi, M. S. Kang, S.-H. Yoo, J.-R. Jang

Coffee break

* Poster presentation

DAY 2 (November 28, 2012) Plenary session presentation Venue: Learning Building 2

		Session D Environmental Sustainability in Paddy Irrigation and Drainage Venue: Lecture Room C11		**Session D Environmental Sustainability in Paddy Irrigation and Drainage** Venue: Lecture Room C12		**Session D Environmental Sustainability in Paddy Irrigation and Drainage** Venue: Lecture Room C14
	ID	Chair: Assoc. Prof. Dr. Kobkiat Pongput, KU	**ID**	Chair: Prof. Seong-Joon Kim, Korea	**ID**	Chair: Prof. Nobumasa Hatcho, Japan
09.00	001	**Paper D1:** Can Asian Experience be transferred to Africa? -Lessons Learned from Drafting a Rice Production Manual in Africa Fujimoto, N.*, K. Osuga and C. Hirose	013	**Paper D6:** Genetic diversities and population structures of small freshwater fishes in Mekong River basin Koizumi, N.*, S. Morioka, A. Mori, B. Vongvichith, K. Nishida, K. Watabe and T. Takemura	027	**Paper D11:** Habitat potential maps of three frog species for paddy field areas of the middle Sakura River basin, Japan Watabe, K.*, A. Mori, N. Koizumi, T. Takemura and K. Nishida
09.20	006	**Paper D2:** Evaluation of field Measurements and Estimated Rice Crop Water Requirement Maina M. M.*, M. S. M. Amin, W. Aimrun, A. Samsuzana	014	**Paper D7:** Characteristics of Drainage Water Quality and Loading from Paddy Field under Cyclic Irrigation and Its Management Options Kurihara, K.*, Y. Matsuno, and N. Hatcho	040	**Paper D12:** Challenges in the decontamination of radioactive cesium of Fukushima: a rural planning perspective Hashimoto, S.*, H. Arita, T. Yasutaka and Y. Iwasaki
09.40	007	**Paper D3:** Effect of Rice Straw Mat Mulch and Soil Amendments on Runoff under Laboratory Rainfall Conditions Won, C., M. Shin, Y. Choi, J. Shin, W. Park, J. Choi*	017	**Paper D8:** Estimating Regional Total Phosphate Concentration in a River Basin through the NARX network Chang, Fi-John et al.	058	**Paper D13:** Soil Macro Nutrient (N, P, K) during Growth Stages under Conventional and SRI (System of Rice Intensification) Practices in Tropical Soil Ardiansyah*, Masrukhi, C. Arif, S.K. Saptomo, B.I. Setiawan
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10.20	004	**Paper D6:** Multi regression analysis of water quality characteristics in lowland paddy fields Kato, T.*,K. Yoshida, I. Azechi, K. Noda, H. Kuroda	022	**Paper D10:** Influential factors in determining the timing of transplanting lowland rice: case study in Lao PDR Ikeura, H.*, S. Inkhamseng, S. Vongphachanh, P. Xaypanya	072	**Paper D15:** Monitoring of Shallow Groundwater Infiltration of Pollutant Loads in Greenhouse and Conventional Farming Practices Hong, E.M.*, J.-Y. Choi, M. S. Kang, S.-H. Yoo, J.-R. Jang
10.30	009*	**Poster presentation D7:** Runoff and NPS Pollution Discharge Characteristics from Sloping Upland Fields in Korea Shin, J.Y., M. Shin, H. Yang, J. Choi				
10.40		**Coffee break**				

Remark: * Poster presentation

Effect of Cotton Mulch Sheets on Water Flow, EC, and Temperature Pattern in *Masa* (Loamy-sandy) Soil under Lettuce Crop Cultivation

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Abstract

Water flow pattern in lettuce growing soil under cotton (CM), plastic (PM), and zero mulch (C) coverage was identified, and corresponded with its electrical conductivity (EC) and temperature distribution during Japan summer of 2009. Three cultivation plots of 300 cm x 100 cm large were prepared. Soil-water content, EC, and temperature at 10 and 20 cm depth were hourly monitored. Water flow in each soil profile was characterized and modeled by using van-Genuchten model. The CM soil showed higher water content (0.29-0.33 $cm^3\ cm^{-3}$) than the PM (0.29-0.31 $cm^3\ cm^{-3}$) and C (0.26 $cm^3\ cm^{-3}$). The soil EC with CM (0.22-0.30 dS m^{-1} at rainfall rate of 32.1 mm d^{-1}) was higher than others (< 0.02 dS m^{-1}). The soil temperature with CM was respectively 2-3 and 4-5 °C lower than with PM and C. The CM plot had higher soil K_{us} (3.1-4.4 cm d^{-1}) compared to the PM (0.18-0.21 cm d^{-1}) and C plot (0.36 cm d^{-1}). The results reflect a unique characteristic of the cotton mulch, in which it is able not only to improve a sufficient water and nutrients availability, but also to control temperature in its underlined soil for an effective growth of the crop.

Keywords: cotton mulch, water flow, lettuce, hydraulic conductivity, loamy-sandy soil

1. Introduction

During last couple of decades, mulch has been utilized in agriculture due to its benefit in maintaining soil moisture and temperature, reducing erosion impact, suppressing weeds and insects, and enhancing soil nutrients (Aladesanwa and Adigun, 2008; Rabary et al., 2008; Jin et al., 2007; Dahiya et al., 2007; Babola et al., 2007; Doring et al., 2005). Over various types of mulches, plastic is most common mulch, which is low cost and easy to applied (Zhou et al., 2009). The mulch also is effective in reducing evaporation rate from soil surface by 55% (Xie et al., 2005). However, an intensive use of plastic mulches may deteriorate soil condition as well as environmental risks (Tarara and Ham, 1999). For instance, polyethylene films generally causes an extreme high temperature inside soil especially in hot-summer, resulting in low soil microbial activities as well as organic matter mineralization, and high rate of soil nutrients volatilization (Moreno and Moreno, 2008). Moreover, the application of a huge amount of plastic mulches, i.e., 60,000 ton yr^{-1}, in Japan, has brought to an agricultural field pollution by its landfill disposal (Ueno et al., 2008).

Cotton sheet is a new type of biodegradable mulch, produced from cotton waste. Ehime University and Marusan Sangyo Co. Ltd., Japan, has proposed the use of cotton mulch in fruits and vegetables cultivation in Ehime's *Masado* or loamy-sandy soil, as an alternative way to minimize potential risk of CO_2 emission by its waste incineration in surrounding areas. Through some experiments on cabbage field by Ueno et al. (2008), it was found that the mulch is effective in suppressing weeds, improving growth and yield of the crop, enhancing soil-N uptake by the crop, and is potential to prevent soil and nutrient loss by erosion. Moreover, the application of the cotton waste on the lettuce crop in summer can provide a suitable nutrient added into the soil (Asagi et al., 2008) as well as good productivity (Kinebuchi et al., 2008). However, the effect of the cotton mulch sheet on the dynamic change of water and temperature in the soil profile including their inter-correlation and relation to nutrients distribution in the soil and uptake by the crop hasn't been evaluated yet.

This research was aimed to characterize the distribution pattern of water, electrical conductivity, and temperature as well as their inter-correlation in the lettuce field soil with the cotton mulch, compared to those with plastic and zero mulch application. This information is essentially required for modeling water and nutrients transports within lettuce field soil in further steps to support the development of a sustainable farming system for the lettuce crop.

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2. Methodology

2.1. Experimental plot and data collection

The research was conducted at Field Science Center, Ehime University, Japan during summer of 2009 (soil type: decomposed-granite or *Masado* in Japanese, Table 1). Three lettuce plots with 300 cm x 100 cm large each were prepared for cotton mulch (CM), plastic mulch (PM), and zero or zero mulch (C), respectively, and the seeds were sowed on each plot with interval of 30 cm x 30 cm (Fig. 1, top). Water content, electrical conductivity (EC), and temperature of soil with depth of 0-10 and 10-20 cm was hourly monitored at each plot by using 5TE moisture sensors coupled with EM50 data logger (Decagon Devices, Inc.) (Fig. 2, bottom). Undisturbed soil samples in the same depths were also sampled for laboratory analysis of water content, dry bulk density, and saturated hydraulic conductivity of soil. Meteorological data, mainly precipitation, aerial temperature, relative humidity, wind speed, and solar radiation was summarized from the local weather station.

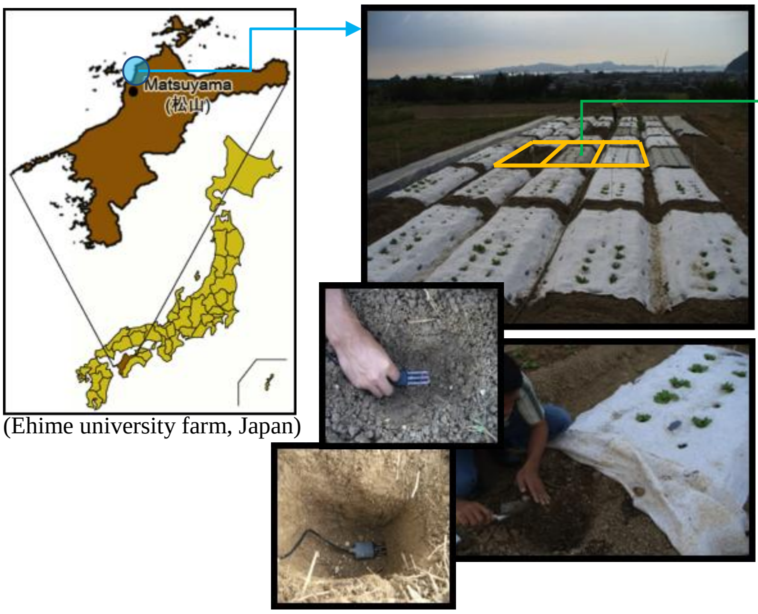

Fig. 1. Schematic diagram of the field monitoring for water content, temperature, and EC in the lettuce growing soil with three different mulches coverage.

Table 1. Physical properties of Shikoku's decomposed-granite soil

Parameters	Value
Texture (Gravel/sand : Silt : Clay) (Kg Kg^{-1})	82.9 : 9.6 : 7.6 (loamy-sand) [3)]
Particle density (g cm^{-3})	2.67 – 2.68 [1)]
Dry bulk density (g cm^{-3})	1.40 – 1.43 [1)]
Porosity (%)	60 – 70 [3)]
Hydraulic conductivity (cm d^{-1})	50.9 – 419.9 [2,3)]
Soil organic matter or C-N ratio (%)	8.68 – 11.01 [4)]

[1)] Farmanullah et al. (1998); [2)] Fujimaki et al. (2004); [3)] Dahal et al. (2008); [4)] Razafindrabe et al. (2010)

2.2. Laboratory analysis and water flow modeling

Prior to field monitoring, 5TE moisture sensors were specifically calibrated by using local *Masa* or loamy-sandy soil to gain more representative field data. This step was conducted by repacking soil into an acrylic cylinder with 8 cm diameter and 7 cm height, and followed by sensor operation into sample for several seconds. Sensor output (in mV) was recorded by using Em50 data logger. Volumetric water content of repacked sample was then measured gravimetrically by using oven dryer, and then was plotted against the output voltage data by employing least square method to obtain a calibration formula.

Soil physical properties mainly dry bulk density and saturated hydraulic conductivity were measured by using gravimetric and falling head method, respectively. The latter was used as one of the inputted hydraulic parameters in water flow ($K(\theta)$ in cm d^{-1}) simulation based on the monitored field data (Fig. 1, bottom) with help of van-Genuchten model (Ritter et al., 2003), as shown in Eqn. (1-3).

$$K(\theta) = K_s S_e{}^{l}\left[1 - (1 - S_e{}^{1/m})^m\right]$$

$$S_e = \theta - \theta_r/\theta_s - \theta_r = 1/(1 + |\alpha h|^n)^m \qquad (2)$$

$$m = 1 - 1/n \qquad n > 1 \qquad (3)$$

where, $K(\theta)$: unsaturated hydraulic conductivity, as a function of volumetric water content (cm d^{-1}), K_s: saturated hydraulic conductivity (cm d^{-1}), S_e: effective saturation (cm^3 cm^{-3}), θ: actual or field volumetric water content (cm^3 cm^{-3}), θ_r: residual volume wetness (cm^3 cm^{-3}), θ_s: saturated volumetric water content (cm^3 cm^{-3}), and n, α, l: fitting parameters

The hydraulic properties data is usually required to determine soil water and nutrients dynamics as well as their balance in an agricultural field, since the parameters are inter-correlated. In this study, water balance at each lettuce plot was determined by quantifying the incoming and outgoing water flow into root zone over certain period of time. The rainfall and irrigation add water to root zone, and part of them might be lost by runoff and deep percolation toward groundwater recharge. The water in the root zone might be also depleted to atmosphere by evapotranspiration. Therefore, the dynamic change in water within soil profile (ΔSW) was calculated by using Eqn. (4).

$$\Delta SW = (P + I) - (R_n + P_c + ET) \qquad (4)$$

where, P, I, R_n, P_c, and ET: added or depleted water by the rainfall (mm), irrigation (mm), runoff (mm), percolation (mm), and actual evapotranspiration (mm), respectively.

The ET was determined by comparing ΔSW and potential evapotranspiration (ET_o, in mm d^{-1}) of Penman-Monteith (Eqn. (5)), in which if the former is superior to the latter, the ET was equalized to the ET_o, instead of ΔSW, and vice versa (Eqn. (6)).

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \dfrac{900}{T + 273} u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.3u_2)}$$

$$ET = \begin{cases} ET_o & ET_o < \Delta SW \\ ET_o & ET_o \geq \Delta SW \end{cases}$$

where, R_n: net radiation at crop surface (MJ m^{-2} d^{-1}), G: soil heat flux density (MJ m^{-2} d^{-1}), T: mean daily air temp. at 2 m height (^{o}C), u_2: wind speed at 2 m height (m s^{-1}), e_s: saturated vapour pressure (kPa), e_a: actual vapour pressure (kPa), Δ: slope of vapour pressure curve (kPa ^{o}C^{-1}), and γ: psychrometric constant (kPa ^{o}C^{-1}).

3. Results and Discussions

3.1. Calibration of 5TE moisture sensors

Fig. 2A shows specific calibration results for 5TE moisture sensors, of which relationship between volumetric water content and output voltage was expressed in a linear regression with R^2 of 0.90. The calibrated equation (Eqn. (7)) was reliable within range of 0.05 – 0.50 cm^3 cm^{-3} volumetric water content, and was overestimated the default equation proposed by Decadon Devices Inc., and also the general calibration results of the previous dielectric constant-based moisture sensors such as TDR proposed by Topp et al. (1980) and Whalley (1993). The former was about 5 – 8 % higher in its calculated data compared to the latters. Furthermore, fitting the data against the gravimetric volumetric water content (Fig. 2B) shows that the calculated data agreed well with the measured ones with high accuracy (R^2 = 0.88) or low error and ($RSME$ = 0.04 cm^3 cm^{-3}). This was similar with the results of the specific calibration for several upland field soils, namely andosol, alluvial, and regosol reported by Wijaya et al. (2003, 2004) and Wijaya and Kuncoro (2008). The whole results above reveals that the specific calibration can be more reliable and applicable, as compared to the default or general ones, to use for the measurement of soil physical properties.

$$\theta = 0.0468 + 0.000648v \qquad (7)$$

where, θ: calculated or predicted volumetric water content by specific calibrated eqution (cm^3 cm^{-3}), and v: output voltage of 5TE moisture sensors read by EM50 data logger (mV).

3.2. Spatio-temporal change in soil water content, EC, and temperature

The distribution pattern of water content in lettuce growing soil profile with various mulches coverage at 0-10 and 10-20 cm depth in response to rainfall and irrigation during 20 – 46 days after transplanting (DAT) is presented in Fig. 3A. In general, the water content change was sensitively depended on rainfall or irrigation rate, due to the basic characteristics of loamy-sandy soil having high total macro-pore inside (Yang et al., 2004; Yamanaka, 1999). The maximum soil water content with CM was higher (0.290 – 0.333 cm^3 cm^{-3}) than that with PM (0.297 – 317 cm^3 cm^{-3}) and C (0.267 cm^3 cm^{-3}). The higher capability of CM over others in intercepting and then distributing rainfall and irrigation water downward, as well as in preventing upward water loss through evaporation (Tolk et al., 1999) might corroborate above results.

Fig. 3B shows the distribution pattern of EC in the lettuce growing soil profile with various mulches coverage at 0-10 and 10-20 cm depth during 20 – 46 DAT. Change in the soil EC, mainly for the cotton mulch (CM) plot, strongly corresponded with rainfall or irrigation rate, in which it reached a maximum value of 0.30 dS m^{-1} when total water supply was in highest rate, i.e., 32.1 mm d^{-1}. Higher decomposed-granite content in *Masado* reflecting higher plasticity or cation exchange capacity (CEC) than common sandy soils (Nishikawa, 1991) might affect such condition. In fact, the plasticity or CEC of a soil generally increases with increasing its water content (and vice versa), since water might act as an electrolyte medium conducting mineral ions to move easily through soil pore (Rhoades et al., 1989; Rhoades and Corwin, 1981). Furthermore, Kachanoski et al. (1988) and Hartsock et al. (2000) reported that when clay is low, as it occurs in loamy-sandy soil, its water content has a greater effect on EC. Accordingly, the higher EC value in CM soil, as compared to that in PM and C soil, was because of its better capability in transmitting the incoming water as well as maintaining or holding the underlined soil water.

Unlike EC that had positive correlation with rainfall or irrigation rate, soil temperature inversely corresponded to both parameters, in which it was decreased with increasing water supply rate and soil water content (Fig. 4A). This was due to high capacity of water in conducting and then transmitting a heat from soil after rainfall or irrigation added to surrounding profile, hence reduced its temperature. Specifically, the soil temperature change in CM plot within both depth was lowest, and consecutively followed by PM and C plot. Lower capacity of PM, as compared to CM, to transmit a heat from soil to atmosphere might be a reason for such condition (Anikwe, 2007; Tarara and Ham, 1999). On other hand, C plot or bare soil could transmit a heat from soil to atmosphere as effective as CM, but it also absorbed a heat directly from solar radiation, resulting in its highest soil temperature. An effective soil temperature reducing by CM, mainly in hot-summer condition, allowed crop to be healthy grown, since leaf and root of the crop are sensitive to hot temperature (Ueno et al., 2008; Ueno, 2010). Moreover, change in microclimate parameters such as aerial temperature and relative humidity were also related to rainfall rate (Fig. 4B), and in turn might correspond to heat or water vapor rate released from lettuce growing soil (Diaz-Perez, 2007).

3.3. Water flow pattern within Lettuce growing soil profile

Unsaturated hydraulic conductivity (K_{us}) is an essential parameter to understand, mainly in upland agricultures and forests, since it represents the dynamic of water in its soil profile (Chen et al., 2009; Shinomiya et al., 2001). Having knowledge of K_{us} will help us in quantifying water and nutrient budget within certain cropping field including lettuce, which is useful to determine an appropriate irrigation scheduling (Leenhardt et al., 1998; Andreu et al., 1997) as well as a suitable dosage of fertilization (Wang et al., 2008; Jackson et al., 1994). In this study, K_{us} was predicted by employing evaporation inverse analysis (i.e., van Genuchten model in Hydrus-1D) based on the observed volumetric water content of the lettuce growing soils, especially after heavy rainfall and irrigation during 30 – 46 DAT (Fig. 3A). As a result, the volumetric water contents of the soils at 10 and 20 cm depth was fitted well with R^2 values of 0.982 – 0.996 (Fig. 5A and Table 2), and it was comparable to the results of Takeshita and Kohno (1993), Fujimaki et al. (2004), and Yang et al. (2004). Concerning with the 1:1 relation, there were a good agreement between the predicted and observed volumetric water content with R^2 of 0.996 and *RMSE* of 0.0028 cm^3 cm^{-3} (Fig. 5B). This suggests that such fitted parameters is acceptable for predicting the water characteristics and hydraulic conductivity as well as modeling water flow in the lettuce cropping soils under different mulch coverage.

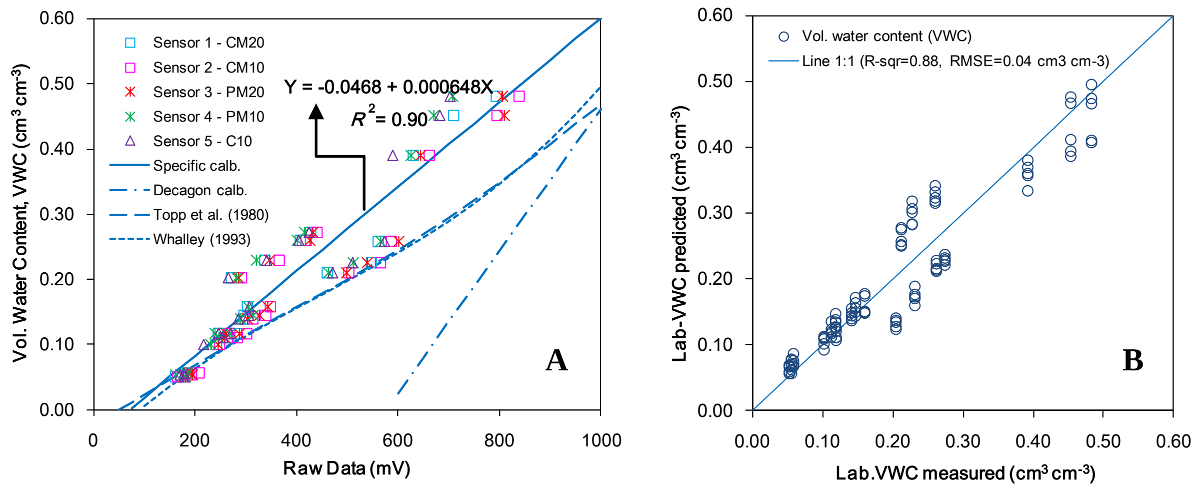

Fig. 2. Calibration of 5TE sensor: volumetric water content vs. sensor output voltage for specific and default/general calibrations (A), and measured vs. predicted volumetric water content (B).

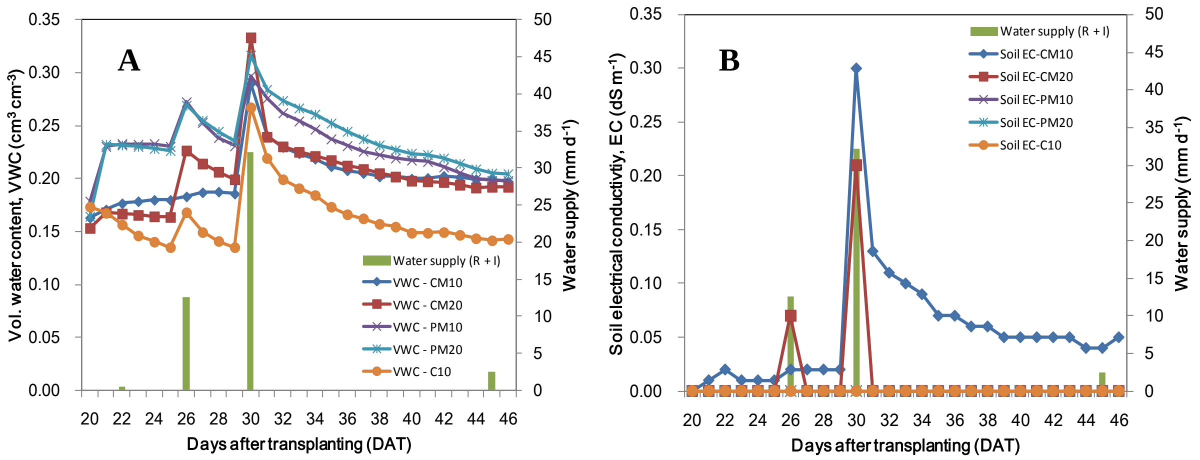

Fig. 3. Distribution pattern of: water (A) and electrical conductivity (B) in lettuce growing soils with cotton, plastic, and zero mulch coverage.

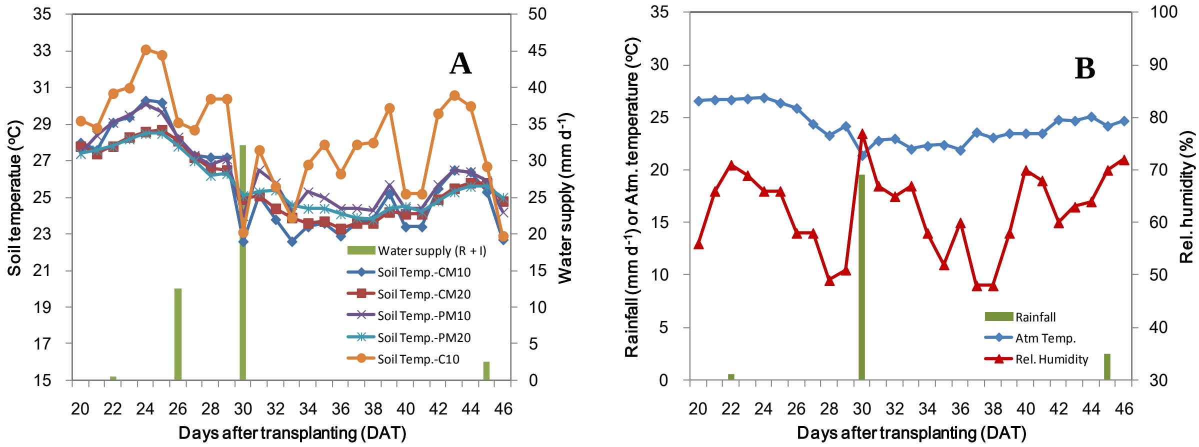

Fig. 4. Distribution pattern of: soil temperature (A) and atmospheric temperature and relative humidity (RH) (B) in the lettuce plots with cotton, plastic, and zero mulches coverage

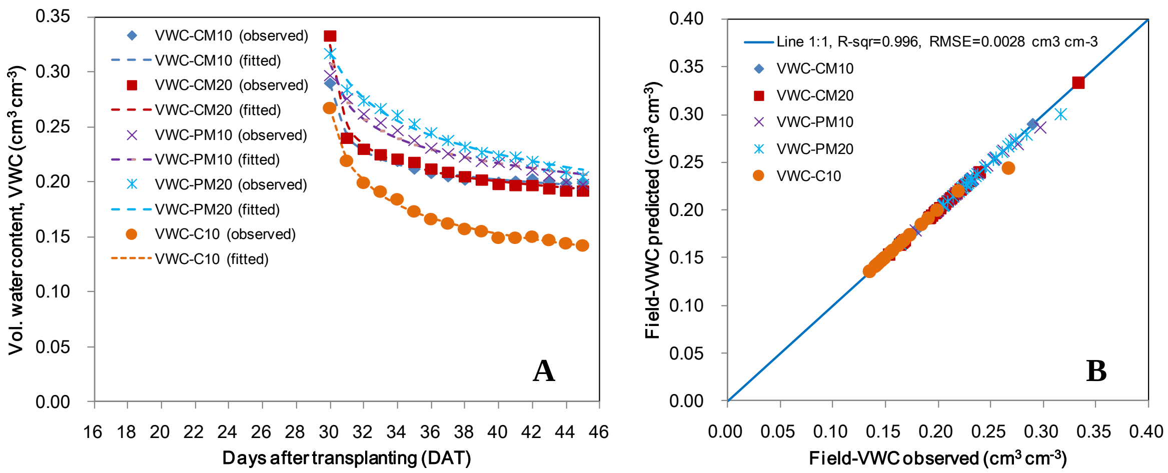

Fig 5. Fitted (or predicted) vs. observed volumetric water contents (VWC) of the lettuce growing soils at 10 and 20 cm depth concerning with: its temporal change during 30 – 46 DAT (A) and 1:1 relation (B).

Table 2. Fitted hydraulic parameters of the lettuce cropping soils with cotton, plastic, and zero mulches coverage at 10 and 20 cm depth

Parameters	Cotton mulch (CM) 10-cm	20-cm	Plastic mulch (PM) 10-cm	20-cm	Zero mulch (C) 10-cm	vG model[5)] (*Masa* or Loamy-sandy soil)
θ_r	0.138	0.144	0.032	0.0000111	0.00813	0.028 – 0.060
θ_s	0.298	0.344	0.308	0.317	0.267	0.314 – 0.350
α	0.116	0.272	0.106	0.094	0.0819	0.079 – 0.940
n	1.335	1.98	1.226	1.140	1.34	1.148 – 1.611
K_s	27.49	9.79	7.07	1.19	5.92	-
l	0.5	0.5	0.5	0.5	0.5	-
R^2	0.991	0.982	0.961	0.985	0.996	0.690 – 0.820
*SSQ***	0.0000716	0.000332	0.000461	0.000209	0.0000666	-

[5)] Takeshita and Kohno (1993); Fujimaki et al. (2004); Yang et al. (2004)

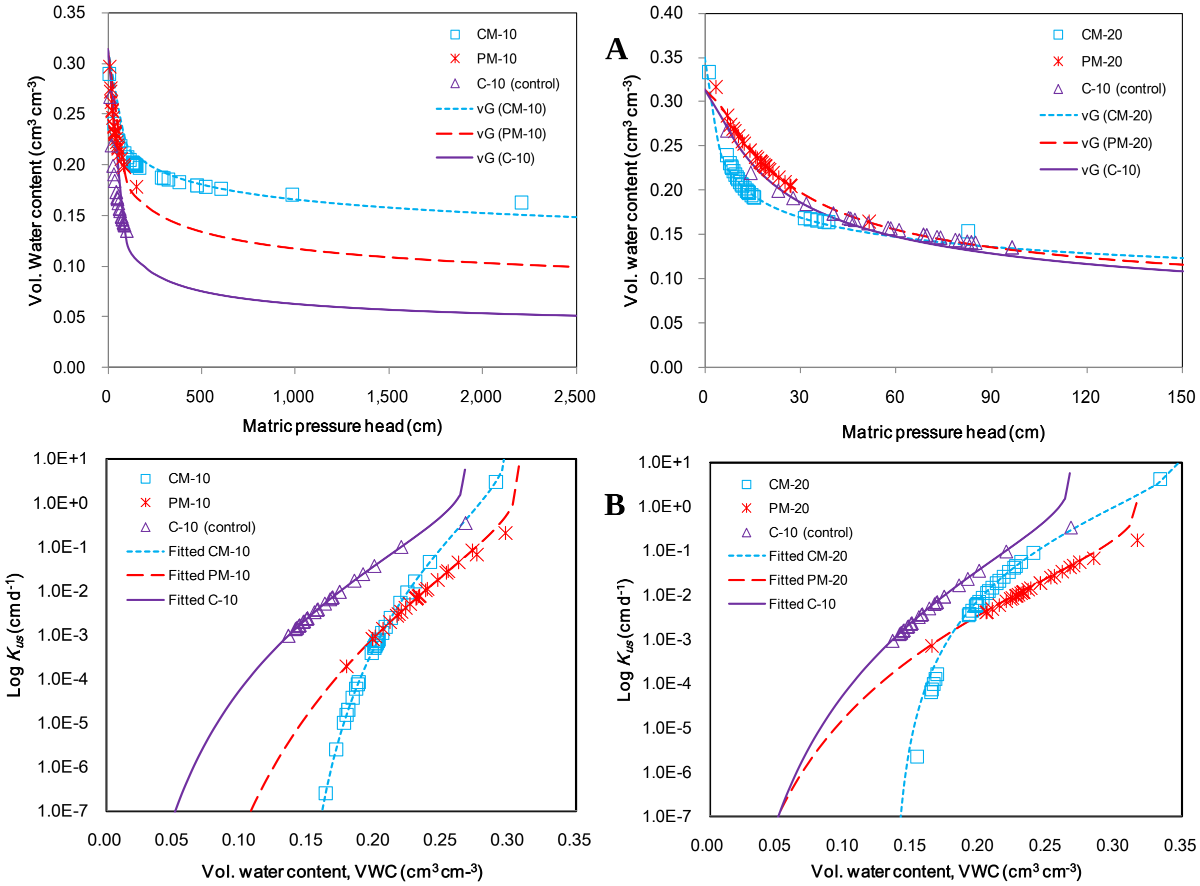

Fig. 6. Soil water characteristics: matric potential vs. VWC (A) and unsaturated hydraulic conductivity vs. VWC (B) of the lettuce soils with various mulches coverage.

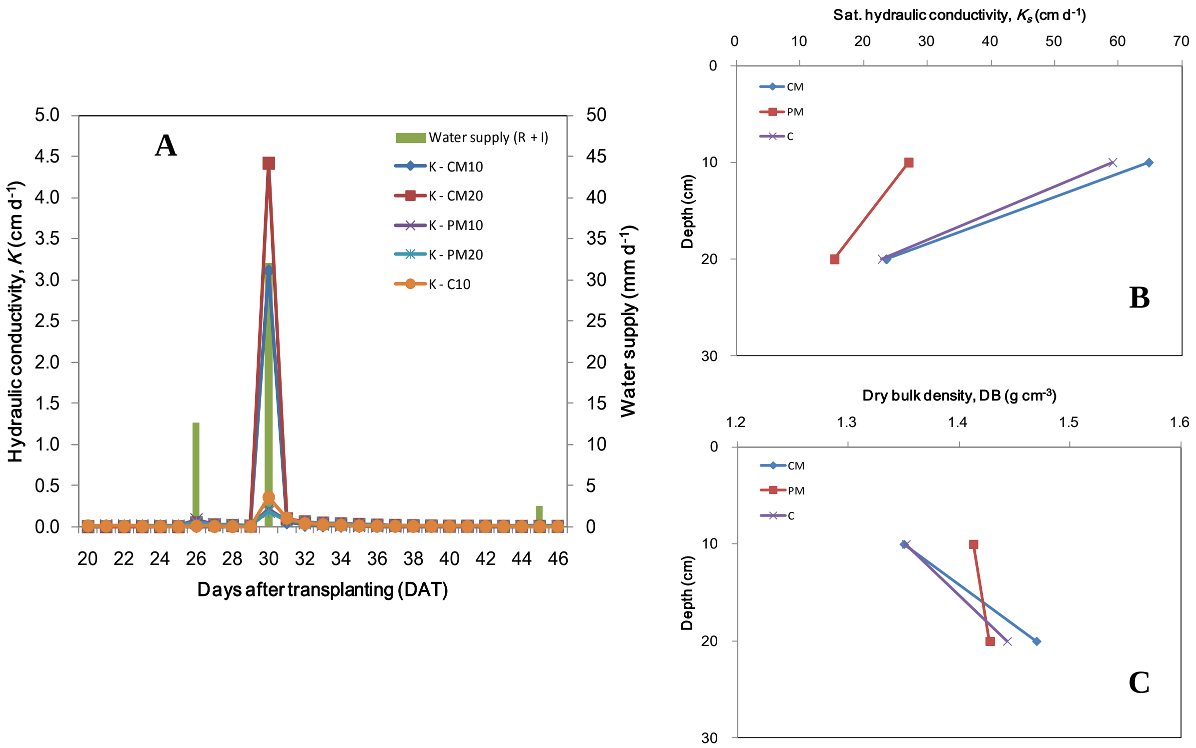

Fig. 7. Temporal (A) and spatial pattern (B) of soil hydraulic conductivity, in relation to its dry bulk density at the end of cultivation period (C), in the lettuce field with various mulches coverage.

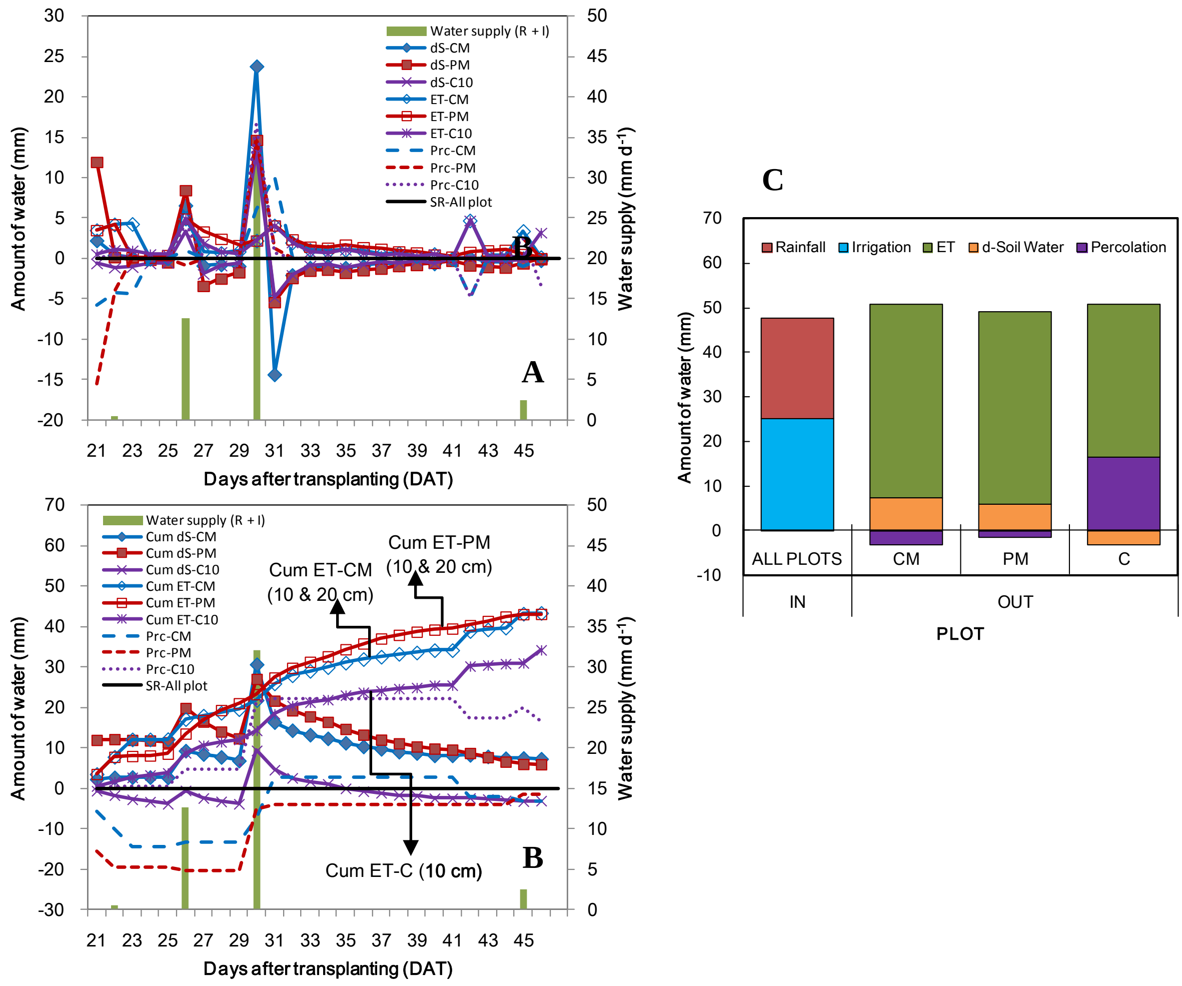

Fig. 8. Water balance, in term of: (A) temporal change, (B) cumulative, and (C) budget in lettuce cropping field with various mulches coverage throughout a cultivation period.

Regarding soil water characteristics curve of each cropping plot (Fig. 6A, B), it was found that CM plot, mainly at 10 cm depth, had highest soil water holding capacity, followed by PM and C, while at 20 cm depth it was relatively similar to others. This was related to the results shown in Fig. 3A, of which CM plot was more effective in transmitting as well as maintaining rainfall and irrigation water input than PM and C plot. Moreover, since CM is biodegradable, it also might improve the underlined soil physical conditions such as bulk density, porosity, and hydraulic conductivity, and also the soil organic matters, especially during the middle to the end of cultivation period (Fig. 7C). Accordingly, the hydraulic conductivity of CM soils at 10 and 20 cm depth were significantly higher compared to that of PM and C soil, in which at field capacity they were ranged between 3.1 – 4.4, 0.18 – 0.21, and 0.36 cm d^{-1}, respectively (Fig. 6B). This reveals that the water flow rate within CM soil profile was either temporary (Fig. 7A) or spatially (Fig. 7B) higher than other mulches covered soils.

3.4. Soil water balance

Fig. 8 shows the water balance in the lettuce growing plot under various mulches coverage within 10 and 20 cm depth during 20 – 46 DAT. The soil water storage in most plots observed was temporary fluctuated, dependent upon the rate of water input. Specifically, CM plot had larger fluctuation in (-14.3 to 23.8 mm) as well as higher cumulative amount of the soil water storage (7.3 mm), mainly during rainfall or irrigation, than PM (fluctuation: -5.4 to 14.7 mm; cumulative: 5.9 mm) and C plot (fluctuation: -4.8 to 13.2 mm; cumulative: -3.0 mm) (Fig 8A, B, C). As compared to PM plot, the ET of CM plot was higher during the initial 20 – 29 DAT, but lower during the last 30 – 46 DAT, while that of C plot was lowest among those three plots and throughout the cultivation period (Fig. 8B). Accordingly, the cumulative ET of CM plot (43.42 mm) was as higher as that of PM plot (43.17 mm), but significantly higher than that of C plot (34.27 mm) (Fig. 8C). In addition, by assuming surface runoff (R_n) was zero due to typically high infiltration rate of sandy soil, it was found that soil water loss by percolation tended to be higher in C plot (16.47 mm within 10 cm depth or 5.15 mm within 0-20 cm depth) than that in CM and PM plot, of which the value was -3.04 mm -1.43 mm, respectively (negative indicated the upward or capillary movement of the soil water) (Fig. 8C).

The above results suggest that the cotton mulch is sufficiently effective in maintaining the underlined soil water that is available to crop. It not only can transmit, and then redistribute the water input from rainfall or irrigation within soil profile, but also can prevent the upward water loss by either evaporation or deeper downward water movement by percolation. Such condition may in turn keep the soil temperature in suitable condition for crop growth (Ueno, 2010; Ueno et al., 2008). Furthermore, the cotton mulch is easily biodegraded in soil, which contributes to a significant improvement of soil physical properties and organic matter (Moreno and Moreno, 2008), hence soil water holding capacity. Although the plastic mulch is almost as effective as the cotton mulch in supporting ET and preventing soil loss by percolation (Zhou at al., 200), it has negative impact on reducing soil water storage, due to its lower transmissible to water input. This plot then may result in higher temperature within its soil profile compared to the cotton plot. In contrast, the zero mulch may allow more water to infiltrate and percolate into the deeper profile, thus reduces its soil water holding capacity as well as ET.

Information on the water balance, like as shown in Fig. 8, is essentially required to support a better water management in a crop cultivation, including irrigation scheduling and fertilizer application to enhance good yield of the crop (Sangare et al., 2012, Pathak et al., 2003). The water balance represents the dynamic movement of water within a crop and its surrounding environment over a cultivation period, in which the effective water uptake by a crop can be determined based on its WUE (water used efficiency) coefficient. The WUE coefficient is calculated by comparing the total aboveground dry matter yield to the cumulative ET value (Mastrorilli et al., 1995). In this study, it was expected that the CM plot might have WUE higher than PM plot, since the former had higher fresh and dry matter compared to the latter, even though both ET values were relatively similar. The high yield of lettuce crop in CM plot was affected by the typical characteristic of the cotton mulch, which was transmissible to water from rainfall or irrigation to produce an appropriate soil water availability and temperature for crop growth. Furthermore, it also was easily biodegraded to enhance organic matters and nutrients accumulated in both the sheet and underlined soil, and to suppress weeds in the field up to about 89%, mainly in hot-summer condition (Ueno, 2010).

4. Conclusions

Water distribution as well as flow in the lettuce field soil under various mulches application such as cotton mulch, plastic mulch, and zero mulch was characterized and modeled with help of 5TE sensor specific calibration and Hydrus-1D analysis. The field with cotton mulch coverage had higher soil water content as well as water holding capacity compared to that with plastic and zero mulch, resulted in its higher soil water and nutrients availability and lower soil temperature than others. The application of the cotton mulch into the lettuce field, mainly in hot-summer condition might contribute to high yield as well as water use efficiency (WUE) of the crop, which was corresponded to its capability in maintaining water and nutrient availability, good temperature condition, and also in suppressing weeds, which is never seen in other mulches.

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References

Aladesanwa, R.D., A.W. Adigun. 2008. Evaluation of sweet potato (*Ipomoea batatas*) live mulch at different spacings for weed suppression and yield response of maize (*Zea mays L.*) in southwestern Nigeria. Crop Protection 27: 968–975.

Andreu, L., J.W. Hopmans, and L.J. Schwankl. 1997. Spatial and temporal distribution of soil water balance for a drip-irrigated almond tree. Agricultural Water Management 35: 123-146 .

Anikwe, M.A.N, C.N. Mbah, P.I. Ezeaku, V.N. Onyia. 2007. Tillage and plastic mulch effects on soil properties and growth and yield of cocoyam (Colocasia esculenta) on an ultisol in southeastern Nigeria. Soil & Tillage Research 93: 264–272.

Asagi, N., H. Ueno, M. Kinebuchi, S. Sano, K. Shimizu, F. Kanke, T. Oomori, N. Fukuda. 2008. Nutrient dynamics in lettuce growing soil with cotton waste mulch. The Crop Science Society of Japan 45: 80-81.

Babalola, O., S.O. Oshunsanya, K. Are. 2007. Effects of vetiver grass (*Vetiveria nigritana*) strips, vetiver grass mulch and an organomineral fertilizer on soil, water and nutrient losses and maize (Zea mays, L) yields. Soil Tillage Research 96: 6–18.

Chen, S., Zhang, X. Chen, and P. Shi. 2009. The impact of land use and land cover changes on soil moisture and hydraulic conductivity along the karst hillslopes of southwest China. Environ.

Earth. Sci., 59 (4): 811-820. DOI: 10.1007/s12665-009-0077-6.

Cook, H.F., G.S.B. Valdes, H.C. Lee. 2006. Mulch effects on rainfall interception, soil physical characteristics and temperature under Zea mays L. Soil Tillage Research 91: 227–235.

Dahal, R.K., S. Hasegawa, A. Nonomura, M. Yamanaka, and K. Nishino. 2008. Failure characteristics of rainfall-induced shallow landslides in granitic terrains of Shikoku Island of Japan. Environmental Geology 56(7): 1295-1310, DOI: 10.1007/s00254-008-1228-x.

Dahiya R., J. Ingwersen, T. Streck. 2007. The effect of mulching and tillage on the water and temperature regimes of a loess soil: Experimental findings and modeling. Soil Tillage Research 96: 52–63.

Diaz-Pe´rez, J.C., R. Gitaitis, B. Mandal . 2007. Effects of plastic mulches on root zone temperature and on the manifestation of tomato spotted wilt symptoms and yield of tomato. Scientia Horticulturae 114: 90–95.

Doring, T.F. M. Brandt, J. Heb, M.R. Finckh, H. Saucke. 2005. Effects of straw mulch on soil nitrate dynamics, weeds, yield and soil erosion in organically grown potatoes. Field Crops Research 94: 238–249.

Gallardo, M. L.E. Jackson, K. Schulbach, R.L. Snyder, R.B. Thompson, and L.L. Wyland. 1996. Production and water use in lettuces under variable water supply. Irrigation Science 16(3):125-137.

Farmanullah, K., K. Sato, and K. Takase. 1998. Effect of soil cohesion on critical flow for riil initiation under different slope conditions. Pak. J. Biol. Sci., 1(4): 244-247.

Fujimaki, H., M. Inoue, and K. Konishi. 2004. A multi-step inflow method for estimating hydraulic conductivity at low pressure under the wetting process. Goderma, 120: 177-185.

Hartsock, N. J., T. G. Mueller, G. W. Thomas, R. I. Barnhisel, and K. L. Wells and S. A. Shearer, 2000. *Soil Electrical Conductivity Variability*. In. P.C. Robert et al. (ed.) Proc. 5th international conference on precision Agriculture. ASA Misc. Publ., ASA, CSSA, and SSSA, Madison, WI.

Jackson, L.E., L.J. Strivers, B.T. Warden, and K.K. Tanji. 1994. Crop nitrogen utilization and soil nitrate loss in a lettuce field. Fertilizer research 37(2): 93-95.

Jin K., Wim M. Cornelis, Wouter Schiettecatte, Junjie Lu, Yuqing Yao, Huijun Wu, Donald Gabriels, Stefaan De Neve, Dianxiong Cai, Jiyun Jin, Roger Hartmann. 2007. Effects of different management practices on the soil–water balance and crop yield for improved dryland farming in the Chinese Loess Plateau. Soil Tillage Research 96: 131–144.

Kachanoski, R.G. E.G. Gregorich, and I.J. Van Wesenbeeck. 1988. Estimating spatial variations of soil water content using no contacting electromagnetic inductive methods. Can. J. Soil Sci. 68:715-722.

Kinebuchi, M., H. Ueno, N. Asagi, S. Sano, K. Shimizu, F. Kanke, T. Oomori, N. Fukuda. 2008. Application effects of the cotton waste mulch on growth and yield of summer sowing lettuce. The Crop Science Society of Japan 45: 78-79.

Leenhardt, D, F. Lafolie, and L. Bruckler. 1998. Evaluation irrigation strategies for lettuce by simulation: 1. Water flow simulations. European J. of Agronomy 8: 249-265.

Mastrorilli, M., K. Katerji, G. Rana, and P. Steduto. 1995. Sweet sorghum in Mediterranean climate: radiation use and biomass water use efficiencies. Industrial Crops and Products 3: 252-260.

Moreno, M.M., A. Moreno. 2008. Effect of different biodegradable and polyethylene mulches on soil properties and production in a tomato crop. Scientia Horticulturae 116: 256–263

Nishikawa, Y. 1991. Application of supercritical fluid extraction/ supercritical chromatography to pesticide residue analysis. Analytical Sci. 7: 567-572.

Pathak, H. P.K. Aggrawal, R. Roetter, N. Karla, S.K. Bandyopahaya, S. Prasad, and H. Van Keulen. 2003. Modelling the quantitative evaluation of soil nutrient supply, nutrient use efficiency, and fertilizer requirements of wheat in India. *Nutrient Cycling in Agroecosystem* 65(2): 105-113.

Rabary, B., S. Sall, P. Letourmy, O. Husson, E. Ralambofetra, N. Moussa, J.L. Chotte. 2008. Effects of living mulches or residue amendments on soil microbial properties in direct seeded cropping systems of Madagascar. Applied Soil Ecology 39: 236 – 243.

Razafubdrabe, B.H.N., B. He, S. Inoue, T. Ezaki, and R. Shaw. 2010. The role of forest stand density in controlling soil erosion: implications to sediment-related disasters in Japan. Environ. Monit. Assess. 160: 337-354. DOI 10.1007/210661-008-0699-2.

Rhoades, J.D. and D. L. Corwin. 1981. Determining soil electrical conductivity-depth relations using an inductive electromagnetic soil conductivity meter. Soil Sci. Soc. Am. J. 45:255-260.

Rhoades, J.D., N.A. Manteghi, P.J. Shouse, and W.J. Alves. 1989. Soil electrical conductivity and soil salinity: new formulations and calibrations. Soil Sci Soc. Am J. 53:433-439.

Ritter, A., F. Hupet, R. Unoz-Carpena, S. Lambot, and M. Vanclooster. Using inverse methods for estimating soil hydraulic properties from field data as an alternative to direct methods. Agricultural Water Management 59: 77-96.

Sangare, K., E. Compaore, A. Buekert, M. Vanclooster, M. P. Sedogo, C.L. Bielders. 2012. Field-scale analysis of water and nutrient use efficiency for vegetable production in a West

African urban agricultural system. Nutrient Cycling in Agroecosystem 92(2): 207-224.

Shinomiya, Y. K. Takahsihi, M. Kobiyama, and J. Kubota. 2001. Evaluation of the tortuosity parameters for forest soils to predict unsaturated hydraulic conductivity. J. For. Res. 6: 221-225.

Takeshita, Y. and I. Kohno. 1993. Evaluation of closed-form analytical models for predicting unsaturated soil hydraulic properties. Memoirs of The Faculty of Engineering, Okayama University, 28(1): 61-69.

Tarara, J.M., J.M. Ham. 1999. Measuring sensible heat flux in plastic mulch culture with aerodynamic conductance sensors. Agricultural and Forest Meteorology 95: 1-13

Tolk, J.A., T.A. Howell, S.R. Evett. 1999. Effect of mulch, irrigation, and soil type on water use and yield of maize. Soil Tillage Research 50: 137-147.

Topp, G.C., J.L. Davis, and A.P. Anna.n 1980. Electromagnetic determination of soil water content: Measurement in coaxial transmission line. Water Resour. Res. 16: 574-582.

Ueno, H., Y. Miyoshi, Y. Yamashita, F. Kanke, T. Oomori, N. Fukuda. 2009. Effects of mulching with no-woven fabric sheet made of cotton wastes on growth of cabbage. *Proceeding of International Conference on Sustainable* Agriculture. Hokkaido University Sapporo, Japan, 2008.

Ueno, H. 2010. Improvement of plant production and soil quality by recycling bilogical waste in local area for sustainable agriculture. *Proceeding of The 3rd GEN Network International Seminar*. Bali, Indonesia, August 7-8, 2010.

Wang, H.J., B. Huang, X.Z. Shi, J.L. Darilek. D.S. Yu, W.X. Sun, Y.C. Zhao. Q. Chang, I. Oborn. 2008. Major nutrient balances in small-scale vegetable farming systems in peri-urban areas in China. Nutrient Cycling in Agroecosystem 81(3): 203-218.

Whalley, W.R. 1993. Consideration on the use of time-domain reflectrometry (TDR) for measuring soil water content. Soil Sci. 44:1-9.

Wijaya, K., T. Nishimura, M. Kato. 2003. Estimation of dry bulk density of soil using amplitude domain reflectrometry probe. J. Jpn. Soil. Phys. 95: 63-73.

Wijaya, K., T. Nishimura, M. Kato, M. Nakagawa. 2004. Field estimation of soil dry bulk density using amplitude domain reflectrometry data. J. Jpn. Soil. Phys. 97: 3-12

Wijaya , K. and P.H. Kuncoro. 2008. Applicatin of Dielectric Constant Method to Predict Spatial Variability of Soil Permeability on Potato Field. J. Inovasi 1(2): 67-77.

Xie, Z.K., Y.J. Wang, F.M. Li. 2005. Effect of plastic mulching on soil water use and spring wheat yield in arid region of northwest China. Agricultural Water Management 75: 71–83.

Yamanaka, T. and T. Yonetani. 1999. Dynamic of the evaporation zone in dry sandy soils. J. Hydrology 217: 135-148.

Yang, H., H. Rahardjo, E.C., Leong, and D.G. Fredlund. 2004. Factor affecting drying and wetting soil-water characteristic curve of sandy soils. Can. Geotech. J. 41: 908-920.

Zhou, L.M., F.M. Li, S.L. Jin, Y. Song. 2009. How two ridges and the furrow mulched with plastic film affect soil water, soil temperature and yield of maize on the semiarid Loess Plateau of China. Field Crops Research 113: 41–47.

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Inquiry for the Letter of Invitation/Acceptance

3 messages

Krissandi Wijaya <kwijaya77@yahoo.com> Fri, Nov 16, 2012 at 10:52 AM
Reply-To: Krissandi Wijaya <kwijaya77@yahoo.com>
To: "sucharit.k@chula.ac.th" <sucharit.k@chula.ac.th>, "pawees2012@gmail.com" <pawees2012@gmail.com>
Cc: Kriss Wijaya <kwijaya77@gmail.com>

Dear PAWEES 2012 Committee,

I would like to have a Letter of Invitation/Acceptance for participating the PAWEES 2012 Intl. Conference in Thailand. The letter will be used for preparing the passport extension and visa as well. Furthermore, I would like also to have your confirmation on the full paper of mine that has been submitted already through pawees2012@gmail.com.

Thank you very much for your attention and cooperation.

With best regards,
Krissandi Wijaya

Home Office:
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Dear Dr. Kriss Wijaya,
Attached is your invitation letter from Pawee Secretariat.
The latest paper review should be finalized early next week.
Regards,
Sucharit K.
nov 16, 12.
[Quoted text hidden]

Invitation leter(dr wijaya).docx
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Krissandi Wijaya <kwijaya77@yahoo.com> Fri, Nov 16, 2012 at 1:02 PM
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Dear Prof. Sucharit Koontanakulvong,
(CC: Committee members)

Thank you very much for sending my invitation letter and your confirmation on my full paper as well.

With best regards,

Sandi

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Subject: Re: Inquiry for the Letter of Invitation/Acceptance
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PAWEES 2012 International Conference

"Challenges of Water & Environmental Management in Monsoon Asia"

27-29 November 2012, Thailand

This is to certify that

Krissandi Wijaya, Ph.D.

Has participated in PAWEES 2012 International Conference as

PRESENTER

of the paper entitled "Effect of Cotton Mulch Sheets on Water Flow, EC, and Temperature Pattern in *Masa* (Loamy-sandy) Soil under Lettuce Crop Cultivation"

Yours sincerely,

Yutaka Matsuno, Ph.D.
Secretary General of PAWEES
Professor, School of Agriculture,Kinki University, Japan

Date: 19 October 2012

Mr. Krissandi Wijaya
Laboratory of Bio-Environmental Control Engineering
Teknik Pertanian Universitas Jenderal Soedirman (UNSOED)
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Invitation to PAWEES 2012 International Conference

Dear Mr. Krissandi Wijaya,

On behalf of Prof. Dr. Tai-Cheol Kim, President of the International Society of Paddy and Water Environment Engineering (PAWEES), and the Organizing Committee, I am very pleased to invite you to participate in PAWEES 2012 International Conference on " Challenges of Water & Environmental Management in Monsoon Asia" that will be held on 27-29 November 2012 in Thailand.

You may be aware that PAWEES was established in 2003 by the Japanese Society of Irrigation, Drainage, and Rural Engineering (JSIDRE), Korean Society of Agricultural Engineers (KSAE), and Taiwan Agricultural Engineers Society (TAES) to dedicate to the advancement of science and technology of paddy irrigation & drainage and water environmental disciplines in order to improve and rationalize sustainable paddy farming systems while protecting nature and environment. In this connection, we strongly believe that your participation in the PAWEES Conference is very valuable for sharing our experiences and improvement of our knowledge in the disciplines.

Please don't hesitate to contact Dr. SucharitKoontanakulvong (Email: sucharit.k@chula.ac.th) or me if you have any inquiries regarding the conference. I am looking forward to meeting with you in in Thailand during the PAWEES 2012 Conference.

Yours sincerely,
Yutaka Matsuno, Ph.D.

Secretary General of PAWEES
Professor, School of Agriculture,Kinki University, Japan

Contact: Yutaka MATSUNO, Ph.D.
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DEKAN FAKULTAS PERTANIAN UNIVERSITAS JENDERAL SOEDIRMAN

Dasar : Surat dari Sekretaris Jenderal PAWEES 2012 Tanggal 19 Oktober 2012 tentang Undangan Presentasi makalah.

MENUGASKAN :

Kepada : N a m a : Krissandi Wijaya, S.TP.,M.Agr.,Ph.D.
NIP : 19771009 200604 1 001
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Untuk : Menjadi Pemakalah pada acara Seminar Internasional PAWEES 2012 International Conference on " Challenges of Water & Environmental Management in Monsoon Asia" pada tanggal 27 s.d. 29 Nopember 2012 di Thailand.

Demikian Surat Tugas ini dibuat untuk dilaksanakan dengan sebaik-baik nya dengan penuh tanggung jawab dan memberikan laporan setelah selesai melaksanakan tugas.

Dikeluarkan di : Purwokerto
Pada tanggal : 21 Nopember 2012

Dekan ,

Dr. Ir. H. Achmad Iqbal, MSi
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(14)_Effect of Cotton Mulch Sheets on Water Flow, EC, and Temperature Pattern in Masa (Loamy-sandy) Soil under Lettuce Crop Cultivation.pdf

by Krissandi Wijaya

Effect of Cotton Mulch Sheets on Water Flow, EC, and Temperature Pattern in *Masa* (Loamy-sandy) Soil under Lettuce Crop Cultivation

Krissandi Wijaya • Hideto Ueno • Budi Indra Setiawan Ardiansyah

Abstract The distribution pattern of water, EC, and temperature in the lettuce cropping (*Masa* or loamy-sandy) soil under cotton (CM), plastic (PM), and zero mulch (C) coverage was identified during Japan summer of 2009. Three cultivation plots with 300 cm x 100 cm large were prepared for each crop-mulch combination. Soil-water content, EC, and temperature with 0-10 and 10-20 cm in depth were monitored using 5TE moisture sensors and EM50 data logger (Decagon Devices, Inc.). Water flow within each soil profile was characterized and modeled from the soil water content data using Hydrus-1D. The CM soil showed higher water content (max: 0.29 – 0.33 cm^3 cm^{-3}) than the PM (max: 0.29 – 0.31 cm^3 cm^{-3}) and C (max: 0.26 cm^3 cm^{-3}). The soil EC with CM (max.: 0.22 – 0.30 dS m^{-1} at rainfall rate of 32.1 mm d^{-1}) was significantly higher than others (max: < 0.02 dS m^{-1}). The soil temperature with CM was 2 – 3 and 4 – 5 ^{o}C lower than with PM and C, respectively. The CM plot had higher soil unsaturated hydraulic conductivity (K_{us}) (3.1 – 4.4 cm d^{-1}) compared to the PM (0.18 – 0.21 cm d^{-1}) and C plot (0.36 cm d^{-1}). The results reflect a unique characteristic of the cotton mulch, in which it is able not only to improve a sufficient water and nutrients availability, but also to control heat in its underlined soil for an effective growth of the crop.

Keywords cotton mulch, water flow, lettuce, hydraulic conductivity, loamy-sandy soil

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1. Introduction

During last couple of decades, mulch has been utilized in agriculture due to its benefit in maintaining soil moisture and temperature, reducing erosion impact, suppressing weeds and insects, and enhancing soil nutrients (Aladesanwa and Adigun, 2008; Rabary et al., 2008; Jin et al., 2007; Dahiya et al., 2007; Babola et al., 2007; Doring et al., 2005). Over various types of mulches, plastic is most common mulch, which is low cost and easy to applied (Zhou et al., 2009). The mulch also is effective in reducing evaporation rate from soil surface by 55% (Xie et al., 2005). However, an intensive use of plastic mulches may deteriorate soil condition as well as environmental risks (Tarara and Ham, 1999). For instance, polyethylene films generally causes an extreme high temperature inside soil especially in hot-summer, resulting in low soil microbial activities as well as organic matter mineralization, and high rate of soil nutrients volatilization (Moreno and Moreno, 2008). Moreover, the application of a huge amount of plastic mulches, i.e., 60,000 ton yr^{-1}, in Japan, has brought to an agricultural field pollution by its landfill disposal (Ueno et al., 2008).

Cotton sheet is a new type of biodegradable mulch, produced from cotton waste. Ehime University and Marusan Sangyo Co. Ltd., Japan, has proposed the use of cotton mulch in fruits and vegetables cultivation in Ehime's *Masado* or loamy-sandy soil, as an alternative way to minimize potential risk of CO_2 emission by its waste incineration in surrounding areas. Through some experiments on cabbage field by Ueno et al. (2008), it was found that the mulch is effective in suppressing weeds, improving growth and yield of the crop, enhancing soil-N uptake by the crop, and is potential to prevent soil and nutrient loss by erosion. Moreover, the application of the cotton waste on the lettuce crop in summer can provide a suitable nutrient added into the soil (Asagi et al., 2008) as well as good productivity (Kinebuchi et al., 2008). However, the effect of the cotton mulch sheet on the dynamic change of water and temperature in the soil profile including their inter-correlation and relation to nutrients distribution in the soil and uptake by the crop hasn't been evaluated yet.

This research was aimed to characterize the distribution pattern of water, electrical conductivity, and temperature as well as their inter-correlation in the lettuce field soil with the cotton mulch, compared to those with plastic and zero mulch application. This information is essentially required for modeling water and nutrients transports within lettuce field soil in further steps to support the development of a sustainable farming system for the lettuce crop.

2. Methodology

2.1. Experimental plot and data collection

The research was conducted at Field Science Center, Ehime University, Japan during summer of 2009 (soil type: decomposed-granite or *Masado* in Japanese, Table 1). Three lettuce plots with 300 cm x 100 cm large each were prepared for cotton mulch (CM), plastic mulch (PM), and zero or zero mulch (C), respectively, and the seeds were sowed on each plot with interval of 30 cm x 30 cm (Fig. 1, top). Water content, electrical conductivity (EC), and temperature of soil with depth of 0-10 and 10-20 cm was hourly monitored at each plot by using 5TE moisture sensors coupled with EM50 data logger (Decagon Devices, Inc.) (Fig. 2, bottom). Undisturbed soil samples in the same depths were also sampled for laboratory analysis of water content, dry bulk density, and saturated hydraulic conductivity of soil. Meteorological data, mainly precipitation, aerial temperature, relative humidity, wind speed, and solar radiation was summarized from the local weather station.

Fig. 1. Schematic diagram of the field monitoring for water content, temperature, and EC in the lettuce growing soil with three different mulches coverage.

Table 1. Physical properties of Shikoku's decomposed-granite soil

Parameters	Value
Texture (Gravel/sand : Silt : Clay) (Kg Kg^{-1})	82.9 : 9.6 : 7.6 (loamy-sand) [3]
Particle density (g cm^{-3})	2.67 – 2.68 [1]
Dry bulk density (g cm^{-3})	1.40 – 1.43 [1]
Porosity (%)	60 – 70 [3]
Hydraulic conductivity (cm d^{-1})	50.9 – 419.9 [2,3]
Soil organic matter or C-N ratio (%)	8.68 – 11.01 [4]

[1] Farmanullah et al. (1998); [2] Fujimaki et al. (2004); [3] Dahal et al. (2008); [4] Razafindrabe et al. (2010)

2.2. Laboratory analysis and water flow modeling

Prior to field monitoring, 5TE moisture sensors were specifically calibrated by using local *Masa* or loamy-sandy soil to gain more representative field data. This step was conducted by repacking soil into an acrylic cylinder with 8 cm diameter and 7 cm height, and followed by sensor operation into sample for several seconds. Sensor output (in mV) was recorded by using Em50 data logger. Volumetric water content of repacked sample was then measured gravimetrically by using oven dryer, and then was plotted against the output voltage data by employing least square method to obtain a calibration formula.

Soil physical properties mainly dry bulk density and saturated hydraulic conductivity were measured by using gravimetric and falling head method, respectively. The latter was used as one of the inputted hydraulic parameters in water flow (*K(θ)* in cm d^{-1}) simulation based on the monitored field data (Fig. 1, bottom) with help of van-Genuchten model (Ritter et al., 2003), as shown in Eqn. (1-3).

$$K(\theta) = K_s S_e^{\,l}\left[1-(1-S_e^{\,1/m})^m\right]$$

$$S_e = \theta - \theta_r/\theta_s - \theta_r = 1/(1+|\alpha h|^n)^m \qquad (2)$$

$$m = 1 - 1/n \qquad n > 1 \qquad (3)$$

where, *K(θ)*: unsaturated hydraulic conductivity, as a function of volumetric water content (cm d^{-1}), K_s: saturated hydraulic conductivity (cm d^{-1}), S_e: effective saturation (cm^3 cm^{-3}), θ: actual or field volumetric water content (cm^3 cm^{-3}), θ_r: residual volume wetness (cm^3 cm^{-3}), θ_s: saturated volumetric water content (cm^3 cm^{-3}), and n, α, l: fitting parameters

The hydraulic properties data is usually required to determine soil water and nutrients dynamics as well as their balance in an agricultural field, since the parameters are inter-correlated. In this study, water balance at each lettuce plot was determined by quantifying the incoming and outgoing water flow into root zone over certain period of time. The rainfall and irrigation add water to root zone, and part of them might be lost by runoff and deep percolation toward groundwater recharge. The water in the root zone might be also depleted to atmosphere by evapotranspiration. Therefore, the dynamic change in water within soil profile (ΔSW) was calculated by using Eqn. (4).

$$\Delta SW = (P + I) - (R_n + P_c + ET) \qquad (4)$$

where, P, I, R_n, P_c, and ET: added or depleted water by the rainfall (mm), irrigation (mm), runoff (mm), percolation (mm), and actual evapotranspiration (mm), respectively.

The ET was determined by comparing ΔSW and potential evapotranspiration (ET_o, in mm d^{-1}) of Penman-Monteith (Eqn. (5)), in which if the former is superior to the latter, the ET was equalized to the ET_o, instead of ΔSW, and vice versa (Eqn. (6)).

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma\dfrac{900}{T+273}u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.3u_2)}$$

$$ET = \begin{cases} ET_o & ET_o < \Delta SW \\ ET_o & ET_o \geq \Delta SW \end{cases}$$

where, R_n: net radiation at crop surface (MJ m^{-2} d^{-1}), G: soil heat flux density (MJ m^{-2} d^{-1}), T: mean daily air temp. at 2 m height (^{o}C), u_2: wind speed at 2 m height (m s^{-1}), e_s: saturated vapour pressure (kPa), e_a: actual vapour pressure (kPa), Δ: slope of vapour pressure curve (kPa ^{o}C^{-1}), and γ: psychrometric constant (kPa ^{o}C^{-1}).

3. Results and Discussions

3.1. Calibration of 5TE moisture sensors

Fig. 2A shows specific calibration results for 5TE moisture sensors, of which relationship between volumetric water content and output voltage was expressed in a linear regression with R^2 of 0.90. The calibrated equation (Eqn. (7)) was reliable within range of 0.05 – 0.50 cm^3 cm^{-3} volumetric water content, and was overestimated the default equation proposed by Decadon Devices Inc., and also the general calibration results of the previous dielectric constant-based moisture sensors such as TDR proposed by Topp et al. (1980) and Whalley (1993). The former was about 5 – 8 % higher in its calculated data compared to the latters. Furthermore, fitting the data against the gravimetric volumetric water content (Fig. 2B) shows that the calculated data agreed well with the measured ones with high accuracy (R^2 = 0.88) or low error and ($RSME$ = 0.04 cm^3 cm^{-3}). This was similar with the results of the specific calibration for several upland field soils, namely andosol, alluvial, and regosol reported by Wijaya et al. (2003, 2004) and Wijaya and Kuncoro (2008). The whole results above reveals that the specific calibration can be more reliable and applicable, as compared to the default or general ones, to use for the measurement of soil physical properties.

$$\theta = 0.0468 + 0.000648v \qquad (7)$$

where, θ: calculated or predicted volumetric water content by specific calibrated eqution (cm^3 cm^{-3}), and v: output voltage of 5TE moisture sensors read by EM50 data logger (mV).

3.2. Spatio-temporal change in soil water content, EC, and temperature

The distribution pattern of water content in lettuce growing soil profile with various mulches coverage at 0-10 and 10-20 cm depth in response to rainfall and irrigation during 20 – 46 days after transplanting (DAT) is presented in Fig. 3A. In general, the water content change was sensitively depended on rainfall or irrigation rate, due to the basic characteristics of loamy-sandy soil having high total macro-pore inside (Yang et al., 2004; Yamanaka, 1999). The maximum soil water content with CM was higher (0.290 – 0.333 cm^3 cm^{-3}) than that with PM (0.297 – 317 cm^3 cm^{-3}) and C (0.267 cm^3 cm^{-3}). The higher capability of CM over others in intercepting and then distributing rainfall and irrigation water downward, as well as in preventing upward water loss through evaporation (Tolk et al., 1999) might corroborate above results.

Fig. 3B shows the distribution pattern of EC in the lettuce growing soil profile with various mulches coverage at 0-10 and 10-20 cm depth during 20 – 46 DAT. Change in the soil EC, mainly for the cotton mulch (CM) plot, strongly corresponded with rainfall or irrigation rate, in which it reached a maximum value of 0.30 dS m^{-1} when total water supply was in highest rate, i.e., 32.1 mm d^{-1}. Higher decomposed-granite content in *Masado* reflecting higher plasticity or cation exchange capacity (CEC) than common sandy soils (Nishikawa, 1991) might affect such condition. In fact, the plasticity or CEC of a soil generally increases with increasing its water content (and vice versa), since water might act as an electrolyte medium conducting mineral ions to move easily through soil pore (Rhoades et al., 1989; Rhoades and Corwin, 1981). Furthermore, Kachanoski et al. (1988) and Hartsock et al. (2000) reported that when clay is low, as it occurs in loamy-sandy soil, its water content has a greater effect on EC. Accordingly, the higher EC value in CM soil, as compared to that in PM and C soil, was because of its better capability in transmitting the incoming water as well as maintaining or holding the underlined soil water.

Unlike EC that had positive correlation with rainfall or irrigation rate, soil temperature inversely corresponded to both parameters, in which it was decreased with increasing water supply rate and soil water content (Fig. 4A). This was due to high capacity of water in conducting and then transmitting a heat from soil after rainfall or irrigation added to surrounding profile, hence reduced its temperature. Specifically, the soil temperature change in CM plot within both depth was lowest, and consecutively followed by PM and C plot. Lower capacity of PM, as compared to CM, to transmit a heat from soil to atmosphere might be a reason for such condition (Anikwe, 2007; Tarara and Ham, 1999). On other hand, C plot or bare soil could transmit a heat from soil to atmosphere as effective as CM, but it also absorbed a heat directly from solar radiation, resulting in its highest soil temperature. An effective soil temperature reducing by CM, mainly in hot-summer condition, allowed crop to be healthy grown, since leaf and root of the crop are sensitive to hot temperature (Ueno et al., 2008; Ueno, 2010). Moreover, change in microclimate parameters such as aerial temperature and relative humidity were also related to rainfall rate (Fig. 4B), and in turn might correspond to heat or water vapor rate released from lettuce growing soil (Diaz-Perez, 2007).

3.3. Water flow pattern within Lettuce growing soil profile

Unsaturated hydraulic conductivity (K_{us}) is an essential parameter to understand, mainly in upland agricultures and forests, since it represents the dynamic of water in its soil profile (Chen et al., 2009; Shinomiya et al., 2001). Having knowledge of K_{us} will help us in quantifying water and nutrient budget within certain cropping field including lettuce, which is useful to determine an appropriate irrigation scheduling (Leenhardt et al., 1998; Andreu et al., 1997) as well as a suitable dosage of fertilization (Wang et al., 2008; Jackson et al., 1994). In this study, K_{us} was predicted by employing evaporation inverse analysis (i.e., van Genuchten model in Hydrus-1D) based on the observed volumetric water content of the lettuce growing soils, especially after heavy rainfall and irrigation during 30 – 46 DAT (Fig. 3A). As a result, the volumetric water contents of the soils at 10 and 20 cm depth was fitted well with R^2 values of 0.982 – 0.996 (Fig. 5A and Table 2), and it was comparable to the results of Takeshita and Kohno (1993), Fujimaki et al. (2004), and Yang et al. (2004). Concerning with the 1:1 relation, there were a good agreement between the predicted and observed volumetric water content with R^2 of 0.996 and *RMSE* of 0.0028 cm^3 cm^{-3} (Fig. 5B). This suggests that such fitted parameters is acceptable for predicting the water characteristics and hydraulic conductivity as well as modeling water flow in the lettuce cropping soils under different mulch coverage.

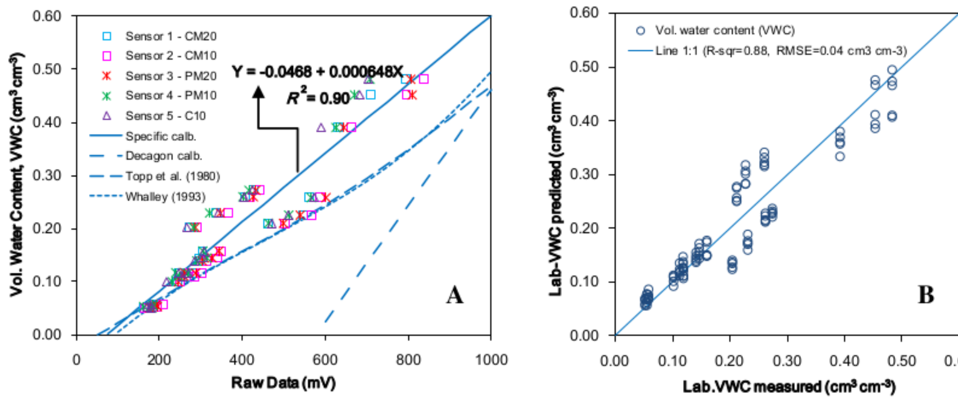

Fig. 2. Calibration of 5TE sensor: volumetric water content vs. sensor output voltage for specific and default/general calibrations (A), and measured vs. predicted volumetric water content (B).

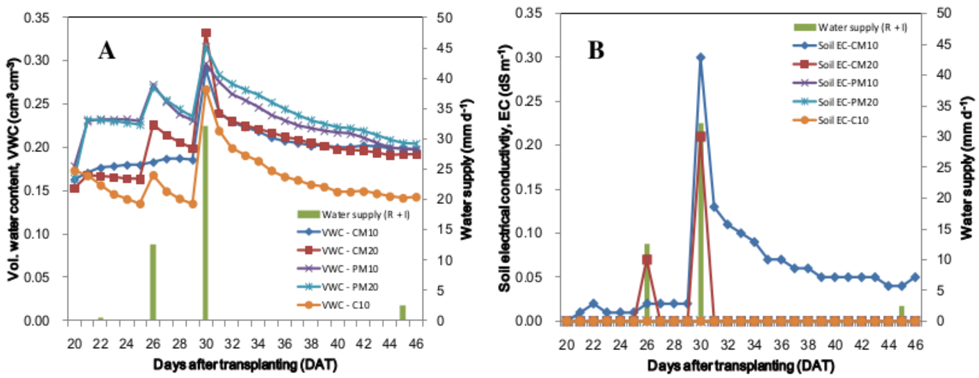

Fig. 3. Distribution pattern of: water (A) and electrical conductivity (B) in lettuce growing soils with cotton, plastic, and zero mulch coverage.

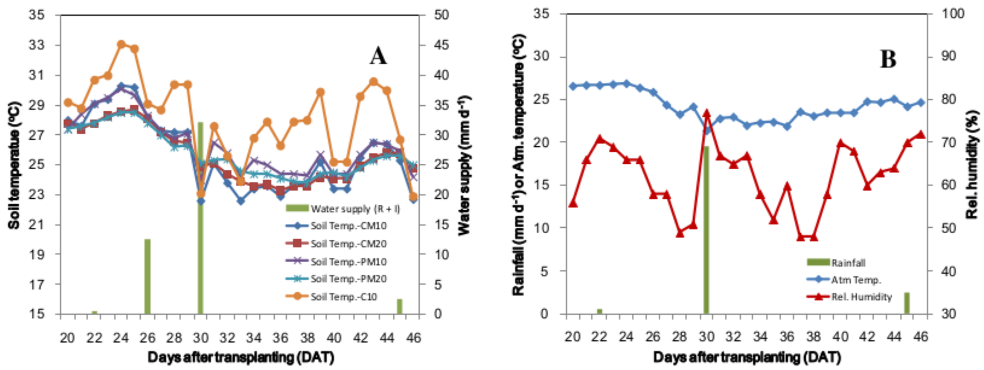

Fig. 4. Distribution pattern of: soil temperature (A) and atmospheric temperature and relative humidity (RH) (B) in the lettuce plots with cotton, plastic, and zero mulches coverage

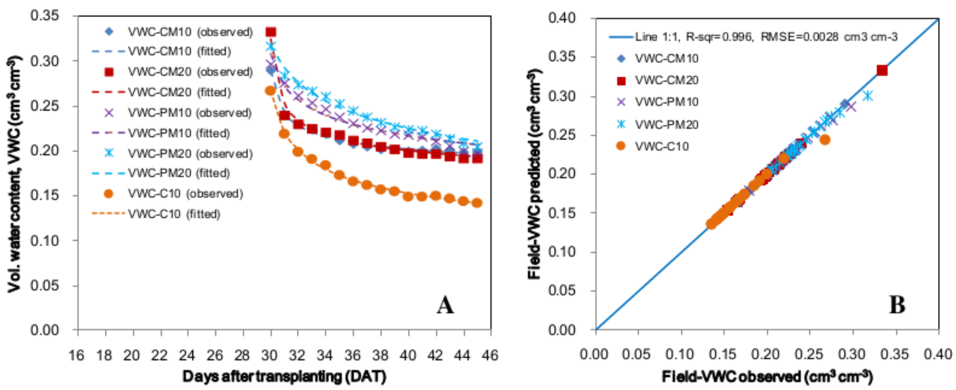

Fig 5. Fitted (or predicted) vs. observed volumetric water contents (VWC) of the lettuce growing soils at 10 and 20 cm depth concerning with: its temporal change during 30 – 46 DAT (A) and 1:1 relation (B).

Table 2. Fitted hydraulic parameters of the lettuce cropping soils with cotton, plastic, and zero mulches coverage at 10 and 20 cm depth

	Cotton mulch (CM)		**Plastic mulch (PM)**		**Zero mulch (C)**	**vG model[5)]**
Parameters	**10-cm**	**20-cm**	**10-cm**	**20-cm**	**10-cm**	**(*Masa* or Loamy-sandy soil)**
θ_r	0.138	0.144	0.032	0.0000111	0.00813	0.028 – 0.060
θ_s	0.298	0.344	0.308	0.317	0.267	0.314 – 0.350
α	0.116	0.272	0.106	0.094	0.0819	0.079 – 0.940
n	1.335	1.98	1.226	1.140	1.34	1.148 – 1.611
K_s	27.49	9.79	7.07	1.19	5.92	-
l	0.5	0.5	0.5	0.5	0.5	-
R^2	0.991	0.982	0.961	0.985	0.996	0.690 – 0.820
*SSQ***	0.0000716	0.000332	0.000461	0.000209	0.0000666	-

[5)] Takeshita and Kohno (1993); Fujimaki et al. (2004); Yang et al. (2004)

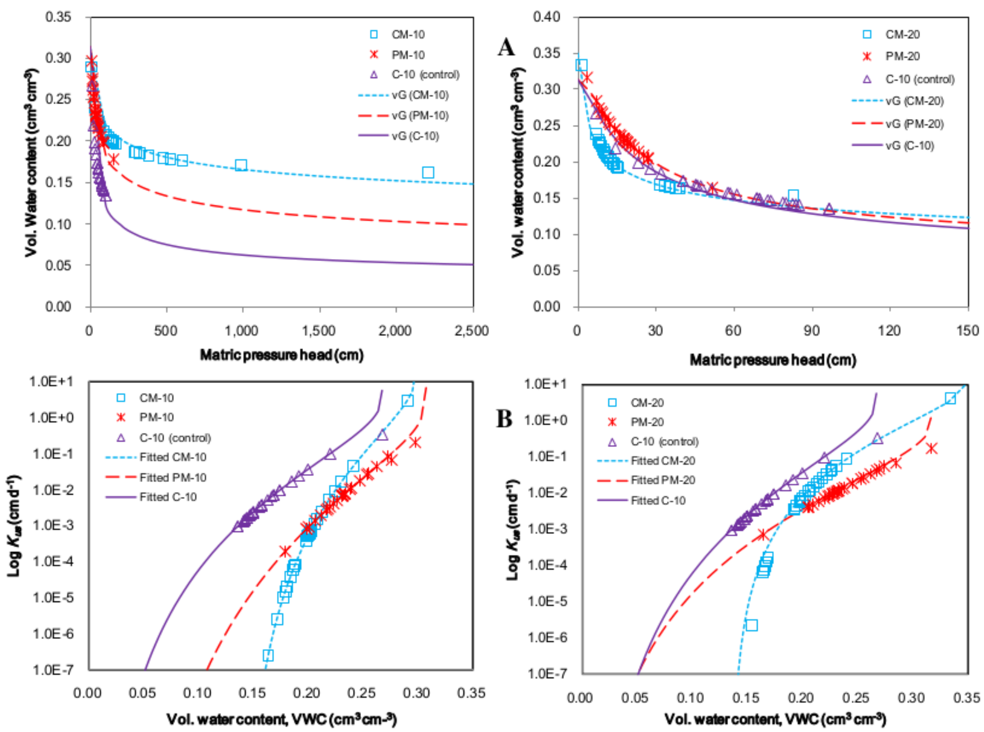

Fig. 6. Soil water characteristics: matric potential vs. VWC (A) and unsaturated hydraulic conductivity vs. VWC (B) of the lettuce soils with various mulches coverage.

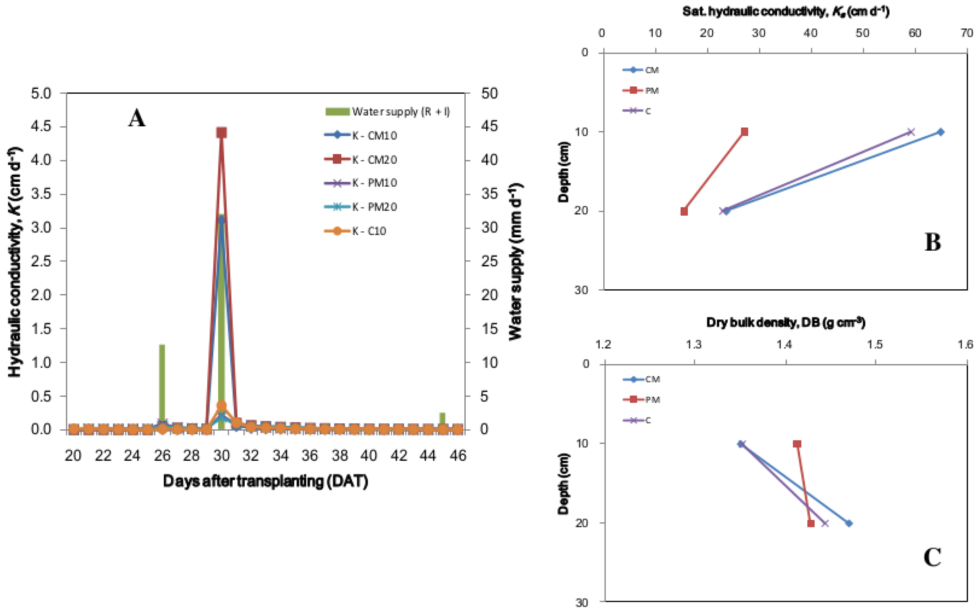

Fig. 7. Temporal (A) and spatial pattern (B) of soil hydraulic conductivity, in relation to its dry bulk density at the end of cultivation period (C), in the lettuce field with various mulches coverage.

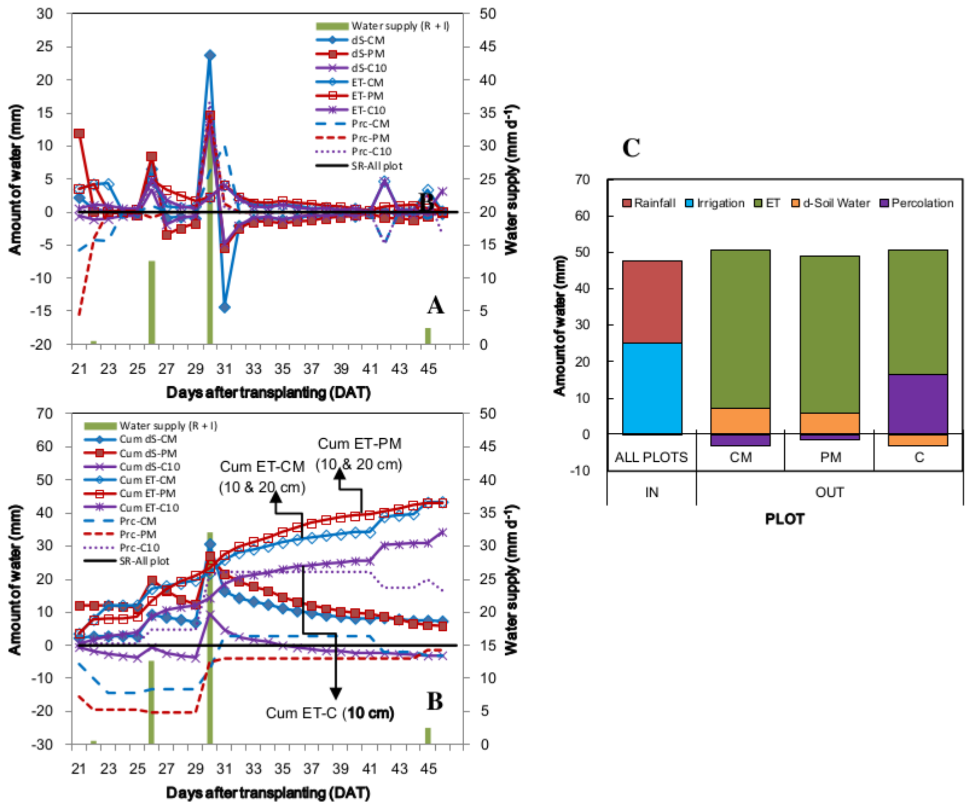

Fig. 8. Water balance, in term of: (A) temporal change, (B) cumulative, and (C) budget in lettuce cropping field with various mulches coverage throughout a cultivation period.

Regarding soil water characteristics curve of each cropping plot (Fig. 6A, B), it was found that CM plot, mainly at 10 cm depth, had highest soil water holding capacity, followed by PM and C, while at 20 cm depth it was relatively similar to others. This was related to the results shown in Fig. 3A, of which CM plot was more effective in transmitting as well as maintaining rainfall and irrigation water input than PM and C plot. Moreover, since CM is biodegradable, it also might improve the underlined soil physical conditions such as bulk density, porosity, and hydraulic conductivity, and also the soil organic matters, especially during the middle to the end of cultivation period (Fig. 7C). Accordingly, the hydraulic conductivity of CM soils at 10 and 20 cm depth were significantly higher compared to that of PM and C soil, in which at field capacity they were ranged between 3.1 – 4.4, 0.18 – 0.21, and 0.36 cm d^{-1}, respectively (Fig. 6B). This reveals that the water flow rate within CM soil profile was either temporary (Fig. 7A) or spatially (Fig. 7B) higher than other mulches covered soils.

3.4. Soil water balance

Fig. 8 shows the water balance in the lettuce growing plot under various mulches coverage within 10 and 20 cm depth during 20 – 46 DAT. The soil water storage in most plots observed was temporary fluctuated, dependent upon the rate of water input. Specifically, CM plot had larger fluctuation in (-14.3 to 23.8 mm) as well as higher cumulative amount of the soil water storage (7.3 mm), mainly during rainfall or irrigation, than PM (fluctuation: -5.4 to 14.7 mm; cumulative: 5.9 mm) and C plot (fluctuation: -4.8 to 13.2 mm; cumulative: -3.0 mm) (Fig 8A, B, C). As compared to PM plot, the ET of CM plot was higher during the initial 20 – 29 DAT, but lower during the last 30 – 46 DAT, while that of C plot was lowest among those three plots and throughout the cultivation period (Fig. 8B). Accordingly, the cumulative ET of CM plot (43.42 mm) was as higher as that of PM plot (43.17 mm), but significantly higher than that of C plot (34.27 mm) (Fig. 8C). In addition, by assuming surface runoff (R_n) was zero due to typically high infiltration rate of sandy soil, it was found that soil water loss by percolation tended to be higher in C plot (16.47 mm within 10 cm depth or 5.15 mm within 0-20 cm depth) than that in CM and PM plot, of which the value was -3.04 mm -1.43 mm, respectively (negative indicated the upward or capillary movement of the soil water) (Fig. 8C).

The above results suggest that the cotton mulch is sufficiently effective in maintaining the underlined soil water that is available to crop. It not only can transmit, and then redistribute the water input from rainfall or irrigation within soil profile, but also can prevent the upward water loss by either evaporation or deeper downward water movement by percolation. Such condition may in turn keep the soil temperature in suitable condition for crop growth (Ueno, 2010; Ueno et al., 2008). Furthermore, the cotton mulch is easily biodegraded in soil, which contributes to a significant improvement of soil physical properties and organic matter (Moreno and Moreno, 2008), hence soil water holding capacity. Although the plastic mulch is almost as effective as the cotton mulch in supporting ET and preventing soil loss by percolation (Zhou at al., 200), it has negative impact on reducing soil water storage, due to its lower transmissible to water input. This plot then may result in higher temperature within its soil profile compared to the cotton plot. In contrast, the zero mulch may allow more water to infiltrate and percolate into the deeper profile, thus reduces its soil water holding capacity as well as ET.

Information on the water balance, like as shown in Fig. 8, is essentially required to support a better water management in a crop cultivation, including irrigation scheduling and fertilizer application to enhance good yield of the crop (Sangare et al., 2012, Pathak et al., 2003). The water balance represents the dynamic movement of water within a crop and its surrounding environment over a cultivation period, in which the effective water uptake by a crop can be determined based on its WUE (water used efficiency) coefficient. The WUE coefficient is calculated by comparing the total aboveground dry matter yield to the cumulative ET value (Mastrorilli et al., 1995). In this study, it was expected that the CM plot might have WUE higher than PM plot, since the former had higher fresh and dry matter compared to the latter, even though both ET values were relatively similar. The high yield of lettuce crop in CM plot was affected by the typical characteristic of the cotton mulch, which was transmissible to water from rainfall or irrigation to produce an appropriate soil water availability and temperature for crop growth. Furthermore, it also was easily biodegraded to enhance organic matters and nutrients accumulated in both the sheet and underlined soil, and to suppress weeds in the field up to about 89%, mainly in hot-summer condition (Ueno, 2010).

4. Conclusions

Water distribution as well as flow in the lettuce field soil under various mulches application such as cotton mulch, plastic mulch, and zero mulch was characterized and modeled with help of 5TE sensor specific calibration and Hydrus-1D analysis. The field with cotton mulch coverage had higher soil water content as well as water holding capacity compared to that with plastic and zero mulch, resulted in its higher soil water and nutrients availability and lower soil temperature than others. The application of the cotton mulch into the lettuce field, mainly in hot-summer condition might contribute to high yield as well as water use efficiency (WUE) of the crop, which was corresponded to its capability in maintaining water and nutrient availability, good temperature condition, and also in suppressing weeds, which is never seen in other mulches.

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References

Aladesanwa, R.D., A.W. Adigun. 2008. Evaluation of sweet potato (*Ipomoea batatas*) live mulch at different spacings for weed suppression and yield response of maize (*Zea mays L.*) in southwestern Nigeria. Crop Protection 27: 968–975.

Andreu, L., J.W. Hopmans, and L.J. Schwankl. 1997. Spatial and temporal distribution of soil water balance for a drip-irrigated almond tree. Agricultural Water Management 35: 123-146 .

Anikwe, M.A.N, C.N. Mbah, P.I. Ezeaku, V.N. Onyia. 2007. Tillage and plastic mulch effects on soil properties and growth and yield of cocoyam (Colocasia esculenta) on an ultisol in southeastern Nigeria. Soil & Tillage Research 93: 264–272.

Asagi, N., H. Ueno, M. Kinebuchi, S. Sano, K. Shimizu, F. Kanke, T. Oomori, N. Fukuda. 2008. Nutrient dynamics in lettuce growing soil with cotton waste mulch. The Crop Science Society of Japan 45: 80-81.

Babalola, O., S.O. Oshunsanya, K. Are. 2007. Effects of vetiver grass (*Vetiveria nigritana*) strips, vetiver grass mulch and an organomineral fertilizer on soil, water and nutrient losses and maize (Zea mays, L) yields. Soil Tillage Research 96: 6–18.

Chen, S., Zhang, X. Chen, and P. Shi. 2009. The impact of land use and land cover changes on soil moisture and hydraulic conductivity along the karst hillslopes of southwest China. Environ.

Earth. Sci., 59 (4): 811-820. DOI: 10.1007/s12665-009-0077-6.

Cook, H.F., G.S.B. Valdes, H.C. Lee. 2006. Mulch effects on rainfall interception, soil physical characteristics and temperature under Zea mays L. Soil Tillage Research 91: 227–235.

Dahal, R.K., S. Hasegawa, A. Nonomura, M. Yamanaka, and K. Nishino. 2008. Failure characteristics of rainfall-induced shallow landslides in granitic terrains of Shikoku Island of Japan. Environmental Geology 56(7): 1295-1310, DOI: 10.1007/s00254-008-1228-x.

Dahiya R., J. Ingwersen, T. Streck. 2007. The effect of mulching and tillage on the water and temperature regimes of a loess soil: Experimental findings and modeling. Soil Tillage Research 96: 52–63.

Diaz-Pe´rez, J.C., R. Gitaitis, B. Mandal . 2007. Effects of plastic mulches on root zone temperature and on the manifestation of tomato spotted wilt symptoms and yield of tomato. Scientia Horticulturae 114: 90–95.

Doring, T.F. M. Brandt, J. Heb, M.R. Finckh, H. Saucke. 2005. Effects of straw mulch on soil nitrate dynamics, weeds, yield and soil erosion in organically grown potatoes. Field Crops Research 94: 238–249.

Gallardo, M. L.E. Jackson, K. Schulbach, R.L. Snyder, R.B. Thompson, and L.L. Wyland. 1996. Production and water use in lettuces under variable water supply. Irrigation Science 16(3):125-137.

Farmanullah, K., K. Sato, and K. Takase. 1998. Effect of soil cohesion on critical flow for riil initiation under different slope conditions. Pak. J. Biol. Sci., 1(4): 244-247.

Fujimaki, H., M. Inoue, and K. Konishi. 2004. A multi-step inflow method for estimating hydraulic conductivity at low pressure under the wetting process. Goderma, 120: 177-185.

Hartsock, N. J., T. G. Mueller, G. W. Thomas, R. I. Barnhisel, and K. L. Wells and S. A. Shearer, 2000. *Soil Electrical Conductivity Variability*. In. P.C. Robert et al. (ed.) Proc. 5th international conference on precision Agriculture. ASA Misc. Publ., ASA, CSSA, and SSSA, Madison, WI.

Jackson, L.E., L.J. Strivers, B.T. Warden, and K.K. Tanji. 1994. Crop nitrogen utilization and soil nitrate loss in a lettuce field. Fertilizer research 37(2): 93-95.

Jin K., Wim M. Cornelis, Wouter Schiettecatte, Junjie Lu, Yuqing Yao, Huijun Wu, Donald Gabriels, Stefaan De Neve, Dianxiong Cai, Jiyun Jin, Roger Hartmann. 2007. Effects of different management practices on the soil–water balance and crop yield for improved dryland farming in the Chinese Loess Plateau. Soil Tillage Research 96: 131–144.

Kachanoski, R.G. E.G. Gregorich, and I.J. Van Wesenbeeck. 1988. Estimating spatial variations of soil water content using no contacting electromagnetic inductive methods. Can. J. Soil Sci. 68:715-722.

Kinebuchi, M., H. Ueno, N. Asagi, S. Sano, K. Shimizu, F. Kanke, T. Oomori, N. Fukuda. 2008. Application effects of the cotton waste mulch on growth and yield of summer sowing lettuce. The Crop Science Society of Japan 45: 78-79.

Leenhardt, D, F. Lafolie, and L. Bruckler. 1998. Evaluation irrigation strategies for lettuce by simulation: 1. Water flow simulations. European J. of Agronomy 8: 249-265.

Mastrorilli, M., K. Katerji, G. Rana, and P. Steduto. 1995. Sweet sorghum in Mediterranean climate: radiation use and biomass water use efficiencies. Industrial Crops and Products 3: 252-260.

Moreno, M.M., A. Moreno. 2008. Effect of different biodegradable and polyethylene mulches on soil properties and production in a tomato crop. Scientia Horticulturae 116: 256–263

Nishikawa, Y. 1991. Application of supercritical fluid extraction/ supercritical chromatography to pesticide residue analysis. Analytical Sci. 7: 567-572.

Pathak, H. P.K. Aggrawal, R. Roetter, N. Karla, S.K. Bandyopahaya, S. Prasad, and H. Van Keulen. 2003. Modelling the quantitative evaluation of soil nutrient supply, nutrient use efficiency, and fertilizer requirements of wheat in India. *Nutrient Cycling in Agroecosystem* 65(2): 105-113.

Rabary, B., S. Sall, P. Letourmy, O. Husson, E. Ralambofetra, N. Moussa, J.L. Chotte. 2008. Effects of living mulches or residue amendments on soil microbial properties in direct seeded cropping systems of Madagascar. Applied Soil Ecology 39: 236 – 243.

Razafubdrabe, B.H.N., B. He, S. Inoue, T. Ezaki, and R. Shaw. 2010. The role of forest stand density in controlling soil erosion: implications to sediment-related disasters in Japan. Environ. Monit. Assess. 160: 337-354. DOI 10.1007/210661-008-0699-2.

Rhoades, J.D. and D. L. Corwin. 1981. Determining soil electrical conductivity-depth relations using an inductive electromagnetic soil conductivity meter. Soil Sci. Soc. Am. J. 45:255-260.

Rhoades, J.D., N.A. Manteghi, P.J. Shouse, and W.J. Alves. 1989. Soil electrical conductivity and soil salinity: new formulations and calibrations. Soil Sci Soc. Am J. 53:433-439.

Ritter, A., F. Hupet, R. Unoz-Carpena, S. Lambot, and M. Vanclooster. Using inverse methods for estimating soil hydraulic properties from field data as an alternative to direct methods. Agricultural Water Management 59: 77-96.

Sangare, K., E. Compaore, A. Buekert, M. Vanclooster, M. P. Sedogo, C.L. Bielders. 2012. Field-scale analysis of water and nutrient use efficiency for vegetable production in a West

African urban agricultural system. Nutrient Cycling in Agroecosystem 92(2): 207-224.

Shinomiya, Y. K. Takahsihi, M. Kobiyama, and J. Kubota. 2001. Evaluation of the tortuosity parameters for forest soils to predict unsaturated hydraulic conductivity. J. For. Res. 6: 221-225.

Takeshita, Y. and I. Kohno. 1993. Evaluation of closed-form analytical models for predicting unsaturated soil hydraulic properties. Memoirs of The Faculty of Engineering, Okayama University, 28(1): 61-69.

Tarara, J.M., J.M. Ham. 1999. Measuring sensible heat flux in plastic mulch culture with aerodynamic conductance sensors. Agricultural and Forest Meteorology 95: 1-13

Tolk, J.A., T.A. Howell, S.R. Evett. 1999. Effect of mulch, irrigation, and soil type on water use and yield of maize. Soil Tillage Research 50: 137-147.

Topp, G.C., J.L. Davis, and A.P. Anna.n 1980. Electromagnetic determination of soil water content: Measurement in coaxial transmission line. Water Resour. Res. 16: 574-582.

Ueno, H., Y. Miyoshi, Y. Yamashita, F. Kanke, T. Oomori, N. Fukuda. 2009. Effects of mulching with no-woven fabric sheet made of cotton wastes on growth of cabbage. *Proceeding of International Conference on Sustainable* Agriculture. Hokkaido University Sapporo, Japan, 2008.

Ueno, H. 2010. Improvement of plant production and soil quality by recycling bilogical waste in local area for sustainable agriculture. *Proceeding of The 3rd GEN Network International Seminar*. Bali, Indonesia, August 7-8, 2010.

Wang, H.J., B. Huang, X.Z. Shi, J.L. Darilek. D.S. Yu, W.X. Sun, Y.C. Zhao. Q. Chang, I. Oborn. 2008. Major nutrient balances in small-scale vegetable farming systems in peri-urban areas in China. Nutrient Cycling in Agroecosystem 81(3): 203-218.

Whalley, W.R. 1993. Consideration on the use of time-domain reflectrometry (TDR) for measuring soil water content. Soil Sci. 44:1-9.

Wijaya, K., T. Nishimura, M. Kato. 2003. Estimation of dry bulk density of soil using amplitude domain reflectrometry probe. J. Jpn. Soil. Phys. 95: 63-73.

Wijaya, K., T. Nishimura, M. Kato, M. Nakagawa. 2004. Field estimation of soil dry bulk density using amplitude domain reflectrometry data. J. Jpn. Soil. Phys. 97: 3-12

Wijaya , K. and P.H. Kuncoro. 2008. Applicatin of Dielectric Constant Method to Predict Spatial Variability of Soil Permeability on Potato Field. J. Inovasi 1(2): 67-77.

Xie, Z.K., Y.J. Wang, F.M. Li. 2005. Effect of plastic mulching on soil water use and spring wheat yield in arid region of northwest China. Agricultural Water Management 75: 71–83.

Yamanaka, T. and T. Yonetani. 1999. Dynamic of the evaporation zone in dry sandy soils. J. Hydrology 217: 135-148.

Yang, H., H. Rahardjo, E.C., Leong, and D.G. Fredlund. 2004. Factor affecting drying and wetting soil-water characteristic curve of sandy soils. Can. Geotech. J. 41: 908-920.

Zhou, L.M., F.M. Li, S.L. Jin, Y. Song. 2009. How two ridges and the furrow mulched with plastic film affect soil water, soil temperature and yield of maize on the semiarid Loess Plateau of China. Field Crops Research 113: 41–47.

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