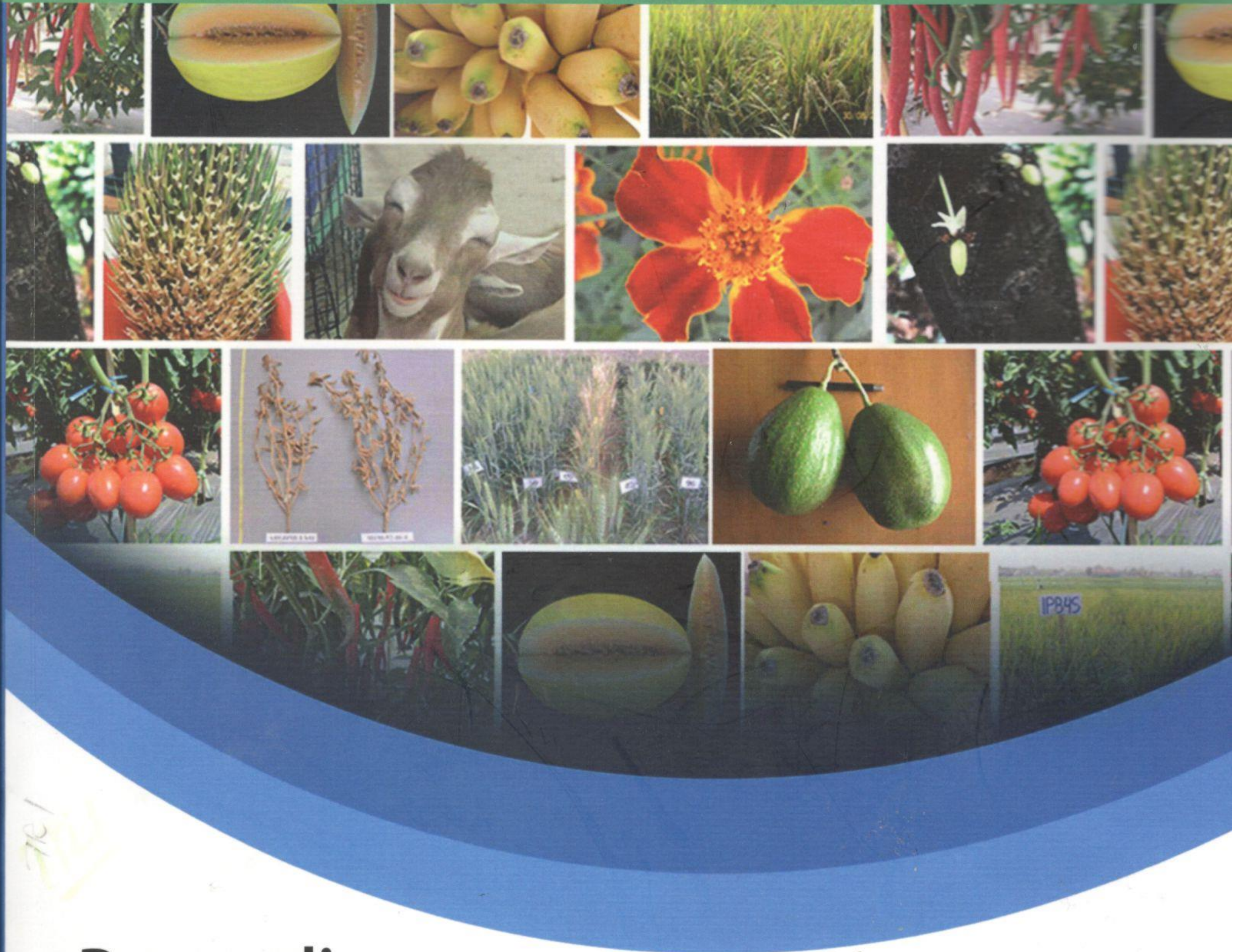

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Dr. Yudiwanti WEK
Dr. Trikoesoemaningtyas
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Table of Contents

List of Participants

Name	Affiliation	Email
Abbdelrehim Ahmed Ali	Agronomy Department, Faculty of Agriculture, Suez Canal University	drrahem@gmail.com
Abdul Rahim Bin Harun	Agrotechnology and Biosciences Division, Malaysian Nuclear Agency	rahim6313@yahoo.com// rahim@nm.gov.my
Abebe Megersa Diriba	Department of Plant Science, Seoul National University	abebemegersa@snu.ac.kr
Ade Astri Muliasari	Department of Agronomy and Horticulture, Bogor Agricultural University	adeastri07@gmail.com
Adi Surya Ikhsan	Biotechnology Department, Cukurova University	adisurya_bioindo@yahoo.com
Ady Daryanto	Department of Agronomy and Horticulture, Bogor Agricultural University	adydaryanto@yahoo.com
Ae Seon Lee	Gwangju Convention & Visitors Bureau	aeseon@gwangjucvb.or.kr
Afifuddin Latif Adiredjo	Agronomy Department, Brawijaya University	al.adiredjo@ub.ac.id
Agung Karuniawan	Padjadjaran University	akaruni@yahoo.com
Aline Sisi Handini	Department of Agronomy and Horticulture, Bogor Agricultural University	
Andari Risliawati	Indonesian Center for Agricultural Biotechnology and Genetic Research (ICABIOGRAD)	boendar@yahoo.co.id
Andi Sauleka	Department of Agronomy and Horticulture, Bogor Agricultural University	
Andi Wahyono	PT BISI International Tbk	genadiputra@yahoo.com
Apri Sulistyo	Indonesian Legumes and Tuber Crops Research Institute (ILETRI)	apri.sulistyo@gmail.com
Arina Saniaty	Department of Agronomy and Horticulture, Bogor Agricultural University	arinaagh162@gmail.com
Aris Hairmansis	Indonesian Centre for Rice Research	a.hairmansis@gmail.com
Arya Widura Ritonga	Department of Agronomy and Horticulture, Bogor Agricultural University	aryagriper@gmail.com
Aryo Benjamin Feldman	Crops For the Future	aryo.feldman@cffresearch.org

Name	Affiliation	Email
Awang Maharijaya	Department of Agronomy and Horticulture, Bogor Agricultural University	awang.maharijaya@gmail.com
Azis Natawijaya	Taman Buah Mekarsari	aznatawijaya@yahoo.com
Backki Kim	Seoul National University	uptfamily@hanmai1.net
Bambang Heliyanto	Indonesian Sweetened and Fibre Crops Research Institute	b.heliyant@gmail.com
Benni Situmorang	Department of Agronomy and Horticulture, Bogor Agricultural University	benniagrohort@gmail.com
Bhalang Suriharn	Deparment of Plant Science and Agricultural Resources, Faculty of Agriculture, Khon Kaen University	bsuriharn@gmail.com
Camelia Rosianti Putri	Department of Agronomy and Horticulture, Bogor Agricultural University	camelia17411@gmail.com
Cucu Gunarsih	Department of Agronomy and Horticulture, Bogor Agricultural University	
Dani Satyawan	Seoul National University	dani_satyawan@snu.ac.kr
Darda Efendi	Center for Tropical Horticulture Studies, Bogor Agricultural University	dardaefendi@gmail.com
Darmawan Saptadi	Faculty of Agriculture, Brawijaya University	darmawansaptadi@gmail.com
Debby Ustari	ICABIOGRAD	debbyustari@gmail.com
Deden Derajat Matra	Tokyo University of Agriculture and Technology	matra6387@gmail.com
Desta Wirnas	Department of Agronomy and Horticulture, Bogor Agricultural University	dwirnas@gmail.com
Dewi Indriyani Roslim	Department of Biology, Riau University	dewiindriyaniroslim@gmail.com
Dewi Sukma	Department of Agronomy and Horticulture, Bogor Agricultural University	dsukma70@yahoo.com
Didy Sopandie	Department of Agronomy and Horticulture, Bogor Agricultural University	didysopandie@gmail.com
Dwi Guntoro	Department of Agronomy and Horticulture, Bogor Agricultural University	dwiguntoro@yahoo.com

Name	Affiliation	Email
Edi Santosa	Department of Agronomy and Horticulture, Bogor Agricultural University	edisang@gmail.com
Edizon Jambormias	Departement of Agriculture, Faculty of Agriculture, Pattimura University, Ambon, Indonesia.	edy_jambormias@yahoo.com
Edy Suprianto	Indonesian Oil Palm Research Institute	edygrey@gmail.com
Eka Jan Virgin Haquarsum	Department of Agronomy and Horticulture, Bogor Agricultural University	virginhaquarsum@gmail.com
Ellina Mansyah	Indonesian Tropical Fruit Research Institute	ellina_mansyah@yahoo.co.id
Endah Retno Palupi	Department of Agronomy and Horticulture, Bogor Agricultural University	erpalupi@yahoo.co.id
Eny Widajati	Department of Agronomy and Horticulture, Bogor Agricultural University	eny.widajati61@gmail.com
Erin Puspita Rini	Department of Agronomy and Horticulture, Bogor Agricultural University	erinpuspitarini@gmail.com
Ery leonardo	Department of Agronomy and Horticulture, Bogor Agricultural University	els.srg25@gmail.com
Estriana Riti	Department of Agronomy and Horticulture, Bogor Agricultural University	ritiestriana@gmail.com
Etti Swasti	Agriculture Faculty, Andalas University	ettiswasti14@yahoo.com
Eunbyeol Koh	Seoul National University	ebkoh@snu.ac.kr
Eunsoo Lee	Seoul National University	les1624@snu.ac.kr
Faradila Danasworo Putri	Department of Agronomy and Horticulture, Bogor Agricultural University	faradiladputri@yahoo.com
Faradila Median Rini	Department of Agronomy and Horticulture, Bogor Agricultural University	dila_me@yahoo.com
Ferra Anggita Agustina	Department of Agronomy and Horticulture, Bogor Agricultural University	ferraanggita@ymail.com
Fitmawati	Faculty Mathematic and Sains Riau University	fitmawati2008@yahoo.com

Name	Affiliation	Email
Fitrah Ramadhan	Department of Agronomy and Horticulture, Bogor Agricultural University	ftramadhan21@gmail.com
Galuh Kusuma Wardhani	Department of Agronomy and Horticulture, Bogor Agricultural University	galuhmawardha@gmail.com
Graham Eagleton	KPT-Kebun Raya Bogor-LIPI	grahameagleton@gmail.com
Gregori Garnadi Hambali	Taman Buah Mekarsari, Cileungsi, Bogor, Indonesia	gregham2010@yahoo.com
Hadian Permana	Tokyo University of Agriculture and Technology	hadijan.permana@gmail.com
Haneul Jeong	Seoul National University	skyts0401@snu.ac.kr
Hapsoh	Faculty of Agriculture University of Riau	hapsohdin@yahoo.co.id
Haris Maulana	Agriculture Faculty, Padjadjaran University	harismaulana89@yahoo.com
Hee-Jong Koh	Seoul National University	heejkoh@snu.ac.kr
Heni Safitri	Indonesian Center for Rice Research	henisafitri2@gmail.com
Herman Syah	Department of Biology, Riau University	hermansyahdan@ymail.com
Hidayati Fatchur Rohmah	Department of Agronomy and Horticulture, Bogor Agricultural University	hidayati_fatchur@yahoo.co.id
Ho Jun Joh	Department of Plant Science, Plant Genomics and Breeding Institute, and Research Institute of Agriculture and Life Sciences, College of Agriculture and Life Sciences, Seoul National University	jun841011@hotmail.com
Hyun-Ju Jang	Seoul National University	janghyunju12@gmail.com
Hyun-Sook Lee	College of Agriculture and Life Sciences, Chungnam National University, Daejeon, 305-764, Korea	leehs0107@gmail.com
Hyun-Su Park	National Institute of Crop Science	mayoe@korea.kr
I Made Tasma	ICABIOGRAD	imade.tasma@gmail.com
Ill-SUP Nou	Department of Horticulture, Sunchon National University	nis@sunchon.ac.kr
Indah Sulistiyorini	Department of Agronomy and Horticulture, Bogor Agricultural University	
Indrastuti Apri Rumanti	Indonesian Center for Rice Research	indrastuti_apri@yahoo.com

Name	Affiliation	Email
Indriati Husain	Universitas Negeri Gorontalo	indriati.husain@ung.ac.id
Izmi Yulianah	Faculty of Agriculture, Brawijaya University	izmiyulianah@yahoo.com
Jabal Ashar	Department of Agronomy and Horticulture, Bogor Agricultural University	jabalashar@gmail.com
JaeBuhm Chun	Crop Breeding Division, National institute of crop science(NICS)	jbchun01@korea.kr
Jayern Lee		leejayern@gmail.com
Jirawat Sanitchon	Deparment of Plant Science and Agricultural Resources, Khon Kaen University	jirawat@kku.ac.th
Jong-Min Jeong	National Institute of Crop Science RDA, Wan ju, Korea	jjm0820@korea.kr
Juanita Elina	Department of Agronomy and Horticulture, Bogor Agricultural University	juanitaelina@gmail.com
Jun Hyeon Cho	Department of Southern Area Crop Science, National Institute of Crop Science	hy4779@korea.kr
Junghoon lee	Department of Plant Science, Plant Genomics and Breeding Institute, and Research Institute of Agriculture and Life Sciences, College of Agriculture and Life Sciences, Seoul National University	jonghoonlee@snu.ac.kr
Ju-Won Kang	Department of Agronomy, Chungnam National University	hgorilla@gmail.com
Khairol Ismail	Research Officers, MARDI, Malaysia	khairol@mardi.gov.my
Kwon Kyoo Kang	Dept. of Horticulture, Hankyong National University	kykang@hknu.ac.kr
Kyu-Chan Shim		zktnrl@gmail.com
Kyung-Ho Kang	Rice Research Dept. of National Institute of Crop Science	khkang@korea.kr
Lukita Devy	Department of Agronomy and Horticulture, Bogor Agricultural University	d_lukita@yahoo.com
M Rauful Mizan	Department of Agronomy and Horticulture, Bogor Agricultural University	miatulmizan@gmail.com
Maera Zasari	Department of Agronomy and Horticulture, Bogor Agricultural University	maera_zasari@yahoo.com

Name	Affiliation	Email
Marina Yuniawati	Department of Agronomy and Horticulture, Bogor Agricultural University	marina@batan.go.id
Mega Dewi H.	Department of Agronomy and Horticulture, Bogor Agricultural University	megadewiindica@yahoo.com
Megumi Kashiwagi	United Graduate School of Agricultural Science, Tokyo University of Agriculture and Technology	mugumi127@gmail.com
Mi-Ok Woo	National Academy of Agricultural Science, Rural Development Administration	miok1004@hanmail.net
Mohd Din Amiruddin	Malaysian Palm Oil Board, Persiaran Institusi	mohddin@mpob.gov.my
Moon Young Kim	Department of Plant Science and Research Institute for Agriculture and Life Sciences,Seoul National University	moonykim@snu.ac.kr
Motoki Kanekatsu	Tokyo University of Agriculture and Technology , Japan	kanekatu@cc.tuat.ac.jp
MR Alfarabi Istiqlal	Department of Agronomy and Horticulture, Bogor Agricultural University	alfa.istiqlal@gmail.com
Muhamad Syukur	Department of Agronomy and Horticulture, Bogor Agricultural University	muhsyukur@yahoo.com
Muhammad Imam Surya	Cibodas Botanical Garden – Indonesian Institute of Sciences	misurya084@gmail.com
Naoya Ueno	Tokyo University of Agriculture and Technology	un.nasuke@gmail.com
Neni Rostini	Agriculture Faculty of Padjadjaran University	nenithamrin@yahoo.com
Ni Made Armini	Department of Agronomy and Horticulture, Bogor Agricultural University	nmarmini@gmail.com
Nita Ekana'ul	Department of Agronomy and Horticulture, Bogor Agricultural University	nitaekanaul@rocketmail.com
Noraziyah Binti Abd Aziz Shamsudin	Faculty of Science and Technology, Universiti Kebangsaan	nora_aziz@ukm.edu.my
Nur Kholilatul Izzah	Indonesian Industrial and Beverage Crops Research Institute	lila_ref@yahoo.co.id
Nurul Hidayatun	Indonesian Center for Agricultural Biotechnology & Genetic Resources	nurulhi23@yahoo.com

Name	Affiliation	Email
Nurwanita Ekasari Putri	Department of Agronomy and Horticulture, Bogor Agricultural University	nurwanita2004@yahoo.com
Panca Jarot Santoso	Indonesian Tropical Fruit Research Institute, IAARD, Jl. Raya Solok-Aripan Km. 8, P.O. Box	jarot305@yahoo.com
Patcharin Tanya	Dept. of Agronomy, Faculty of Agriculture at Kamphaeng Saen, Kasetsart University, Kamphaeng Saen, Nakhon Pathom 73140, Thailand	altanya55@yahoo.com
Peerasak Srinives	Kasetsart University	agrpss@yahoo.com
Pieter Lontoh	Department of Agronomy and Horticulture, Bogor Agricultural University	
Prakit Somta	Department of Agronomy, Kasetsart University	pksomta@gmail.com
Puji Lestari	ICABIOGRAD	plestari129@yahoo.com
Rahmatika Alfi	Department of Agronomy and Horticulture, Bogor Agricultural University	
Rahmi Henda Yani	Department of Agronomy and Horticulture, Faculty of Agriculture, Bogor Indonesia, 16680	rahmi_hendayani@yahoo.com
Rakesh Kumar Singh	Plant Breeding, Genetics, and Biotechnology Division, International Rice Research Institute, Philippines	r.k.singh@irri.org
Ramakrishnan Madhavan Nair	AVRDC – The World Vegetable Center, South Asia, ICRISAT Campus, Patancheru	ramakrishnan.nair@worldveg.org
Ratih Wahyuni	PT BISI International Tbk	nunik_ratih@yahoo.com
Razlin Azman Halimi	Crops For the Future (CFF)	razlin.azman@cffresearch.org
Reflinur	ICABIOGRAD	reflinur@yahoo.com
Reni Indrayanti Sukardiono	Dept. Biologi, Universitas Negeri Jakarta	reni_yanti@yahoo.com
Respatijarti Atmadji	Faculty of Agriculture, Brawijaya University	patiatmadji@gmail.com
Rima Margareta Retnyo Gumelar	Department of Agronomy and Horticulture, Bogor Agricultural University	rimamargareta@gmail.com
Rossa Yunita	Department of Agronomy and Horticulture, Bogor Agricultural University	rossa_yunita@yahoo.com

Name	Affiliation	Email
Rudy Soehendi	Indonesian Ornamental Crop Research Instituti-IAARD	rsoehendi@gmail.com
Sandra Arifin Aziz	Department of Agronomy and Horticulture, Bogor Agricultural University	sandraaziz@yahoo.com
Sangnag Ahn	Chungnam National University	ahnsn@cnu.ac.kr
Sangrea Shim		sangreashim@gmail.com
Satoto	Indonesian Center for Rice Research	satoto_ski@yahoo.com
Sentoor Kumeran Govindasamy	Fakulti Pertanian, Universiti Putra Malaysia	sentoor@mardi.gov.my
Sherly Lapuimakuni	Department of Agronomy and Horticulture, Bogor Agricultural University	lapuimakunisherly@gmail.com
Shungo Higuma	Graduate School of Agricultual Science, Tokyo University of Agriculture and Technology	grizzly9266@gmail.com
Sigit budi santoso	Indonesian Cereals Research Institute	nanoboed@gmail.com
Simon H.T. Raharjo	Faculty of Agriculture, Pattimura University	indobio@gmail.com
Siti Marwiyah	Department of Agronomy and Horticulture, Bogor Agricultural University	wie.marwiyahs@gmail.com
Siti Nurhidayah	Department of Agronomy and Horticulture, Bogor Agricultural University	dayah.ipb@gmail.com
Sofyan Zaman	Department of Agronomy and Horticulture, Bogor Agricultural University	
Sri Sunarti	Indonesian Cereals Research Institute	sri.sunarti01@yahoo.co.uk
Suchila Techawongstien	Faculty of Agriculture, Khon Kaen University Khon Kaen	suctec.kku@gmail.com
Sudarsono	Department of Agronomy and Horticulture, Bogor Agricultural University	s_sudarsono@ymail.com
Suluh Nurmasiwi	PERIPI	snsuluhsiwi10@gmail.co
Surjono H Sutjahjo	Department of Agronomy and Horticulture, Bogor Agricultural University	surjonohadisutjahjo@yahoo.com
Suseno Amien	Faculty of Agriculture, University of Padjadjaran	suseno2011@gmail.com
Suskandari Kartikaningrum	Indonesian Ornamental Crop Research Institute	suskandari@gmail.com

Name	Affiliation	Email
Suyeon Ha		hasuyeon@snu.ac.kr
Syarifah Iis Aisyah	Department of Agronomy and Horticulture, Bogor Agricultural University	syarifahiis@yahoo.com
Tae-Hwan Jun	Department of Plant Bioscience, Pusan National University	thjun76@pusan.ac.kr
Taeyoung Lee	Department of Plant Science and Research Institute for Agriculture and Life Sciences, Seoul National University	alima9002@gmail.com
Tantri Dyah Ayu A		tantrianggraeni210@gmail.com
Taryono	Faculty of Agriculture, University of Gadjah Mada	tariono60@gmail.com
Tengku Laila Kamaliah	Department of Agronomy and Horticulture, Bogor Agricultural University	tengkulailakamaliah@gmail.com
Tri Hastini	Department of Agronomy and Horticulture, Bogor Agricultural University	trihastini@gmail.com
Trias Sitaresmi	Indonesian Center for Rice Research	sitares_trias@yahoo.com
Trikoesoemaningtyas	Department of Agronomy and Horticulture, Bogor Agricultural University	trikadytia@gmail.com
Untung Susanto	ICCR of IAARD	untungsus2011@gmail.com
Usamah Jaisyurahman	Department of Agronomy and Horticulture, Bogor Agricultural University	usamah_jaisyu@yahoo.com
Victor Manotar Pademan Manalu	Department of Agronomy and Horticulture, Bogor Agricultural University	victormpmanalu@yahoo.com
Willy Bayuardi Suwarno	Department of Agronomy and Horticulture, Bogor Agricultural University	bayuardi@gmail.com
Wiwik Hardaningsih	PS. Budidaya Tanaman Pangan,Jurusan Budidaya Tanaman, Politani	jeng_wiwik@yahoo.com
WooJae Kim	National Institute of Crop Science, RDA	wjkim1993@gmail.com
Yeong-Ho Lee		yhl413@hanmail.net
Yong-Gu Cho	Department of Crop Science, Chungbuk National University	ygcho@cbnu.ac.kr
Young Chan Cho	National Institute of Crop Science, RDA	yccho@korea.kr

Name	Affiliation	Email
Yudhistira Nugraha	Indonesian Center for Rice Research	yudhistira.nugraha@gmail.com
Yudiwanti Wahyu	Department of Agronomy and Horticulture, Bogor Agricultural University	yudiwanti@apps.ipb.ac.id
Yuliasti	Center for Application Isotope Radiation Jakarta Indonesia	upikyuliasti@yahoo.com
Yun-A Jeon		jya0911@cnu.ac.kr
Yunandra	Department of Agronomy and Horticulture, Bogor Agricultural University	yunandraasnur71@gmail.com
Yuni Widyastuti	Indonesian Center for Rice Research	yuniweicrr@gmail.com
Yunjoo Kang	Chungnam National University	yunjook.92@gmail.com

ESTIMATION OF COMBINING ABILITY AND HETEROSIS FOR YIELD COMPONENT IN HALF DIALLEL OF LOCAL TOMATOES IN LOWLAND

Gumelar RMR[1*], Sutjahjo SH[1], Wirnas D[1], Herison C[2], Sulastri I[3], Nindita A[1], and Marwiyah S[1]

[1]Bogor Agricultural University
[2]Bengkulu University
[3]Indonesian Vegetable Research Institute
*Corresponding Author: rimamargareta@gmail.com

SUMMARY

Demand for tomatoes in Indonesia continues to rise but National consumption can't be fulfilled from national production. Improvement of the quality and quantity of tomatoes should also continue to be made to meet consumer demand. Varieties based on local germplasm is a way to answer these problems. The research aims to study specific combining ability (SCA), general combining ability (GCA), heterosis and heterobeltiosis F_1 populations in a half diallel cross of local tomatoes. The experiment was conducted in July to December 2014 at the experimental field Leuwikopo, IPB, using Randomized Complete Block Design Group with three replications. Genetic material consisted of 5 local tomato genotypes as parents and 10 F_1 crosses half diallel results. Genetic parameters observed were SCA, GCA, heterosis, and heterobeltiosis. GCA value and SCA were analyzed by Griffing's method II. Heterosis is calculated based on the average value of both parents and heterobeltiosis calculated based on the average value of the highest parents. Kudamati 1 is the best combiner for the characterof number of fruits per plant, Aceh 5 and Gondol for fruit size, and Lombok 4 is the best combiner for the character of weight per fruit. Hybrid Lombok 4 x Gondol has the highest and most positive value of SCA, heterosis, and heterobeltiosis for all the characters that are directed to hybrid varieties.

Keywords: genotype, heterobeltiosis, hybrid, genetic parameter, GCA, SCA

INTRODUCTION

Tomatoes are one of the high-value commodities that can be consumed fresh or processed first. Tomatoes also contain several important nutrients for health, namely, potassium, folic acid, vitamin C, vitamin E, lycopene and ′ -carotene (Willcox *et al.,* 2003). The lycopene content in tomatoes serves as an antioxidant and have a favorable effect in lowering the risk of various chronic diseases including cancer (Agarwal and Rao, 2000; Kailaku *et al.* 2007)

According to Pusdatin (2014), consumption of tomatoes in Indonesia at 1:55 kg capita-1 year-1 in 2002 and in 2013 increased to 1.76 kg capita-1 year-1 with an average growth of 3.66% per year. Tomatoes harvested area in Indonesia during the period 1990–2013 also tended to increase with average growth of 1.91% per year and was followed by an increase in production by 6:27% per year. Despite the increase in production, Indonesia's still importing tomatoes to meet domestic demand. In 2012, Indonesia imported tomatoes for 12 157 tonnes (Deptan, 2013) and increased to 12 613 tonnes in 2013 (Deptan, 2014).

The problems faced by tomato plants in the tropics, namely the plants are susceptible to pests and diseases, high rainfall, high temperatures and low fruit quality (Villareal, 1979). Cultivation of tomato plants in Indonesia is still widely practiced in the highlands and must compete with other horticultural crops so it is necessary to expand the planting area to the middle and lower plains. Therefore, tomatoes commodity in Indonesia still requires serious attention in terms of increased yield and fruit quality in the lowlands.

Indonesia has a diverse germplasm potential as a source of diversity that can be used as initial capital for the varieties. Assembly of hybrid varieties is one way that can be done to obtain tomato varieties with superior characters. Hybrid varieties are F1 generation of a pair or more parents who have superior properties. The excellence of hybrid varieties iscaused by the events of heterosis (Poespodarsono, 1988). Heterosis is a situation which shows that F1 has a better value than the parents. The circumstances can be an increase in size, vigor, or productivity. There are three theories on heterosis, which is the dominant theory, over-dominant, and epistasis. The dominant theory assumed a dominant gene has a much better value than the recessive genes so heterosis occurs because the dominant gene cover the effect of a recessive gene on a character. Over-dominant theory suspect that heterosis is caused by heterozygous genes at a locus has a better value than the locus with homozygous genes. Epistasis theory suspect that heterosis is caused by an interaction between alleles in different locus. (Poespodarsono, 1988; Syukur *et al.,* 2012)

Additional information that's needed for the formation of hybrid varieties is the parents combining ability. The information can be used to obtain potential parents. Combining ability consist of general combining ability (GCA) and specific combining ability (SCA). GCA can be interpreted as a measure of the average appearance of the parents. SCA is a picture of a cross combinations which have the best performance compared to he average cross (Sprague and Tatum, 1942). The purpose of this study was to estimate the combining ability and heterosis from half-diallel crosses in the lowlands.

MATERIALS AND METHODS

The research was conducted from July to December 2014 in Leuwikopo, IPB, Bogor with altitude ± 230 m above sea level. The planting materials are 5 local tomato genotypes as parents and 10 F1 half-diallel cross. The 5 genotypes consist of Kudamati 1 (K1), Ranti (R), Aceh 5 (A5), Lombok 4 (L4), and Gondol (GL).

The experimental design used was randomized complete block design (RCBD) with three replications. Each replication consisted of 15 genotypes so there were 45 experimental units. The number of individuals in each experimental units was 20 plants. Each experimental unit wasthe beds measured 5mx1m which was covered in black-silver plastic mulch. Seedling was transfered to the field at ± 4 weeks old. Maintenance consisted of fertilizing, replanting, watering, plant pest and disease controlling, stakes installing, pruning, weeding, and binding.

Fertilizer used was NPK Mutiara (16:16:16) at a dose of 10 g/l. Fertilizer was given in a solution form and each plant was given 250 ml. Plant pest and disease control was done chemically once a week using gfungicides and insecticides. Stakes installation was carried out shortly after planting. Watering was done in the morning or evening when it was not raining. Weeding was done manually. Harvesting was done when the fruit was yellow-reddish and done twice a week up to 8 times.

Observationn was madeon 10 plants sample. The characters observed including weight per fruit, fruit size, fruit weight per plant, and number of fruits per plant. Weight per fruit and fruit size were observed on the same fruit that was harvested at the second up to fourth harvest time. The prediction of general combining ability (GCA) and sepcific combining ability (SCA) was based on Griffing's method II (Singh and chaudhary, 1979). Heterosis prediction value was seen by the median of two parents (mid-parent), while heterobeltiosis value was seen by best parent.

$$\text{Heterobeltiosis} = \frac{(F_1 - BP)}{BP} \times 100$$

$$\text{Heterosis} = \frac{(F_1 - MP)}{MP} \times 100$$

Keterangan:

F1 = Mean of F_1

MP = Mean of parents $(\frac{P_1 + P_2}{2})$

BP = Mean of best parents

RESULT

General Combing Ability and Special Combining Ability

The result of variance analysis shows that genotype effects on all the characters observed (Table 1). GCA doesn't significally effect all characters, while SCA has a very significant effect on weight per fruit, number of fruits per plant, and fruit weight per plant (Table 2).

The result of analysis of SCA and GCA estimation are presented in Table 3. The crosses that have a positive SCA for the character of weight per fruit are Kudamati 1 X Ranti, Aceh 5 X Lombok 4, Aceh 5 X Gondol, Lombok 4 X Gondol. Fruit size is calculated by the length and diameter of the fruit. Kudamati 1 X Ranti, Kudamati 1 X Gondol, Ranti X Lombok 4, Aceh 5 X Lombok 4, Aceh 5 X Gondol, Lombok 4 X Gondol are crosses that have positive SCA for fruit size. Crosses that have positive SCA for the characters of fruit weight per plant and fruit number per plant are Kudamati 1 X Ranti, Ranti X Lombok 4, Aceh 5 X Gondol, and Lombok 4 X Gondol. Cross of Ranti X Gondol also has a positive SCA for numbers of fruit per plant. Among the crosses that have a positive SCA value, Lombok 4 x Gondol has the highest SCA and is positive for all characters.

Table 1. Analysis of varience of tomato yield components

Source of variance	df	Means Square			
		WpF	FZ	FWpP	NFpP
Replication	2	20.281	43.861	93.177	39956.936
Genotype	14	35.295**	23.251**	59.359**	21482.711*
Error	24	228.672	172.497	410.772	184033.903
CV (%)		19.388	9.107	20.791	12.005

WpF: Weight per fruit, FZ: fruit size, FWpP: fruit weight per plant, NFpP: number of fruits per plant, *: significant at 5% level probability, **: significant at 1% level probability

Table 2. Analysis of variance of combining ability in half diallel

Source of variance	df	Means Square			
		WpF	FZ	FWpP	NFpP
GCA	4	14.648ns	28.649ns	16.712ns	1586.814ns
SCA	10	24.335**	31.293ns	26.391**	11385.558**
Error	28	7.517	16.872	8.022	2748.546

WpF: Weight per fruit, FZ: fruit size, FWpP: fruit weight per plant, NFpP: number of fruits per plant, *: significant at 5% level probability, **: significant at 1% level probability, ns: not significant

Table 3. General combing ability and special combining ability

Genotype	WpF	FZ	FWpP	NFpP
	GCA			
Kudamati 1	-0.98	-0.61	22.07	1.99
Ranti	-1.40	-2.34	0.11	0.60
Aceh 5	-1.48	1.79	-10.55	0.34
Lomok 4	0.68	-1.24	-16.79	-2.11
Gondol	2.18	2.40	5.15	-0.81
	SCA			
Kudamati 1 X Ranti	2.38	2.86	1.05	0.21
Kudamati 1 X Aceh 5	-0.23	-0.25	-63.32	-3.25
Kudamati 1 X Lombok 4	-5.19	-7.60	-73.92	-3.19
Kudamati 1 X Gondol	-4.60	1.40	-28.41	-1.33
Ranti X Aceh 5	-5.18	-8.44	-120.26	-7.25
Ranti X Lombok 4	-0.56	3.10	8.30	3.31
Ranti X Gondol	-6.40	-8.21	-38.39	0.23
Aceh 5 X Lombok 4	5.46	2.54	-6.12	-2.76
Aceh 5 X Gondol	0.95	0.25	104.92	5.91
Lombok 4 X Gondol	6.30	6.66	206.90	7.68

WpF: Weight per fruit, FZ: fruit size, FWpP: fruit weight per plant, NFpP: number of fruits per plant

Table 4. Estimate heterosis over MP and BP for weight per fruit

Genotype	Mean			Percent heterosis	
	P_1	P_2	F_1	MP	BP
Kudamati 1 X Ranti	16.313	16.525	14.453	-11.971	-12.537
Kudamati 1 X Aceh 5	16.313	13.002	12.773	-12.857	-21.698
Kudamati 1 X Lombok 4	16.313	19.218	13.457	-24.252	-29.978
Kudamati 1 X Gondol	16.313	20.692	16.579	-10.392	-19.874
Ranti X Aceh 5	16.525	13.002	11.096	-24.843	-32.854
Ranti X Lombok 4	16.525	19.218	13.168	-26.319	-31.480
Ranti X Gondol	16.525	20.692	13.252	-28.784	-35.954
Aceh 5 X Lombok 4	13.002	19.218	20.122	24.897	4.700
Aceh 5 X Gondol	13.002	20.692	17.108	1.546	-17.321
Lombok 4 X Gondol	19.218	20.692	23.610	18.317	14.103

Table 5. Estimate heterosis over MP and BP for fruit size

Genotype	Mean			Percent heterosis	
	P_1	P_2	F_1	MP	BP
Kudamati 1 X Ranti	27.393	27.471	26.729	-2.562	-2.700
Kudamati 1 X Aceh 5	27.393	33.354	27.751	-8.634	-16.798
Kudamati 1 X Lombok 4	27.393	32.982	26.057	-13.683	-20.996
Kudamati 1 X Gondol	27.393	31.565	30.006	1.788	-4.938
Ranti X Aceh 5	27.471	33.354	26.748	-12.048	-19.805
Ranti X Lombok 4	27.471	32.982	26.339	-12.860	-20.140
Ranti X Gondol	27.471	31.565	27.998	-5.150	-11.301
Aceh 5 X Lombok 4	33.354	32.982	29.915	-9.806	-10.310
Aceh 5 X Gondol	33.354	31.565	31.263	-3.685	-6.268
Lombok 4 X Gondol	32.982	31.565	34.634	7.314	5.010

Table 6. Estimate heterosis over MP and BP for fruit weight per plant

Genotype	Mean			Percent heterosis	
	P_1	P_2	F_1	MP	BP
Kudamati 1 X Ranti	307.236	255.659	204.023	-27.509	-33.594
Kudamati 1 X Aceh 5	307.236	202.092	129.003	-49.343	-58.011
Kudamati 1 X Lombok 4	307.236	119.470	168.240	-21.144	-45.240
Kudamati 1 X Gondol	307.236	68.600	269.412	43.367	-12.310
Ranti X Aceh 5	255.659	202.092	75.135	-67.171	-70.610
Ranti X Lombok 4	255.659	119.470	172.412	-8.078	-32.561
Ranti X Gondol	255.659	68.600	221.490	36.613	-13.364
Aceh 5 X Lombok 4	202.092	119.470	147.337	-8.361	-27.093
Aceh 5 X Gondol	202.092	68.600	280.319	107.113	38.708
Lombok 4 X Gondol	119.470	68.600	376.059	299.913	214.771

Table 7. Estimate heterosis over MP and BP for number of fruit per plant

Genotype	Mean			Percent heterosis	
	P_1	P_2	F_1	MP	BP
Kudamati 1 X Ranti	18.746	13.937	13.779	-15.679	-26.494
Kudamati 1 X Aceh 5	18.746	15.333	10.055	-40.987	-46.359
Kudamati 1 X Lombok 4	18.746	6.366	11.500	-8.412	-38.653
Kudamati 1 X Gondol	18.746	3.111	16.239	48.594	-13.372
Ranti X Aceh 5	13.937	15.333	7.000	-52.170	-49.775
Ranti X Lombok 4	13.937	6.366	12.777	25.864	-8.319
Ranti X Gondol	13.937	3.111	16.500	93.566	18.387
Aceh 5 X Lombok 4	15.333	6.366	6.444	-40.604	-57.971
Aceh 5 X Gondol	15.333	3.111	16.408	77.929	7.013
Lombok 4 X Gondol	6.366	3.111	15.738	232.121	147.207

Heterosis

Heterosis value is calculated based on mid-parent (heterosis) and best parent (heterobeltiosis). Heterosis for the characters of weight per fruit ranges from -10.392% - 24.897% while heterobeltiosis ranges from -32.854% - 14.103% (Table 4). The character of fruit size has a heterosis -12.860% - 7.314% and range of heterobeltiosis is -20.996% - 5.010% (Table 5). The value of heterosis for the characters of fruit weight per plant ranges from -49.343% - 299.913% and heterobeltiosis ranges from -70.610% - 214.771% (Table 6). Character of fruit number per plant has a heterosis values -40.987% - 232.121% and heterobeltiosis range from -52.170% - 147.207% (Table 7). Cross of Aceh 5 x Lombok has the highest value of heterosis, but Lombok 4 x Gondol has the highest heterobeltiosis for the character of weight per fruit (Table 4). Cross of Lombok 4 x Gondol is a hybrid that has the highest heterosis and heterobeltiosis value for the character of fruit size, fruit weight per plant, and fruit number per plant (Table 5 -7).

DISCUSSION

General Combing Ability and Special Combining Ability

Estimation of combining ability can be done if the genotypes central square was highly significant or tangible (Singh and Chaudhary, 1979). Hafsah *et al.* (2007) stated that the character which has a real effect GCA indicates that the observed character was controlled by additive genes, while the character that has a real effect SCA was controlled by non-additive genes action. Based on this fact, it can be seen that the weight per fruit, fruit number per plant, and fruit weight per plant in this genotype is controlled by non-additive gene.

According to Rustikawati *et al.* (2012) an parent who has a high general combining ability indicating that the parents have the ability to combine well with other parents in producing hybrids. Kudamati 1 is the best combiner for the character of fruits per plant, Aceh 5 and

Gondol for the fruit size, and Lombok 4 is the best combiner for the character of fruit weight. This happends because the parents are having a positive GCA values (Table 3).

High SCA value is generally derived from the parents with high GCA (Sujiprihati *et al.*, 2007, Iriany *et al.*, 2011). The results shows a cross between parents which have positive GCU with parents which have negative GCA produces high and positive SCA. This occurs at the cross of Aceh 5 x Gondol and Lombok 4 x Gondol towards the character of fruit weight per plant (Table 3). The genotypes that have positive and negative GCA generally produces high SCA effect because the genes that are profitable can cover the adverse genes and are able to join well (Iriany *et al.*, 2011).

Heterosis

The hybrid that has a positive heterosis and heterobeltiosis value is a hybrid which is expected for the characters that affect production. If a descendant decrease the desired character, then the heterosis is negative. According to Shankar *et al.*, (2014), F_1 which exceeds the average parent (heterosis) would be useless if it wasn't better than the best parents, so heterosis estimation which is based on the best elders (heterobeltiosis) needs to be done. Lombok 4 x Gondol is a cross which can be recommended for further development into hybrid varieties. The cross has a positive and high heterosis and heterobeltiosis values for all the result components (Table 4, 5, 6, and 7).

Hybrid of Aceh 5 x Gondol also can be developed into a hybrid variety. The genotype also has a high heterosis and heterobeltiosis value for the character of weight and fruits number per plant but still lower when compared to Lombok 4 x Gondol (Table 6 and 7). A positive heterosis and heterobeltiosis value indicate that the cross combinations have better value than the median of two parents and median of best parents. According to Iriany et al. (2011) a high heterosis and heterobeltiosis value of the observed characters is caused by the parents that are used in the crosses have a distance genetic.

The character of fruit weight per plant in Lombok 4 x Gondol has a high heterosis (299.913%). The result of research by Hannan *et al.* (2007), Sekhar et al. (2010), Ahmad *et al.* (2011), Farzane *et al.* (2012), and Souza *et al.* (2012) also shows that the character of fruit weight per plant has a high heterosis range from -39.19% - 211.00%. High heterosis reflect the differences in the frequency of alleles which are owned by the parents is very huge and the parents have genes which are benefical and also have positive interactions if combined (Falconer, 1981; Wricke and Weber, 1986).

CONCLUSION

Hybrid Lombok 4 X Gondol has the best specific combining ability for all character. There are differences in the level of heterosis and heterobeltiosis among 10 tested hybrid. Hybrid of Lombok 4 x Gondol is a hybrid that has a high and positive heterosis and heterobeltiosis for all yield components. Lombok 4 X Gondol also can be recommended to be developed further to become a high yielding hybrid varieties in the lowlands.

REFERENCES

Agarwal S, Rao AV. (2000). Tomato lycopene and its role in human health and cronic disease. *CMAJ*. 163(6):739–744.

Ahmad S, Quamruzzaman AKM, Islam MR. (2011). Estimate of heteosis in tomato (*Solanum lycopersicum* L.). *Bangladesh J. Agril. Res.* 36(3):521–527.

[DEPTAN] Departemen Pertanian. (2013). Impor tomat pernegara asal periode Januari s/d Desember 2012 [Internet]. [diunduh 2014 Juni 28]. Tersedia pada:

[DEPTAN] Departemen Pertanian. (2014). Impor tomat pernegara asal periode Januari s/d Desember 2013 [Internet]. [diunduh 2014 Juni 28]. Tersedia pada:

Falconer DS. (1981). *Introduction to Quantitative Genetics*. New York (US): Longman.

Farzane A, Nemati H, Arouiee H, Kakhki AM, Vahdati N. (2012). The estimate of combining and heterosis for yield and yield components in tomato (*Lycopersicon esculentum* Mill). *J. Bio. Environ. SCI.* 6(17):129–134.

Hannan MM, Ahmed MB, Roy UK, Razvy MA, Haydar A, Rahman MA, Islam MA, Islam R. (2007). Heterosis, combining ability and genetics for brix% days to first fruit ripening and yield in tomato (*Lycopersicon esculentum* Mill.). *Middle-East J. Sci. Res.* 2(3-4):128–131.

Iriany RN, Sujiprihati S, Syukur M, Koswara J, Yunus M. (2011). Evaluasi daya gabung dan heterosis lima galur jagung manis (*Zea mays* var. *saccharata*) hasil persilangan dialel. *J.Agron.Indonesia*. 39(2):103–111.

Kailaku SI, Dewandari KT, Sunarmani. (2007). Potensi likopen dalam tomat untuk kesehatan. *Bul Pascapanen Tanaman Pertanian*. 3:50–58.

[PUSDATIN] Pusat Data dan Sistem Informasi Pertanian. (2014). Outlook komoditi tomat. Jakarta (ID): Kementrian Pertanian.

Poespodarsono S. (1988). *Dasar-dasar Ilmu Pemuliaan Tanaman*. Bogor (ID): PAU,Institut Pertanian Bogor. 169 hlm.

Rustikawati, Suprijono E, Romeida A, Herison C, Sutjahjo SH. (2012). Analisis daya gabung umum dan daya gabung khusus 6 mutan dan persilangann dalam rangka perakitan kultivar hibrida jagung tenggang kemasaman. Simposium dan seminar bersama PERAGI-PERHORTI-PERIPI-HIGI mendukung kedaulatan pangan dan energi yang berkelanjutan; 2012 Mei 1–2; Bogor, Indonesia. Bogor (ID): Departemen Agronomi dan Hortikultura Fakultas Pertanian Institut Pertanian Bogor. Hlm 286–291.

Singh RK, Chaudhary BD. (1979). *Biometrical method in Quantitatif Genetical Analysis.* New Delhi (IN): Kalyani Publication.

Souza LM, Paterniani MEAGZ, de Melo PC, de Melo AMT. (2013). Diallel cross among fresh market tomato inbreeding lines. *Horticultura Brasileira.* 30:246–251.

Sujiprihati S, Syukur M, Yunianti R, Undang. (2007). Pendugaan nilai heterosis dan daya gabung beberapa komponene hasil pada persilangan dialel penuh enem genotipe cabai (*Capsicum annuum* L). *Bul.Agron*. 35(1):28–35.

Villareal RL. (1979). Tomato production in the tropics-problem and progress. Di dalam: Cowell R, editor. *1st international symposium on tropical tomato*; 1978 Oktober 23-27; Shanhua, Taiwan. Taiwan (TW): AVRDC. hlm 6–21.

Sekhar I, Prakash BG, Salimath PM, Channayya, Hiremath P, Sridevi O, Patil AA. (2010). Implications of heterosis and combining ability among productive single cross hybrids in tomato. *Electron J. Plant Breed.* 1(4):706–711.

Sprague GF, Tatum LA. (1942). General vs specific combining ability in single crosses of corn. *Jour Amer Soc Agron.* 34:923–932.

Syukur M, Sujipriharti S, Yunianti R. (2012). *Teknik Pemuliaan Tanaman*. Jakarta (ID): Penebar Swadaya.

Wilcox JK, Catignani GL, Lazarus S. (2003). Tomatoes and cardiovascular health. *Critical Reviews in Food Science and Nutrition..* 43(1):1–18.

Wricke G, Weber WE. (1986). *Quantitative Genetics and Selection in Plant Breeding*. Berlin (DE): Walter de Gruyter.