Hebicides-mediated weed control of soybean saturated on tidal swamp

Achmad Yozar Perkasa, Munif Ghulamahdi, and Dwi Guntoro

Department of Agronomy and Horticulture, Faculty of Agriculture, Bogor Agricultural University, Indonesia

ABSTRACT

Herbicide can be used to control some weeds in soybean saturated cultivation on tidal swamp environment. The objective of this study was to obtain the most effective herbicides for controlling weeds on soybean saturated culture grown in tidal swamp. The research was conducted on tidal swamp at Banyu Urip village, Tanjung Lago sub districts, Banyuasin, Palembang, South Sumatera Province from July to December 2013. The experiment was done in a randomized block designed with one factor and three replications. There were eight treatments including control (P0), manual weeding at 4 weeks after planting (P1), 2 L ha^{-1} of paraquat application at 4 weeks after planting (P2), 3 L ha^{-1} of glyphosate application at 4 weeks after planting (P3), 2 L ha^{-1} of oxyfluorfen application 3 days before planting (P4), 2 L ha^{-1} of oxyfluorfen followed by paraquat application 3 days before planting and 4 weeks after planting (P5), 2 L ha^{-1} and 3 L ha^{-1} of oxyfluorfen followed by glyphosate application 3 days before planting and 4 weeks after planting (P6), 1 L ha^{-1} of penoxulam application at 2 weeks after planting (P7). The results showed that paraquat effectively suppressed the total weight of weed at 4, 6, and 8 weeks after planting. The highest soybean productivity was 3.76 tons ha^{-1} as resulted from glyphosate treatment. Our results indicate that weeds eradication by applying herbicide as pre-treatment prior planting is necessary and that the herbicide application should be carried out in a way to minimize toxicity in plants.
Keywords: saturated soil culture, soybean, tidal swamp, weed controls.

INTRODUCTION

Although soybean has been cultivated in Indonesia for a long time, the development of the planting area in term of of agricultural cultivation is very slow, thus, soybean had never been a major crop. Soybean production in Indonesia in the year 2013 was only 851.647 tons of dry beans with productivity 1.48 tons ha^{-1} which inadequately enough to fit the national demand of soybean for approximately 2.3 million tons. National shortage of soybean demand is supplied through imports as much as 1.7 million tons in 2010 and progressively increased to 1.9 million in 2012 (CBS, 2013). Thus it is essentially important to improve soybean productivity to fulfill national demand of soybean. Productivity of soybean plant can be increased efforts of the development of potential agricultural land, one is tidal swamp. Taufiq et al., (2008) revealed that the success of soybean cultivation in the tidal area can be obtained with soybean cultivation technique improvement in tidal land type C which can increase the productivity of approximately 30% soybean. Ghulamahdi et al., (2009) proved that yellow soybean varieties Tanggamus yielded high productivity (4.63 tons ha^{-1}) with water saturated cultivation techniques. Moreover, the water-saturated culture technology effectively promotes growth and production of soybean, particularly, in saline tidal swamp (Sagala et al., 2013). The utilization of tidal are for soybean agriculture has many obstacles including soil biophysical problems that decrease soybean production and the presence of weeds. Weeds in the tidal area is still a limiting factor of production and become important issue in

agriculture. It is due to the investment of weeds is quite large, very fast and fertile. Thus, the growth of weeds should be managed properly without any harmful side effects. Utomo et al., (2014) stated that weed control treatments by vinegar herbicide, glyphosate and paraquat on soybean agriculture does not affect number of seeds per plant and seed weight of one hundred pre-planting application. Generally, weed control management in soybean crop is done manually. Certain factors including the availability of labor, cost and extent of crop limits weed control management. The use of herbicides to control weeds in a wide planting area and labor is relatively expensive, on the other hand, it is an effective and efficient approach to control weed without disturbing soil structure. Although several types herbicides are widely known to control weed in soybean plants, however, the most effective one remains unknown. Thus, the purpose of this research was to obtain the most effective herbicide to control weeds in soybean cultivation in the water saturated tidal swamp.

MATERIALS AND METHODS

The experiment was conducted in tidal swamp Banyu Urip village, district of Tanjung Lago, Banyu Asin, South Sumatra province in July to December 2013. Materials and tools used were soybean seed varieties Tanggamus, paraquat herbicide ingredient active, glyphosate, oxyfluorfen, and penoxsulam. The fertilizer used in this study including urea, SP-36, and KCl. Marshall, pesticides, semi automatic sprayer, plastic lid bottle of mineral water, quadrant measuring 0.5 m x 0.5 m and other supporting tools were also used. Research was donse by using randomized complete block design with one factor, namely the type of herbicides. The experiment consisted of 8 treatments and was done in three independent replications. Treatments category as follows: control, manual weeding 4 weeks after planting (WAP), paraquat 4 WAP 2 L ha^{-1}, glyphosate 4 WAP 3 L ha^{-1}, oxyfluorfen 3 days before planting (DBP) 2 L ha^{-1}, oxyfluorfen - paraquat 3 DBP and 4 WAP 2 L ha^{-1}, oxyfluorfen - glyphosate 3 DBP and 4 WAP 2 L ha^{-1} and 3 L ha^{-1}, and penoxsulam 1 L ha^{-1}.

Herbicides were applied by using semi-automatic pressurized sprayer 1 kg cm^{-2} (15-20 psi) with spray volume of 400 L ha^{-1}, yellow T-jet nozzle spray width of 0.5 m. The lid sprayer with plastic bottles of mineral water to avoid harmful effect of herbicides toward soybean plants. Variables measured were the dominant weed species, total weed dry weight, dry weight of weeds per species, plant height, number of branches, number of three folia leaves, days to flowering, leaf area index (LAI), net assimilation rate (NAR), relative growth rate (RGR), the number of empty pods, number of pods, harvesting age, weight per tile production, production per hectare weight, the weight of one hundred seeds and phytotoxicity. Data were analyzed by using analysis of variance with further Duncan's multiple range test at the 5% significance level.

RESULTS AND DISCUSSION

The results of the analysis of vegetation prior to weed control treatment in field trials showed that the land was dominated by *Cyperus iria* with 37.77% dominance value, followed by grass that were *Axonopus compressus* and *Cynodon dactylon* with 15.44% and 9.56% dominance value, respectively (Table 1).

Table 1 Vegetation condition in soybean agriculture before weed control application

No	Species	Group	SDR (%)
1	*Cyperus iria*	Grasses	37.77
2	*Axonopus compressus*	Grasses	15.44
3	*Borreria alata*	Broad Leaves	13.85
4	*Phylanthus urinaria*	Broad Leaves	12.87
5	*Melastoma affine*	Broad Leaves	10.51
6	*Cynodon dactylon*	Grasses	9.56

Based on the weed dominancy value in Table 1, high dominancy of *Cyperus iria* may occur due to wide adaptability of this weed species toward diverse environmental conditions. In addition, herbicides treatment resulted low inhibitory effect toward *C. iria* growth due to strong *C. iria* `s defensive mechanism against environmental stresses. One of the mechanism is mediated by morphological adaptation such as the presence of lignin that prevents harmful substance to enter plant body (Schulz & Feriebe 1999). It is likely that the presence of lignin in the cell wall of *Cyperus iria* prevents the entry of chemical compounds via membrane, thus, avoiding cell damage.

In this study, herbicide treatment of glyphosate, oxyfluorfen, and oxyfluorfen - glyphosate on 4WAP has the same effectiveness in suppressing weeds with that manual weeding treatment (Table 2).

Damalas (2004) Paraquat stated that chemically active compounds of herbicides might inhibit enzymatic activity as well as physiological processes of weeds through various mode of actions. Paraquat was the most effective herbicides in suppressing weeds as indicated by the lowest weed dry weight at 4, 6, and 8 WAP. On the other hand, treatment of penoxsulam and oxyfluorfen were less effective in suppressing weeds at 4 WAP and 6, 8 MST, respectively (Table 2). The dry weight of *Cyperus iria* appeared to be the highest as compared to other weed species. However, paraquat treatment significantly reduced the dry weight of *C. iria* at the end of the observation (Table 3).

Table 2 Effects of various herbicide treatments on total weed weight

Treatments	Total weight of dry weeds (g 0.25 m^{-2})			
	2 WAP	4 WAP	6 WAP	8 WAP
Control	46.49a	57.27a	69.34a	50.06a
Manual	44.75a	18.92bc	31.25bc	16.05bc
Paraquat	38.23a	13.72c	9.34c	6.67c
Glyphosate	47.43a	27.23bc	24.22bc	16.55bc
Oxyfluorfen	29.50a	25.07bc	37.40b	23.20b
Oxyfluorfen-paraquat	38.42a	11.98c	13.73bc	12.72bc
Oxyfluorfen-glyphosate	28.77a	21.55bc	27.72bc	18.99bc
Penoxsulam	46.95a	39.59ab	34.56bc	19.54bc

Note : Numbers followed by the same letter in the same column indicate results that are not significantly different by DMRT-test at *α 5%, WAP: Week After Planting*

Table 3 Effect of various herbicide treatments on the dry weight of weeds per species

Treatment	Time	*C. iria*	*A. compressus*	*B. alata*	*P. urinaria*	*M. affine*	*C. dactylon*
		Dry weight (g 0.25m^{-2})					
Control	Start	38.07a	1.33bc	4.34a	3.12a	3.97ab	2.91a
	Finish	35.19a	2.23a	1.53a	3.43a	4.60a	4.64a
Manual	Start	35.00a	3.33a	2.47a	2.41ab	2.67ab	1.97a

Treatment	Time	*C. iria*	*A. compressus*	*B. alata*	*P. urinaria*	*M. affine*	*C. dactylon*
		Dry weight (g 0.25m^{-2})					
	Finish	17.17b	1.22bc	0.53c	1.11b	0.56b	0.47b
Paraquat	Start	32.67a	2.66abc	2.29a	2.07ab	2.00ab	2.00a
	Finish	3.59b	1.38ab	0.06c	1.20b	0.26b	0.20b
Glyphosate	Start	41.33a	3.00ab	3.00a	1.23ab	1.97ab	3.96a
	Finish	14.86b	1.00bcd	0.81b	0.36b	0.40b	1.23b
Oxyfluorfen	Start	25.33a	1.67abc	1.67a	1.00b	0.74b	3.00a
	Finish	8.40b	0.40cd	0.00c	0.33b	0.43b	1.20b
Oxyfluorfen-paraquat	Start	30.33a	0.83c	3.00a	1.33ab	1.41ab	3.80a
	Finish	10.52b	0.26d	0.19bc	0.70b	0.97b	0.68b
Oxyfluorfen-glyphosate	Start	51.00a	1.40bc	1.33a	0.87b	1.78ab	2.73a
	Finish	10.71b	0.23d	0.28bc	0.83b	0.51b	0.27b
Penoxsulam	Start	34.67a	1.23bc	1.85a	1.97ab	6.00a	2.15a
	Finish	16.66b	0.39cd	0.53bc	1.18b	1.15b	0.78b

Note: Numbers followed by the same letter in the same column indicate results that are not significantly different by DMRT-test at α 5%.

Paraquat effectively suppressed the growth of weeds because paraquat is a fast acting and direct-contact type of herbicides. Adnan et al. (2012) observed that the application of paraquat increases the percentage of weed control and reduces the dry weight of weeds in dose dependent manner, which further enhances crop yield as well as yield components of soybean plants. In this study, observed that herbicides treatment affect the vegetative growth of soybean plants only, without causing any significance physiological alterations (LAI, NAR, and RGR). The treatment effect on the vegetative growth of plants including plant height, number of branches, number of three folia leaves and days to flowering, but does not affect the physiology of soybean plants that LAI, NAR, and RGR. Oxyfluorfen - paraquat double treatment resulted the lowest plant height, while, paraquat and glyophosate treatments increased the number of branches and leaves, respectively. On the other hand, oxyfluorfen treatment caused longer flowering time than that other herbicides treatments. (Table 4).

Table 4 Effect of various herbicide treatments on both vegetative growth and physiology of soybean plant

Treatment	HoP	NoB	NoL	DoF	LAI	NAR	RGR
	cm	fruits	leaves	dap		g cm^{-2} day	g m^{-2} day
Control	72.80ab	5.20abc	27.80ab	39.00bc	0.623a	0.025x10^{-2}a	0.041a
Manual	79.00a	5.60ab	27.40ab	37.66c	0.543a	0.017x10^{-2}a	0.032a
Paraquat	69.20ab	5.73a	29.66a	38.66bc	0.436a	0.014x10^{-2}a	0.026a
Glyphosate	74.20ab	4.33c	30.06a	38.66bc	0.540a	0.013x10^{-2}a	0.026a
Oxyfluorfen	61.66ab	4.86abc	16.93c	43.33a	0.516a	0.021x10^{-2}a	0.038a
Oxyfluorfen-paraquat	58.33b	4.86abc	20.00bc	40.00b	0.596a	0.023x10^{-2}a	0.037a
Oxyfluorfen-glifosat	67.53ab	4.40bc	21.40bc	39.66bc	0.646a	0.014x10^{-2}a	0.025a
Penoxsulam	72.93ab	4.26c	26.33ab	39.00bc	0.570a	0.021x10^{-2}a	0.037a

Note: The numbers followed by the same letter are not significantly different at DMRT 5%. HoP (height of plant), NoB (number of branches), NoL (number of leaves), DoF (days to flowering), LAI (leaf area index), NAR (net assimilation rate), RGR (relative growth rate), DAP (days after planting)).

How it works herbicides give effect to the components of the soybean plant growth. Adnan et al. (2012) stated that the herbicides treatments directly affect the growth yield as well as yield component of soybean plants, depends on respective herbicide's mode of actions. In addition, the

growth and yield of plant are influenced by water, nutrients and light (Hassanudin et al., 2012). The presence of weed may essentially cause growth alteration on soybean plants as both weed and crop compete water, nutrients, light, space to grow as well as oxygen and carbon dioxide for growth (Utami and Rahadian, 2010). It is reported that high water and nutritions absorption by weeds leads to stunted growth of soybean plant (Prasetyo and Hajoeningtijas, 2009). Results indicated that the treatment of herbicides signficantly affected the variable number of empty pods, but did not essentially alterthe number of pods, harvesting age, weight per tile production, weight production per hectare and the weight of a hundred grains (Table 5). Lyphosate treatments markedly reduced the number of empty pods which essentially increased soybean yield, as shown by high value of both weight production per tile and weight production per hectare (Table 5).

Table 5 Effect of various herbicides treatments on both yield and quality of soybean plants

Treatment	NoEP	NoP	H	WPPT	WPPH	OHSW
	fruit	fruit	dap	g m^{-2}	ton ha^{-1}	g
Control	12.53a	85.00a	105.00a	261.00b	2.16b	10.56a
Mannual weeding	8.60ab	93.80a	104.33a	348.67ab	2.90ab	10.30a
Paraquat	8.46ab	105.13a	101.66a	386.67ab	3.23ab	10.19a
Glyphosate	4.46b	94.33a	103.66a	453.00a	3.76a	10.80a
Oxyfluorfen	5.40b	97.87a	103.66a	262.00b	2.16b	10.85a
Oxyfluorfen-paraquat	9.53ab	96.93a	103.66a	352.67ab	2.93ab	10.82a
Oxyfluorfen-glifosat	8.60ab	102.87a	104.33a	393.33ab	3.26ab	10.84a
Penoxsulam	6.60b	87.13a	101.66a	315.67ab	2.63ab	10.50a

Note: The numbers followed by the same letter are not significantly different at DMRT 5%. NoEP (number of empty pods), NoP (number of pods), H (harvesting), WPPT (weight production per tile), WPPH (weight production per hectare), OHSW (one hundred seed weight), DAP (days after planting).

Results indicated that higher concentration and systemic treatment of herbicides provide better plant growth, similar to that previous research conducted by Utomo et al., (2014). The better growth of plants are shown by the number of leaves, total dry weight of the plant, number of seeds per plant, as well as the weight of a hundred grains due to the low level of competitions. The poisonous effect of oxyfluorfen were visible only after 7 DAT, however, the toxicity was relatively mild as shown by less normal growth of leaves. The application of paraquat, on the other hand, caused visible poisoning effect after 21 DAT, as indicated by the presence of burning-like leaves (Table 6).

Table 6 Toxicity of various herbicides on the soybean crop plants

Treatment	7 DAP	14 DAP	21 DAP	35 DAP
Control	0	0	0	0
Mannual weeding	0	0	0	0
Paraquat	0	0	2	1
Glyphosate	0	0	1	2
Oxyfluorfen	1	1	1	0
Oxyfluorfen-paraquat	1	1	2	1
Oxyfluorfen-glyphosate	1	1	1	2
Penoxulam	0	0	2	2

Note: Scale qualitative assessment based scoring method leaf damage. Pesticides Commission (2000). 0 = The level of toxicity (shape and color of the leaves is not normal 0-5%); 1 = Mild (5-10%); 2 = Moderate (10-20%); 3 = severe (20-50%); and very severe (> 50%). DAT = days after planting).

Treatment of glyphosate caused mild poisoning effects 35 DAP of soybean plant, the effect of systemic herbicide glyphosate new work at the age of 35 DAP but there after toxic symptoms slowly begin to decrease. These results were similar to previous reports (Ngawit 2007) as the level of toxicity experienced by legume crops in coffee planting ground cover, do not pose significant alterations to the physiological and metabolic activities of plants tissue because plants can tolerate the toxic properties or molecules of the herbicide. The leaves of plants that were mildly affected by herbicides treatment did not affect the overall growth of plant, since the leaves were able to grow back to normal. However, the plant growth might be significantly hampered if the network of growing points (meristems) were severely damaged.

CONCLUSION

Herbicide paraquat effectively suppresses weeds growth in soybean cultivation, as its treatment resulted the lowest dry weight of weeds in 4, 6, and 8 WAT. The most potential herbicides used in tidal land is glyophosate, as indicated by relatively high productivity of soybean plant for approximately 3.76 tons ha^{-1}. Weeding and herbicides treatments should be done prior planting, however, restraint application of herbicides treatment is fundamental to avoid harmful effects toward plants.

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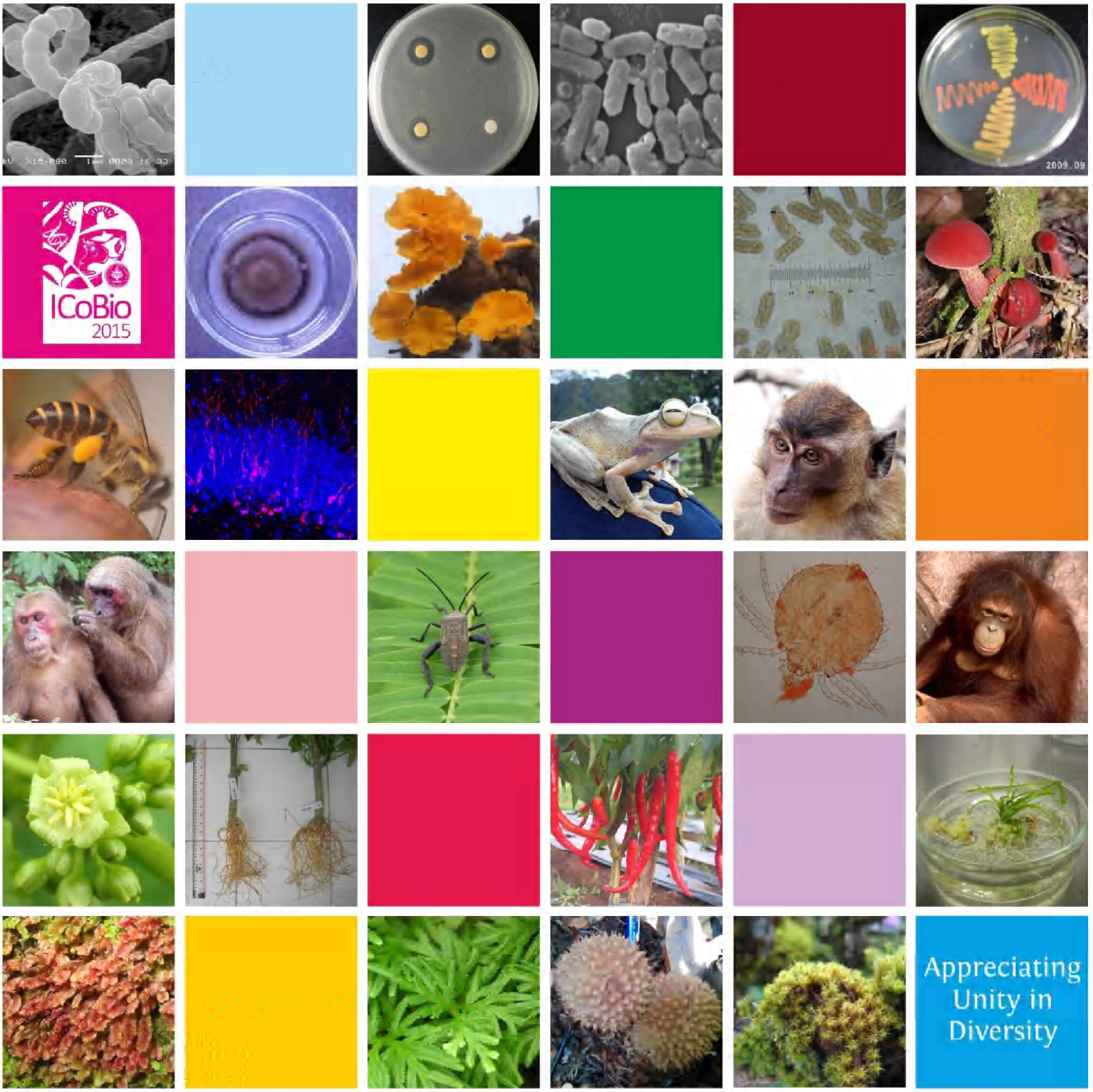

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Foreword

International Conference on Biosciences, ICoBio 2015, took place in Bogor, Indonesia, on August 5-7, 2015. The ICoBio 2015 have the theme of "Appreciating Unity in Diversity". This conference is intended to gain insight into current trends in research and teaching related to biology, such as interdisciplinary approaches that are important for understanding the biology and its applications. Moreover, to encourage the formation of networks between biologists and relevant stakeholders to accelerate our efforts to understand the biological phenomena and their applications.

The ICoBio 2015 is attended by more than 200 participants from several countries including Japan, Malaysia, India, Pakistan, Germany, Thailand, and Indonesia. The conference is the first international conference organized by the Department of Biology, Faculty of Mathematics and Natural Sciences, Bogor Agricultural University, Indonesia and is expected to serve as an initial step to be held continuously every two years (bianually). This activity is also the first step in the framework of collaboration between the Faculty of Mathematics and Natural Sciences (especially Department of Biology) Bogor Agricultural University, Indonesia with the Faculty of Science, Kasetsart University, Thailand.

One of the activities in this conference is the preparation of the proceeding. We received 9 keynote papers and more than hundred papers from oral presentations, workshops, and poster presentations. To collect paper we communicate with the authors and reviewers. One paper was reviewed by a competent reviewer. Reviewers provide comments and further authors revise his/her paper and return it to the editor of this proceeding. Therefore we highly indebted and appreciated to the reviewers who have taken the time, energy, and experience to review the papers.

Finally, there are the 16 accepted papers from oral presentations published in this book. Their topics cover a wide range of biosciences. In the conference, they presented the papers in the main four groups focusing on Biodiversity, ecology, and evolution (group 1); physiological, developmental, and behavioral sciences (group 2); Molecular biology, biotechnology, and omic technology (group 3); and Applied and interdisciplinary biology (group 4).

We do hope that this proceeding will provide you, the reader, the opportunity to get acquainted in greater detail with the ideas and results of the conference participants and also, perhaps, to recall some of the friendly and inspiring atmosphere of ICoBio 2015.

Bogor-Indonesia, August 24, 2015

Prof. Aris Tri Wahyudi
Conference Chairperson

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