GROWTH AND LEAVES DIGITAL IMAGE ANALYSIS OF RICE CULTIVATED IN VARIOUS LEVELS OF NITROGEN CONCENTRATION AND BROWN PLANTHOPPER INFESTATION

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ABSTRACT

The information of recommended fertilizer dosage and pest control that is location-spesific is required by the farmer for the success of its agricultural cultivation. In this research, digital image analysis of the rice leaf sample was conducted to obtain a basis data for determining its nutrient sufficiency status and pest attack level. Hydroponic rice planting is performed in the green house with variations of nitrogen sufficiency and variations of brown planthopper population. Along the rice crop development, rice leaf photography is performed to capture the digital image of rice leaf from various treatments of nitrogen sufficiency variation, pest attack level variation, and plant period variation. The process of digital image processing is performed to obtain image parameter, which are Red (R), green (G), dan blue (B). The variation of nitrogen content from 10% - 150% of recommended dosage produces various rice leaf greenness, amount of tillers, amount of panicles, and plant biomass weight. The increase of nitrogen content from 10% - 150% causes color diversity from greenish yellow with the value of R: 86, G: 131, and B: 46, to dark green with the value of R: 119, G: 169, and B: 72. Rice crop that is attacked by brown planthopper changes from green with the value of R: 206, G: 193, and B: 159 into brownish yellow with the value of R: 196, G: 98, and B: 86 along with the increase of it population.

Keywords**:** rice crop, nitrogen, planthopper, digital image.

INTRODUCTION

In 2014, the government targets a surplus of hulled rice in the amount of 10 million tons (Tri, 2012). The production means whose role is very vital in supporting the national rice production improvement is fertilizer. The recommendation of N, P, and K fertilizing on the Rice of Location-Specific Rice Field is regulated with Minister of Agriculture Regulation No. 40/Permentan/OT.140/04/2007 (Deptan RI, 2007). However, this recommendation has a limitation such as this recommendation is assembled on district level. The actual fertilizer dosage also can be lower than recommended dosage if its soil fertility variability is high. The use of PUTS is limited to the availability of equipments in the field so that the farmer cannot use it when needed (Virgawati, 2010). The productivity levelling off and the increase of fertilizer price is a stimulation to improve the efficiency of agro-business system especially the efficiency of fertilization on rice field which is the biggest fertilizer consumer. Therefore, the determination of precise fertilizer dosage becomes urgent for achieving an efficient fertilization.

In 2010, *Education for Sustainable Development* (ESD) UPN “Veteran” Yogyakarta research team conduct a research about the application of *Precision Agriculture* (PA) concept and technology in several district in Magelang Regency (Virgawati et al., 2010). *Precision Agriculture* designs soil and crop management carefully according to diversity that is found in the land (Shibusawa, 2001). Plant and characteristic of soil in the land is not only varied on distance and depth, but also time. This diversity problem becomes the basic difference between *Precision Agriculture* dan *Conventional Agriculture* (Srinivasan, 2006).

Pest attack often becomes a problem in the rice productivity improvement effort. The main rice pest in Indonesia is green planthopper and brown planthopper. Green planthopper is a vector that spreads ‘tungro’ disease while brown planthopper spreads dwarf virus. This pest can form a huge population only in a short time and damage plants on every single growth phase. Planthopper attack can cause a loss whose amount is depended on the attack level, from low attack level until fail to pay back level (Anonim, 2010).

This research is designed to produce information especially recommended fertilizer dosage and pest control that is location-specific. For that reason, digital image analysis of the rice leaf sample was conducted to obtain a basis data for determining its nutrient sufficiency status and pest attack level. This research is aimed to assemble technology that combines *artificial neural network (ANN*) technique with digital image data communication technique to determine fertilizer need and pest control recommendation. This technology is designed so that the farmer can find out recommended fertilizer dosage and pest control recommendation needed for the agricultural land only by sending data in the form of rice leaf image through short messages (MMS) to the system.

MATERIALS AND METHODS

The details of each phase are as follow:

A. Hydroponic rice planting in green house with nitrogen nutrient sufficiency variation and pest attack level variation.

1. This phase begins with preparing plant media in the form of river sand. Before used, the sand is cleansed with tap water until the water is clear. The aim is to remove materials except sand that are possible to carry nutrition.
2. Planting is performed in 69 plastic pots, consists of 23 treatments with 3 repetitions. The variety chosen is Ciherang with consideration as the most popular variety that is planted in the research area and shows a clear visual indication of planthopper attack.
3. The liquid media of hydroponic is prepared with complete nutrient composition which is based on the need of rice crop according to IRRI (Yoshida *et al.*, 1976), except for the nitrogen content, variations of sufficiency percentage are made with the value of 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%,

110%,120%, 130%, 140%, 150%.Meanwhile, for the pest attack treatments, rice is planted with optimum hydroponic media composition (100%) and infested with brown planthopper with population 1, 2, and 3 pair of adult planthopper (age of 4 days) with male and female comparison of 1:1 to arouse pest attack level variations.

4. The plant is kept until harvest age.

B. Observation of plant growth and planthopper population

1. Growth of the rice plant was observed for plant height, wet and dry weight of plant biomass, amount of tiller, and amount of panicle per pot.
2. Population of planthopper was observed every week from week 1 until week 7 to monitor the population change.

C. Photography of hydroponic rice leaf in green house.

1. This photography is performed to record digital image of rice leaf from various treatments of nutrient sufficiency variation, pest attack level variation, and plant age variation. This photography is performed by using digital camera Canon EOS 500D.
2. This photography is performed on selected leaf sample that has been completely developed (*fully expanded leaf*), starting from plant age of three weeks after transplanting (WAT) in 10 days of interval. This photography is performed until it comes into bud.

D. Parameter analysis of the digital image of rice leaf.

The process of digital image processing is performed to obtain image parameters, which are: Red (R), Green (G), dan Blue (B).

RESULT AND ANALYSIS

The plant height is mostly ranged between 95 and 105 cm. There are two treatments that produce plant height below 90 cm, i.e. 30% and 130% N concentration. The four topmost plant heights are treatment of 70%, 80%, 90%, and 100% (Figure 1). This result indicates a better nitrogen sufficiency in those four levels of nitrogen concentration.

The average amount of tillers per hill shows the mode in between 80% and 110% N concentration (Figure 2). It might be said that optimum nitrogen content for tillering is around 80% to 110% of recommended concentration. Lower or higher N concentration is resulted in the lesser amount of tiller per hill.

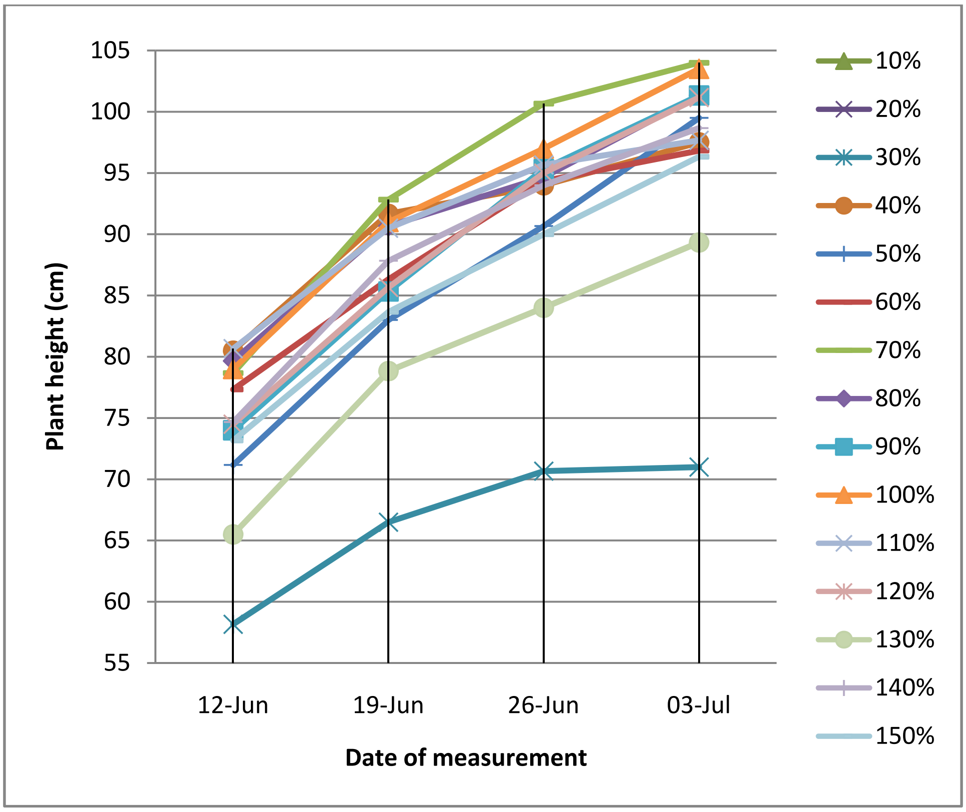

Figure 1. The average height of rice crop up to maximum vegetative

The pattern of amount of tiller per hill is similar to the average amount of panicles per hill (Figure 3). The weight of panicles per hill is connected with the amount of panicles per hill so that the weight diversity of panicles is similar with the amount of panicles per hill pattern (Figure 4). It can be seen that the most weight panicle was produced by 100% N concentration treatment.

The weight of plant tissue which includes straw and root shows that on treatment with nitrogen content higher than 100% until 150% produced plant tissue weight that is similar to treatment with nitrogen 100% (Figure 5). The rice straw on treatment with high nitrogen content (above 100% of dosage) still shows a high vegetative growth during panicles maturation. One of the indications is the leaf which tends to be constant in green although the panicles have turned into yellow until harvest age. Nevertheless, the produced tissue contained less dry weight as compared to 100% N concentration treatment (Figure 5).

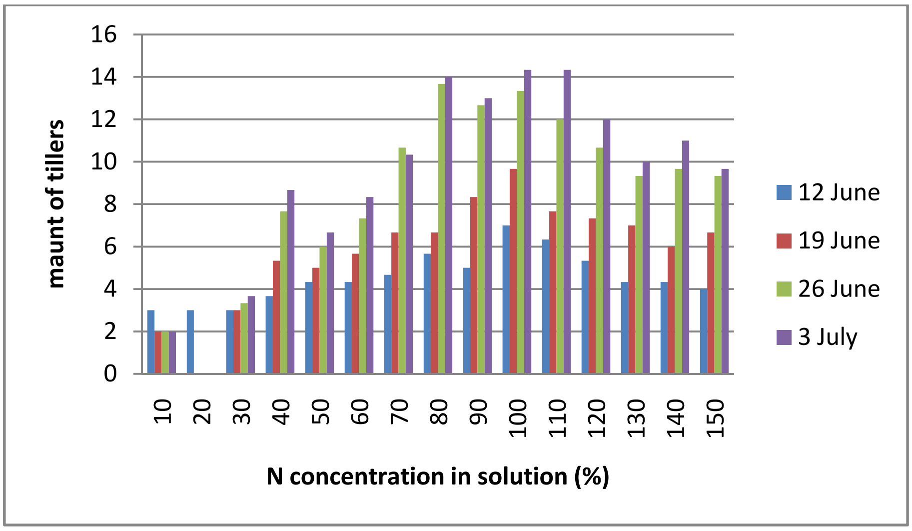

Figure 2. The average amount of tillers per hill at the harvest time

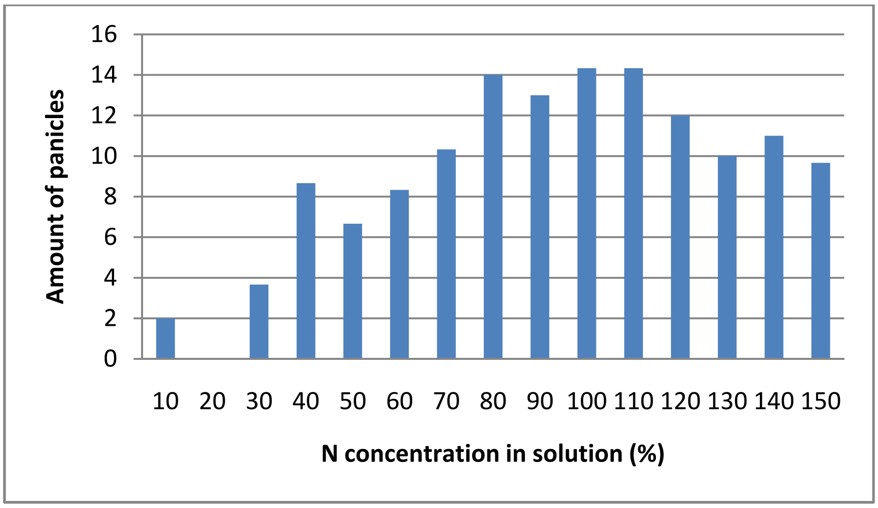

Figure 3. The average amount of panicles at the harvest time

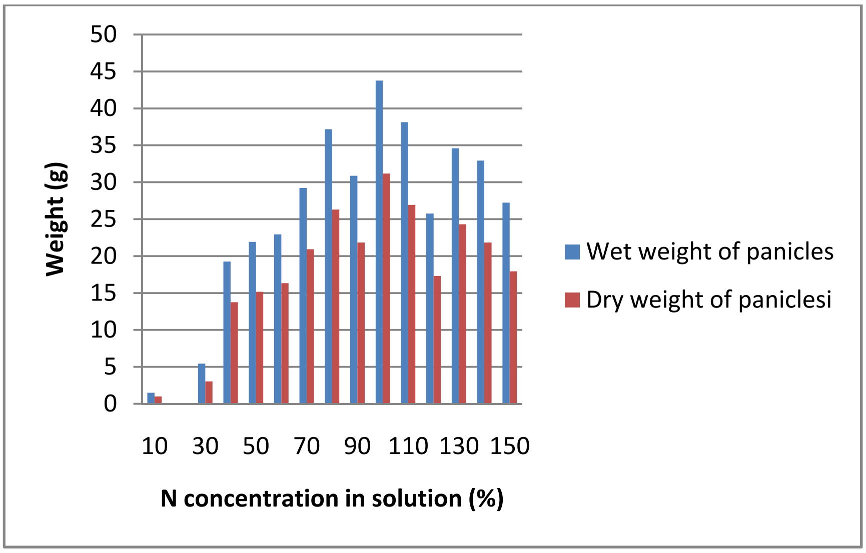

Figure 4. The average wet and dry weight of panicles

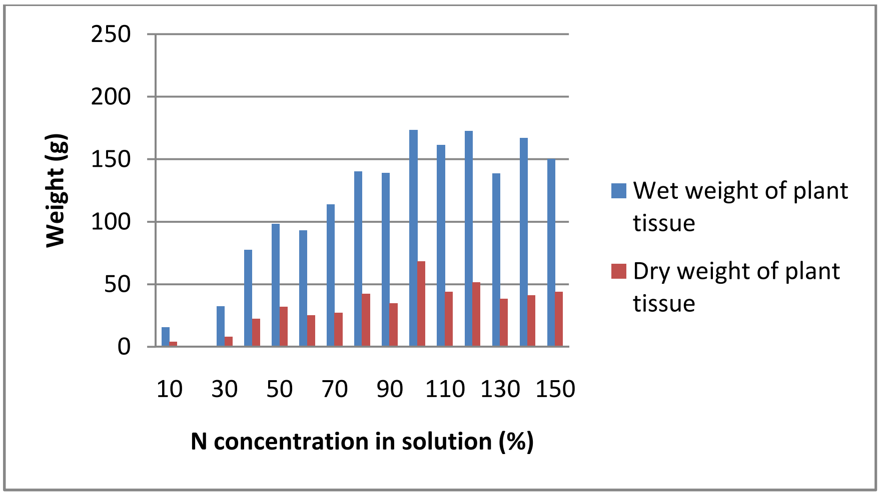

Figure 5. The average wet and dry weight of plant tissue

The experiment pot that is infested with brown planthopper is made into three limits of initial planthopper population with three repetitions and it uses hydroponic nutrition composition with 100% of nitrogen content. The experiment pot of brown planthopper attack is given a cover made from mica sheet. The infestation of brown planthopper is performed when the rice crop attains the age of 1 week. The population of brown planthopper is observed every 7 days so that the fluctuation of planthopper population can be obtained. The initial population of brown planthopper influences the population development. The rice crop that is infested with adult brown planthopper (imago at the age of 4 days) with higher initial population will develop its population faster. The population of brown planthopper with three pair initial population is developed faster than two pair and one pair initial population. This rapid population increase is followed by rapid decrease as well. Rice crop that is relatively young is more sensitive toward brown planthopper attack, so that the high population will rapidly decrease its ability to provide nutrition for the next offspring. The low initial population will increase population slowly and the crop damage as well, so that the population of brown planthopper will decrease slowly as the plant is increasingly damaged (Figure 6).

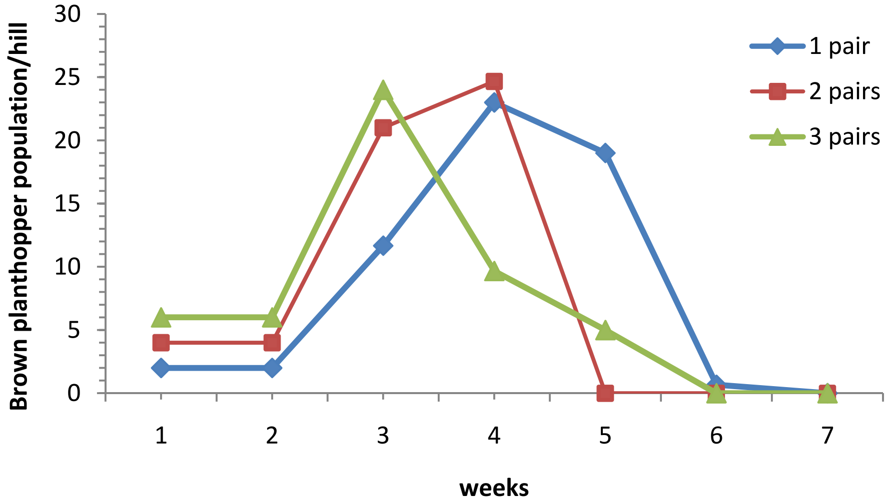

Figure 6. The population dynamic of brown planthopper on rice crop Ciherang variety, with initial population of 1, 2, and 3 pairs

The digital image parameter that has been successfully extracted from the data of leaf image for all treatments is Red, Green, dan Blue (RGB). The output of digital image processing is listed on Table 1.

Table 1. The parameter of digital image of rice leaf from a number of variations of nitrogen (N) sufficiency, pest attack, at the age of 1, 7, and 8 weeks

Treatment	No	Week 1			Week 7			Week 8		
		Red	Green	Blue	Red	Green	Blue	Red	Green	Blue
01-1-10 %	1	146	217	79	158	184	91	186	176	116
01-2-10%	2	121	199	87	102	165	34	125	136	111
01-3-10%	3	79	139	51	86	131	46	134	149	117
02-1-20%	4	129	185	88	129	139	111	130	142	88
02-2-20%	5	158	234	102	130	178	126	229	222	214
02-3-20%	6	80	134	38	189	196	156	165	175	129
03-1-30%	7	126	176	41	69	115	51	118	180	57
03-2-30%	8	151	219	80	106	165	57	154	194	119
03-3-30%	9	129	206	74	94	130	43	141	175	99
04-1-40%	10	149	214	70	71	132	52	112	152	86
04-2-40%	11	156	216	84	72	120	60	137	153	97
04-3-40%	12	113	181	68	90	131	63	134	149	95
05-1-50%	13	143	178	74	54	100	51	92	133	62
05-2-50%	14	138	185	81	99	171	107	92	134	58
05-3-50%	15	153	234	93	60	103	34	124	163	100
06-1-60%	16	86	132	33	62	120	59	108	145	74
06-2-60%	17	129	188	78	41	83	33	122	140	90
06-3-60%	18	134	222	60	135	185	116	124	150	90
07-1-70%	19	100	140	41	126	173	119	120	144	86
07-2-70%	20	154	196	84	137	178	120	148	153	105
07-3-70%	21	137	217	60	126	164	77	125	152	76
08-1-80%	22	153	244	104	71	131	61	176	187	116
08-2-80%	23	148	247	102	103	166	113	152	147	108
08-3-80%	24	150	242	104	81	124	53	120	141	98
09-1-90%	25	184	241	124	169	183	121	144	165	102
09-2-90%	26	154	240	120	86	152	90	122	140	94
09-3-90%	27	153	217	118	102	143	55	87	121	72
10-1-100%	28	141	223	95	114	176	79	101	118	48
10-2-100%	29	139	219	105	91	146	61	114	160	124
10-3-100%	30	153	223	95	76	127	52	131	185	110
11-1-110%	31	200	255	155	172	175	117	97	134	100
11-2-110%	32	160	225	97	159	176	110	103	154	111
11-3-110%	33	153	217	120	93	131	58	109	118	80
12-1-120%	34	157	217	97	140	148	83	80	127	62
12-2-120%	35	158	240	114	93	145	83	102	147	47
12-3-120%	36	153	237	97	102	143	75	122	162	101
13-1-130%	37	138	224	89	90	140	77	129	147	78
13-2-130%	38	124	176	68	177	181	112	129	147	78
13-3-130%	39	151	238	125	146	160	72	101	144	86
14-1-140%	40	68	115	35	106	125	52	127	175	76
14-2-140%	41	114	177	70	91	136	95	128	166	127
14-3-140%	42	100	166	56	121	167	105	124	153	78
15-1-150%	43	57	111	17	62	118	57	108	150	86
15-2-150%	44	95	167	57	73	124	67	83	125	58
15-3-150%	45	138	203	87	123	180	39	90	145	74
H1-1	61	81	121	33	133	117	104	152	127	97
H1-2	62	80	119	30	69	91	53	112	135	88
H1-3	63	75	110	75	152	123	105	206	193	159
H2-1	64	60	121	32	140	112	98	255	255	255
H2-2	65	79	121	30	165	129	105	236	218	204
H2-3	66	102	144	48	165	147	127	217	195	172
H3-1	67	94	140	32	126	109	93	210	191	148
H3-2	68	80	130	30	167	154	136	196	98	86
H3-3	69	94	118	32	161	145	130	232	218	183

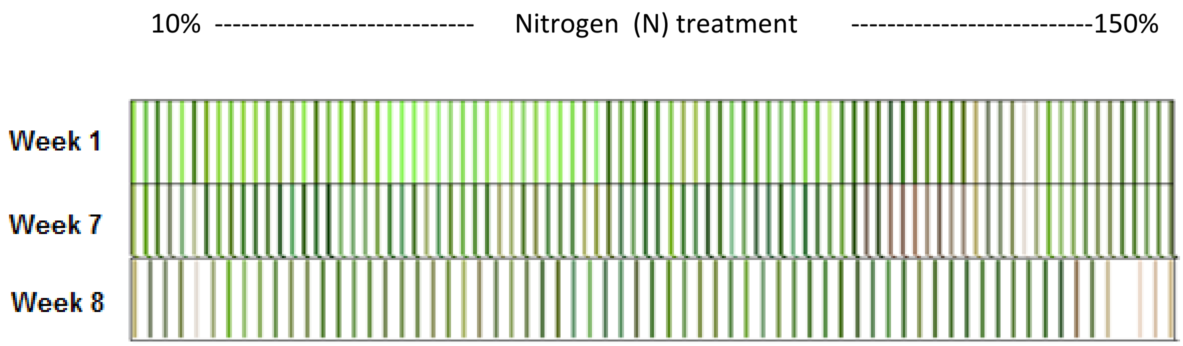

Figure 7. The color diversity of rice leaf on nitrogen (N) content treatments from 10% until 200%

CONCLUSION AND SUGGESTION

1. The variation of nitrogen content from 10% - 150% of recommended dosage produces various rice leaf color, amount of tiller, amount of panicles, and plant tissue weight.
2. The increase of nitrogen content from 10% - 200% causes color diversity from greenish yellow with the value of R: 86, G: 131, and B: 46, to dark green with the value of R: 119, G: 169, and B: 72.
3. The initial population of brown planthopper influences the population development. This rapid population increase is followed by rapid population decrease because of food source insufficiency from rice crop.
4. Rice leaf that is attacked by brown planthopper turns from green with the value of R: 206, G: 193, and B: 159 into brownish yellow with the value of R: 196, G: 98, and B: 86 along with the increase of brown planthopper population.

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Preface

Over the past decades, rapid growth of global economic has lifted millions of people out of poverty. In line with rising population, rapid urbanization, and industrialization, it has also led to increase consumption of resources and generate of waste almost beyond the limits of the ecological carrying capacity.

The coming decades will likely witness of the increasing pressures on industries to shift to more resource-efficient and low-carbon production processes as part of global efforts to sustain growth, conserve resources and slow down the pace of climate change. Countries and regions that successfully manage this transition will get a better position to exploit the opportunities created by the shift towards a low-carbon world economy. It is green industry's initiation, a pattern of industrial development that is sustainable in economic, environment and social.

Universitas Pembangunan Nasional "Veteran" Yogyakarta in conjunction with its global partners is proud to announce the International Conference on Green Agro-Industry, to be held on November 11-14, 2013, at Yogyakarta, Indonesia. The basic aim of the conference is to contribute to the development of highly productive methods and technologies for the various segments of the agro-industries. This conference is designed to provide a forum for the presentation, discussion and debate on state-of-the-art and emerging technologies in the field of agro based industry and any issues related to sustain the environment.

Finally, we would like to express our gratitude to the Rector UPN “Veteran”, Yogyakarta for the financial support, the Dean of the Faculty of Agriculture for hosting, and the Scientific and Steering Committee. We wish to thank the keynote speaker Director of PT Astra Agro Lestari Tbk and Plenary Speakers: Prof. Sakae Shibusawa (Tokyo University of Agriculture and Technology, Japan), Prof. Raj. Khosla, Ph.D. (Colorado State University, USA), Prof. Dr. Nilda Burgos (University of Arkansas, USA) Ir. Toine Hattink (Director of Department of Horticulture, HAS den Bosch, Netherlands) Prof. Dr. Endang Gumbira Sa’id (Bogor Agricultural University, Indonesia) . Nur Iswanto, PhD. (IKAGI, International Society of Sugar Cane Technologists Councillor), Prof. Wijitapure Wimalaratana. (Department of Economics, University of Colombo), Prof. Hassan M. El Shaer (Desert Research Center, Cairo, Egypt), Dr. Mofit Eko Poerwanto (UPN “Veteran” Yogyakarta, Indonesia) as well as participants for their contribution in making the International Conference on Green Agro-Industry.

We wish to thank PT Astra Agro lestari as the major sponsor and all other sponsors for their contribution in making this Conference possible. As a Chairperson, I highly appreciate the great efforts of the members of the organizing committee whose hard work made this seminar a great success.

Yogyakarta, November 11 , 2013

Sri Wuryani

Chairperson, ICGAI 2013

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