Thesis report

Evaluation of local rice genotypes under conventional and organic cultivation in Indonesia

RatihSandrakirana (Reg. Number : 830720680010)

Wageningen, June 2015 - February 2016

Plant Breeding and Genetic Resources

WAGENINGEN UNIVERSITY
WAGENINGEN UR

Evaluation of local rice genotypes under conventional and organic cultivation in Indonesia

Student Name	:	RatihSandrakirana
Reg. Number	:	830720680010
Credits	:	39 ECTS
Course code (name)	:	PBR-80436 (Msc Thesis Plant Breeding)
Period	:	June 2015 - February 2016
Supervisors :		prof.dr.ir. ET (Edith) Lammerts van Bueren,
		dr.ir. Egbert A. Lantinga,
		Uma Khumairoh,MSc
Examiner	:	dr.ir. Egbert A. Lantinga,

Table of contents

List of tables

List of figures

Preface

The thesis report is a part of my study at Master degree for Plant Breeding program of Wageningen University, Netherland. It is a descriptive presentation of my experiment that was done on June – December 2015. Mainly, my experiment was concerned on finding prospective genotypes for supporting organics agriculture cultivation improvement in Indonesia. For that purpose, I used several genetic materials which were gathered from local farmer collection. The idea to use these materials came from the fact that Indonesia has various rice genetic resources which is undeveloped yet. Usually, they were kept by the local farmer who got inheritance from their ancestor. By combining these resources with conventional cultivation, monoculture organic and complex rice system which was improved by Uma Khumairoh, this experiment was designed.

I wish to thank my thesis supervisor prof.dr.ir. ET (Edith) Lammerts van Bueren and dr.ir. Egbert A. Lantinga for their guidance and insightful feedback. Thanks to prof.dr.ir. ET (Edith) Lammerts van Bueren who always available for helping me and for your patiently to share your knowledge about organic breeding. Thanks to dr.ir. Egbert A. Lantinga for the AMMI and GGE articles which is helping me to depict my data analysis and report structure. My special thanks for Uma Khumairoh, MSc for her willingness to accept me as a part of her project, ideas sharing, field supervision and giving advice during this project.

I also wish to thank dr. Kartika Noerwijati and Ayda Krisnawati, SP, MSc from Indonesian Legumes and Tuber Crops Research Institute (ILETRI) for the guidance in AMMI and GGE analyses. Additional wish thank to dr. Indrastuti Apri Rumanti from Indonesian Centre for Rice Research (ICRR) for sharing information about rice genetic resource. I would like to thanks to my scholarship sponsor, IAARD for their funding support. Thanks for mr. and mrs.Pohnari and their colleague who were helping me during my field activity.

Finally, my special gratitude goes to my husband, my sons (Bumi and Bima), my parents and my parent in-law for their support and encouragement during this thesis process. Special thanks to all of my friends for the help and support during this process. This is a part of my single step for approaching my thousand miles of journey in life. Hopefully this journey will lead me to be a better person with a better meaning for others people life.

Ratih Sandrakirana

Wageningen, March 2016

Abstract

The country of Indonesia has a great opportunity to strengthen its organic agriculture sector. However, there is not enough information about which crop genotypes perform well under an organic cultivation approach. Through an organic breeding methodology, this purpose can be obtained. The overall objective of this study was to compare the performance of six genotypes under diverse rice cultivation systems. The specific research objectives were: (1) to analyze the morphologic performance of six rice genotypes in three cultivation systems (conventional, organic, and complex); (2) to analyze the genotype × management (G x M) interaction; and (3) to identify the traits of importance for adaptation to organic cultivation systems to obtain a good yield and tolerance to biotic and abiotic stresses. This study was conducted between July and December of 2015 in Trenggalek regency of East Java Province, Indonesia. Six genotypes (G1, G2, G3, G4, G5 and G6) were tested under three different cultivation systems (conventional, monoculture organic, and complex). Overall, 17 data groups were collected, as follows: leaf blade hair, leaf ligule (i.e. presence, shape, and color), flag leaf attitude, flowering time (i.e. first flower and 50% population flowering), plant height, leaves length, culm habit, grain endosperm, number of tillers, panicle number per plant, panicle (i.e. branches attitude and expression), yield production, Harvest Index (HI), crop damage, diseases incidence, protein content, and cooking test.

With the exception of genotype G3, which showed an erect culm in the complex system, morphological performance was similar under the three different cultivation systems. Quantitative data were analyzed using AMMI and GGE biplots. The results showed that genotypes G2 and G3 attained stable yield production across cultivation systems in the third crop's life cycle. On the other hand, there are some genotypes that could perform as a prospective specific genotype for each cultivation system. In this study, the commonly used, Ciherang, was performing well in the conventional system; G1, G3, and G4 were performing well in the monoculture organic system; whilst G1 and G5 were performing well in the complex system. Genotype variation due to different cultivation systems was depicted by productive tiller numbers, plant height, 50% heading time, harvest time, and yield. Moreover, flag leaf and grain endosperm color could be perceived as an important trait for genotype selection in rice. Taking these traits into consideration, black rice has an added value for further improvement due to its high content levels of antioxidants and proteins. Genotype G3 showed a unique characteristic for its sensitivity to nitrogen content in the soil that might be related to its sensitivity to leaf brown spot. Additionally, conventional and organic systems provided different results with respect to genotype performances. It was found that the complex system indicated an added value compared to organic monoculture system. On average, it provided better disease resistance and grain protein content. Genotypes G1, G4, G5, and G6 under complex cultivation system also performed better in yield compared to organic system.

1. Introduction

Indonesia is one of the biggest rice producers and consumers in the world. According to International Rice Research Institute (IRRI), Indonesia was positioned as the 3rd country with the highest number for both rice total consumption and total production in 2013 (IRRI, 2016). Around 75% of farmers in this country grow rice intensely, mainly on Java Island. They are able to cultivate rice at a rate of three crops cycles per year. The first round is usually in December–March, the second round in April – July, whilst August-November is the last round (Sumarno, 2006)Indonesia was placed at the 7thin the world as highest rice consumption per capita position, with approximate amountof239 kg/person per year (USDA, 2012; SI, 2015). The national government estimated that Indonesian people had about 40-50% of their daily calories from rice (USDA, 2012). To fulfill these requirements, conventional farmer in this country need to supply high amount of fertilizer to the soil, which is will result in a high demand for fertilizer. International Fertilizer Industry Association (IFA) estimated that the world urea consumption will increase up to about 16% over 2013, reach 245 mega tones in 2018, with Indonesia being one of the main contributors (IFA, 2014). According to Indonesian Association of Fertilizer Producer (IAFP), roughly 63% of urea used in Indonesia was applied to rice cultivation in year 2015. Besides this, it is advised that farmers apply chemical controls, as problems with pests and disease in rice cultivation has become a serious problem in every season (Lobell *et al.*, 2009). Furthermore, these conditions lead to an additional input costs for the farmer, such as chemical fertilizer and a chemical controller for pests and diseases. The price for both components tends to increase from time to time as well (Kariyasa, 2005; Sudarmo, 2005). In 2014, the government announced a new official price for subsidized urea fertilizer which was 12.5% higher compared to the 2011 price (AMI, 2011; AMI 2014). Unfortunately, fertilizer scarcity has become a common phenomenon. This situation has consequently lead to an increase in retail price of up to 5.3 – 23.8%, higher than the official price which is determined by the national government (Pandin, 2008).

Organic farming systems can offer solutions to these problems. In an organic farming system, farmers are allowed to use natural pesticides and fertilizers (EPA, 2015). This plays an important role since in Indonesia various types of bio-fertilizer and bio-control agent for pests and disease are available (Mayrowani, 2012). Indonesia has a great opportunity to strengthen the organic agriculture sector. Large areas are available to be used for this practice. This sector has become a popular trend since about six years ago, when the Indonesian government launched its *"Go Organic"* program in 2010 (Mayrowani, 2012). According to an IFOAM survey in 2014, Indonesia was positioned as the fourth country which has the largest organic area in Asia. In 2012, 90.141 ha of land in Indonesia were certified as organic, whilst 134.721 ha were uncertified. Moreover, the number of organic producers and consumers in Indonesia has increased over time. In 2011, at least 9.805 organic producers were certified as organic (AOI, 2011). Thus, generally Indonesia has a good prospect for organic agriculture developments.

From 2010 onwards, research on organic agriculture in Indonesia has received more attentions. Some of the organic practices indicated in research are successful since organic agriculture leads to higher profits for the farmer (Mayrowani, 2012). Several studies have been conducted on biological controllers for pests and disease that can be used to replace those artificially made. Examples of this are mahogany (*Swietenia mahagoni)* to reduce *Aphis sp* attacks, tobacco (*Nicotiana tabacum*.), Mexican sunflower (*Tithonia diversifolia*) as insecticide, betel leaf (piper betle L.) as bactericide, and fungicide or billy goat-weed *(Ageratum conyzoides Linn.)* as nematicide (Darwis, 1992; Susilowati, 2006; Taofik *et al.*, 2010). Using a bio-fertilizer to replace the artificial fertilizer has been studied as well (Sutanto, 2002). Compost which is made from plant biomass is a good source of N, P and K nutrient (Kastono, 2005). Besides that, cattle manure is a common organic fertilizer source (Hartatik & Widowati, 2006). Application of organic agriculture concerning paddy rice has been done in various ways, such as monoculture and as an integration of paddy rice and beef cattle in Southern Sulawesi Province (Kariyasa, 2005). Another practice of organic agriculture in Indonesia is rice-fish farming cultivation, known as "*minapadi*". This practice has been present in Indonesia for more than 100 years (Cruz, 1992). Using *Azolla mycrophylla* in minapadi system, rice production can increase by up to 16 - 20% (Sasa & Syahromi, 2006). This system can therefore add value for nearly every agricultural sector (Sariubang & Nurhayu, 2005).

Since Indonesia has large areas that might be used for organic production purposes, suitable varieties are needed. Through an organic breeding approach, this new potential challenge can be met (Nauta *et al.*, 2003). By providing access to certain genotypes which are adapted to the organic agriculture farming system, plant breeding can give a real contribution to the development of the organic system. However there is not enough information about which genotypes could give optimal performance under organic cultivation approaches. More than 95% of crop genotypes used in organic agriculture are bred under conventional growing conditions (Lammerts van Bueren *et al*., 2011). Organic farmers need suitable genotypes for organic agriculture cultivation that also meet the needs of the organic market (Fontaine, Rolland, & Bernicot, 2008). In accordance with this, specific adapted varieties may provide new hope to support organic agriculture progress in a more positive direction (Wissuwa, Mazzola, & Picard, 2009). Through organic breeding approaches, this purpose can be obtained (Nauta et al., 2003). In addition, the integration between breeding methodology and local knowledge has become a new trend in several breeding programs. Hereby, farmers are offered a chance to give suggestions about the required traits for plant breeding (Cox, 2009).

The overall objective of this study was to compare genotype performance (of various plants/cultivar) in different rice cultivation systems.

1.1. Specific objectives

The specific objectives of this study were:

1. To analyze the morphologic performance of six rice genotypes in three cultivation systems (conventional, organic and a complex).
2. To analyze the genotype × management (G x M) interaction.
3. To identify traits of importance for adaptation to organic cultivation systems to obtain yield and tolerance to biotic and abiotic stresses.

1.2. Hypotheses

1. Different varieties would perform differently under different cultivation systems.
2. Organic management systems required other varieties than conventional systems.

2. Material and system

Figure 1: Map of Trenggalek Regency

2.1. Experimental Site

This experiment was conducted in Sumbergedong Village. It is a lowland area (112 m.a.s.l) which is located in north east, part of Trenggalek Regency (111º 24'-112º 11' E and 7º 63'- 8º 34' S). Located in East Java, 46.78% agriculture area in this regency was used to grow paddy rice with alluvial soil texture (STR, 2013). The field experiment was conducted from August 7th 2015 to December 3rd 2015. The nitrogen content in the experimental field was0.21% with 16.5 mg/kg Phosporus olsen, 0.012 me/kg of Kalium and 1.49 me/kg of Calsium (Soil Laboratorium of Brawijaya University, 2015).

Formerly, farmers in the experimental region applied a conventional monoculture cultivation system. Every year, the rice was planted three times without any rotation. Commonly, they used different varieties that were saved from the previous harvest or exchange with another farmer. It was barely for them to use new seed from agriculture shop. The seed was sown in the field and seedlings were replanted around three weeks after. During the study, almost no rain fell and the average of daily temperature ranged from 31to 33 ^{o} C (Table 1). Water supply came from Bendungan dam through small rivers next to the experimental location.

Table 1. Monthly rainfall (cm) and average temperature (^{o} C) in Trenggalek in 2015

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature	33	34	33	34	33	32	**30**	**31**	**32**	**32**	**33**	33
Rainfall	19.3	22.03	17.71	22.33	15.63	10.07	**1.04**	**1.48**	**0.29**	**0**	**10.9**	17.78

Source : Public Service of Trenggalek regency (2015)

In this research, a Split Plot Design was used with three different types of cultivation systems as a main plot and 6 different genotypes as the sub plot with three replications. Thus, there were six experimental units as the sub plots and 18 experimental units as the whole plot, with 12 m x 5 m in size for each main plot within the whole plot.

2.2. Genotypes (G Factor)

Six genotypes were observed. Generally, they were chosen based on local market demand and they included:

1. Black rice (G1)

   Based on a previous study on black rice in Java; this rice type generally is harvested after a growth cycle of about 105 days (Budiman et al., 2012). Black rice was a promising landrace about 15 years ago because in Indonesia, the organic black rice price was2 - 3 times higher as compared to the conventional white rice. This rice has a dark black color and will turn to dark purple after cooking. The color is affected by its high anthocyanin content (Ichikawa et al., 2001). Anthocyanins were identified as a source of antioxidants which have an anti-inflammatory effect (Hu *et al*., 2003). Earlier studies showed that anthocyanin could decrease blood cholesterol levels as well as inhibited the development of liver cancer (Chen et al., 2006; Salgado et al., 2010).

2. Red rice 1 (G2)

   Red rice 1 has a 108 - 114 day of growth cycle. Red rice is a source of carbohydrate and contain protein, beta-carotene, antioxidant, and irons (Becker & Frei, 2004).

3. Red rice 2 (G3)

   Red rice 2 is a red rice type with a 104 – 110 day of growth cycle. Red Rice 2 has an additional special characteristic. Based on previous field experiments, Red Rice 2 showed an uniformity in heading time. After first flower emerged, 50% of the population flowered within 2 weeks (Uma Khumairoh, pers.comm.).

4. Sticky rice (G4)

   The fourth genotype in this study required a 104 – 106 day of growth period. This rice is characterized with grains round shape and has a sticky moist texture after it is cooked. Market demand for this rice is increasing since the numbers of Japanese restaurants emerge in Indonesia.

5. Menthik Wangi (G5)

Menthik wangi is a local cultivar which has a 107-112 day of growth cycle and an average plant height of 124 cm. Average yield is five tones/ha and the potential yield around seven ton/ha. Grain shape is round with a special grain fragrance. This is a common local rice cultivar which is consumed by Javanese people who like a fluffier rice texture (Martani, 2015).

6. Ciherang (G6)

Ciherang is the common genotype usually grown in Indonesia. It is encouraged on about 60% of rice production area in this country. This variety was bred by Indonesian scientists using accessions which were collected by IRRI (Zeigler, 2011). Then rice breeder from Indonesia bred it by crossing. This cultivar is characterized with an average yield of 5-7 tones/ha, a growth cycle of 116-125 days, a plant height of 107-115 cm, resistant to the brown leafhopper biotype two and three, resistant to the blast diseases strain III and IV, and can be planted during both the rainy as well as the hot season at 500 m.a.s.l (IAARD, 2015).

2.3. Cultivation systems (the Management (M) Factor)

In this study, three different management systems were included. They consisted of one conventional and two organic cultivation systems, see Figure3:

1. Conventional system (Con.)

The conventional (con.) system was the common system in which local farmers used a non-organic monoculture rice treatment (R+NO) (Figure 2a). To fulfill plant needs for nutrient, 167 kg/ha Urea (ca. 77 kg Nitrogen) and 222 kg/ha phonska (ca. 33 kg Nitrogen content) had been added at early growth stage. Chemical fungicides named Fujiwan 400 EC and insecticide named Landep 450 SL with active ingredients Isoprothiolane 400 gr/L and Dimehypo 450 gr/L for each were applied to protect the plant from fungi and insect attacks.

2. Organic monoculture rice system (Org.)

The organic system (Org.) in this trial meant that no synthetic fertilizers and no pesticides inputs were allowed (figure 2b). Additional nutrient were applied using 5 tonnes/ha of goat manure (ca. 76 kg Nitrogen content) and 2.3 t/ha compost (ca. 34 kg Nitrogen content). Thus, the N from organic fertilizers was equal to N from synthetic fertilizers applied in conventional treatment. Goat manure was applied at the same day of ploughing, 14 days before planting. Goat manure has a higher N content compared to other cattle manure (Wijayanti, 2013).

Three bio-controllers for plant pest and disease were used. The first material was tobacco (*Nicotiana tabacum*.). Using cattle urine, dried tobacco leaves were fermented for organic pesticide. Whilst Mexican sunflower (*Thitonia diversifolia*) and betel leaf (*Piper betle L*.), were applied when the pests, fungi, and bacteria were attacking the plants. It was made by crushing and soaking the leaves in water for one night and spraying it on the suffered plant one day after.

3. Complex system (Com.)

The Complex (Comp) plots (see Figure 2c and 3) have been treated as a combination of rice (R), compost (C), and azolla (A) with pest management using duck (D) and fish (F) (Khumairoh, Groot, & Lantinga, 2012), and also with an additional element of margin plants such as vegetables on the bunds. *Azolla microphylla* was inoculates at a 2 tonnes/ha rate. Local duck was used named Peking duck (*Anas peking*), Mojosari (*Anas platyrhynchos* Javanicus), and Alabio duck (*Anas plathycusborneo*). Various kinds of ducks were used since it was quite difficult to find the same ducks around the experiment location which were about three weeks old. Totally, nine ducks were included in the three plots. Besides that, Nile tilapia (*Oreo chromisniloticus)* with 10 - 12 cm long was inoculated as well. There were fish living in each pond of 5 m x 1.2 m x 0.5 m in size. Each plot was separated with a bund of 40-50 cm in height and 60 cm wide to prevent the movement of nutrients, azolla, and fish between plots. A fence made from bamboo and polynet was used to keep the ducks in the complex plots only (Khumairoh *et al*., 2012). Long bean, green mustard, and sun hemp were grown on the bund to separate each treated plot. Ducks was fed with a mixture of rice bran and sun hemp. Sun hemp was cut every month as the additional nutrient for the soil. The same material with organic cultivation systems was used to protect the plants from pest, fungi, and bacteria attacks.

Figure 2: Cultivation system: (a) conventional, (b) organic and (c) complex

In general, all cultivation systems followed the SRI guidelines in terms of seedling age (8-10 days after sowing), single seedling distance of 25 x 25 cm, with intermittent irrigation in early stages.

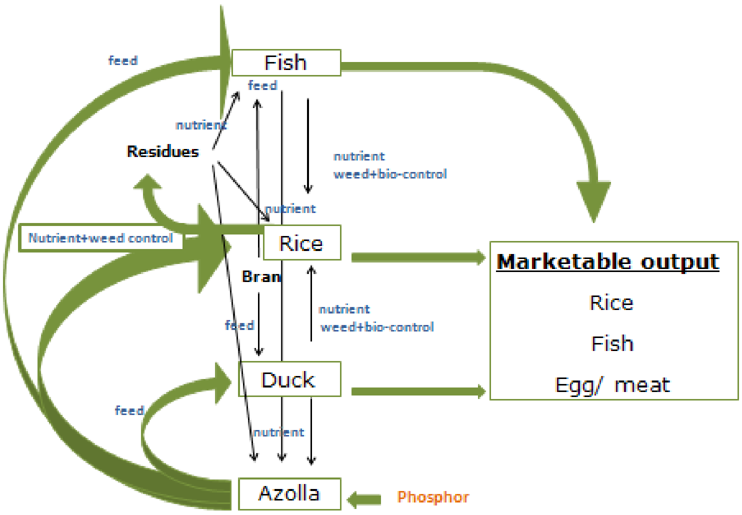


Figure 3: Complex rice system (Uma Khumairoh, 2011)

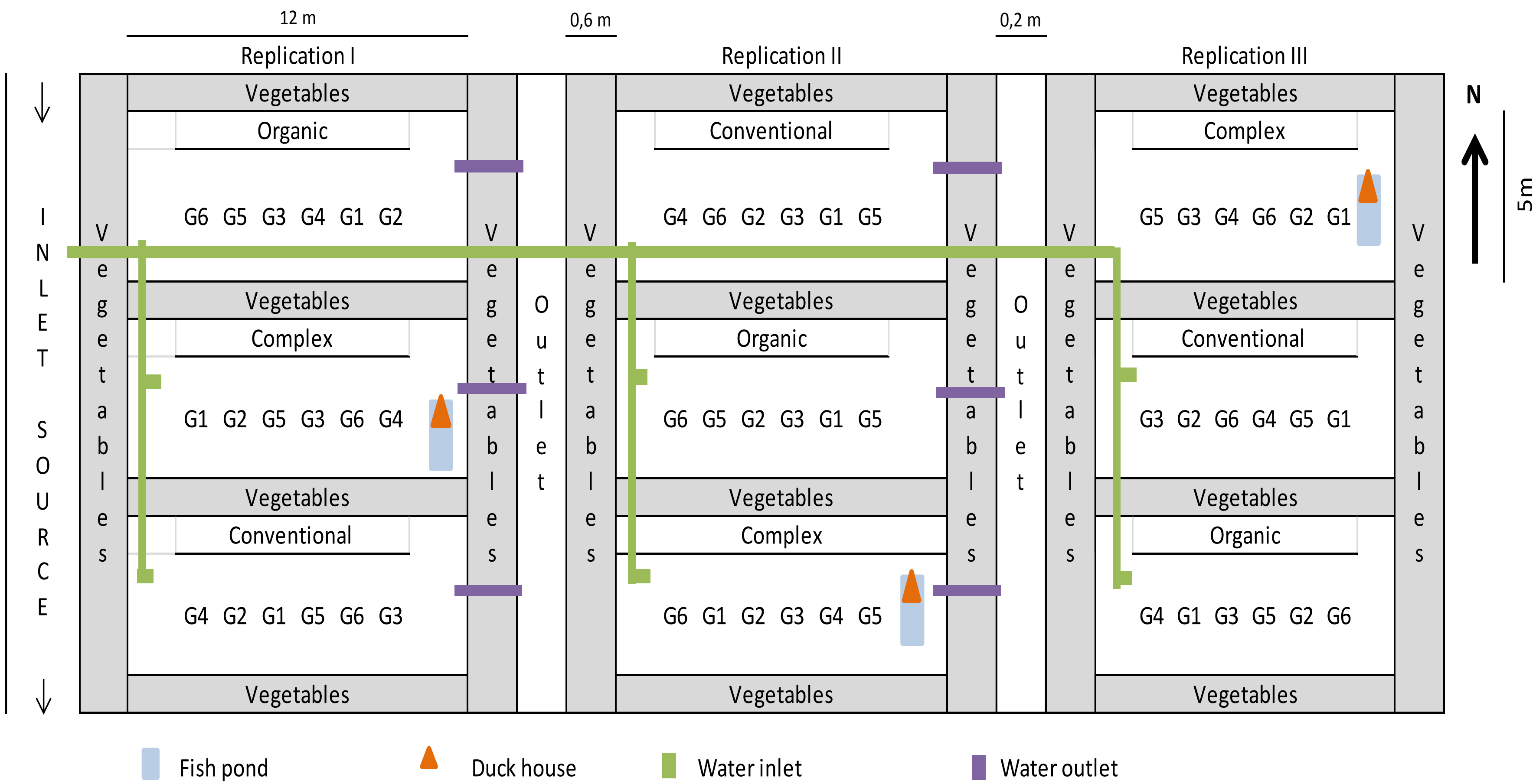


Figure 4: Experimental Design including six varieties (V) and three rice cultivation systems (conventional (con.), organic (org.) and complex system (com.)

2.4. Cultivation

Field Preparation

Cultivation preparation started with field measurement and soil sampling to create the experimental field according to the layout design and ended up with ploughing each plot. These processes took five work days since July 29^{th} – August 3^{rd}2015. Then, goat manure was applied at the organic and complex plots. Meanwhile, *Azolla microphylla* was multiplied in ponds before it was inoculated to the complex field. Three duck cages were built in this step. It was made from bamboo (pillars) and steel wire for the cage floor and straw for the roof. It was laid over the ponds with 1,5 m x 1 m x 1 m in size, see Figure 5.

Figure 5: Field condition

Then long bean, green mustard, and sun hemp were planted in the bund one week after the field preparation finished (Figure 6). At the same time sun hemp was planted in the bund around the complex system.

Figure 6: (a) Green mustard, (b) long bean and (c) sun hemp

Seedling, transplanting, and replanting

The raising of the seedlings for the six rice genotypes was conducted in trays which were filled with growing media consisting of sand, topsoil, and compost in a 1:1:1 ratio. Seeds soaking, germinating, and sowing followed after. In 10 days after sowing date, single seedling transplantation was conducted on the $17^{th}$of August, 2015 in the field with plant density 25 x 25 cm which was in accordance with SRI (System of Rice intensification) recommendation, see Figure7. In order to replace died plants, continuous re-plantation was done until two weeks after the initial transplantation.

Figure 7: Seedling (left) and transplanting (right)

Inoculating Azolla microphylla, Fish and Duck

Azolla microphylla, fish, and duck were introduced between $19^{th}$and 22^{nd} August, 2015. Duck feeds were supplied twice per day (Figure 8). There was no need to feed the fish since they could eat plankton and duck leftovers. *Nicotiana tabacum* was applied to control caterpillar which attacked azolla.

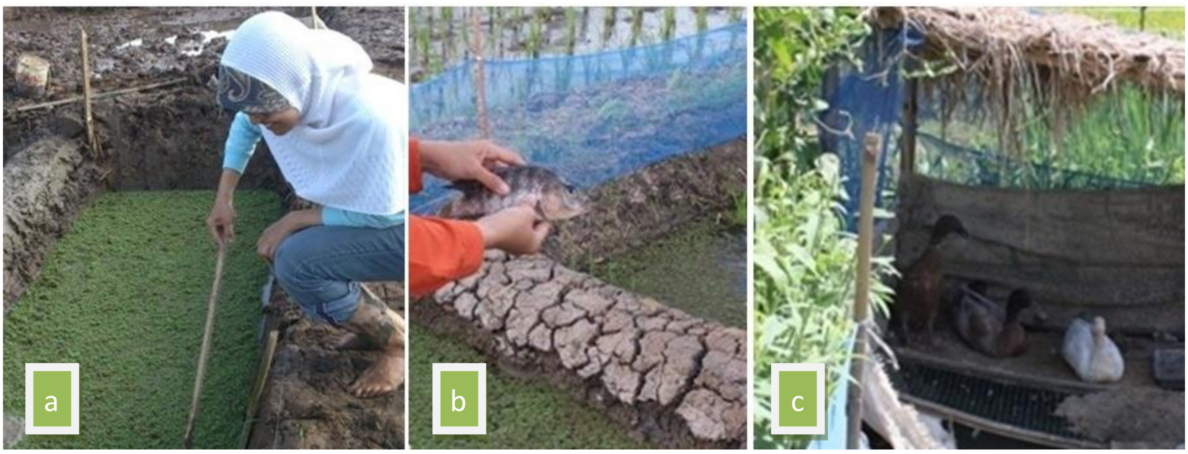


Figure. 8: (a) Azolla inoculation, (fish inoculation), (c) ducks in the cage

2.5. Observations

In this study, some morphological traits which showed specific characteristic have been evaluated. Some other quantitative traits which were related to yield (e.g. dry matter, tiller numbers and panicle numbers) were also assessed.

Morphological traits

a. Leaf blade hair

Identification for leaf blade hair was done on October 17th, 2015 (60 days after planting (DAP)). To asses this trait, identification was done through visual approach and finger touch over the leaf surface from the tip downwards. This trait was scored using three categories: glabrous (smooth—including ciliated margins), intermediate, and pubescent. Since there were various position combinations for leaf blade hairs, the additional trait for hair location was identified as upper, lower, or both leaf surfaces.

b. Leaf ligule presence, shape, and color were observed on October 17th, 2015 (60 dap) as well. Ligule shape was grouped into three categories: truncate, acute, and cleft. Additionally, ligule color was categorized as: colorless, green, green with purple lines, light purple, and purple.

c. Observation for flag leaf attitude was conducted to identify whether the flag leaf was erect, semi-erect, or horizontal. This activity was observed on October 18th, 2015.

d. Culm habit

The culm habit was evaluated ranging1-9 by the inclination angle of the main culm from the vertical and observed after 50% heading time (November 8th, 2015). Categories for culm habit were divided into erect (<15°), semi-erect (intermediate) (~20°), Open (~40°), spreading (>60–80°, culms not laying on the ground), and procumbent (culm or its lower part laying on ground surface).

e. Panicle branches attitude was assessed in five categories, those were erect, erect – semi erect, semi –erect, semi erect – spreading, and spreading. Panicle was grouped based on its expression. It was grouped into erect, semi –erect, semi prostate, and prostate. the identification for both traits was conducted on November 23rd, 2015.

f. Grain endosperm

Grain endosperm was studied after harvesting time including shape, color, and 1 000 grains weight. Grain endosperm shape was determined based on ratio between length and width of the grain, with spindle shape (>3), medium (2,1 – 3), oval (1.1 - 2.0), and round 9 (< 1). For the color trait, there were nine color categories: white, light brown, variegated brown, dark brown, light red, red, variegated purple, purple, and dark purple/black. All of these traits were identified on December 4th, 2015.

Quantitative trait

g. Number of Tillers

Two categories of tillers were studied. First category was for "all tillers" category, including non-productive tillers, which had been identified at a late vegetative phase (October 12th, 2015). Then, the second category was for "productive tillers". This parameter was recorded on November 23rd, 2015 by averaging the total number of grain-bearing tillers of 40 plants per subplot.

h. The flowering time was recorded at two time points. The first time point was chosen when the first flower came up (days after sowing). This activity took time since October 17th until November 1st, 2015. Second category was recorded from October 24thto November 6th 2015, when 50 % of plant population had already flowered (days after sowing). These activities were done over long period since the flowering time for each genotype in each plot was so varying.

i. Leaves length

Leaves length was measured on November 1st, 2015 in a non-destructive way. Measurement on ten leaves for 40 plant samples/per subplot was conducted.

j. Plant height [cm]

The measurement of the plant height was taken from shoot base until the tallest panicle of the plant. It took place after 50% of the population already formed panicles. The value was calculated on November 8th, 2015 from the average of 40 random samples per plot.

k. Panicle numbers

Panicle number per plant was calculated before harvesting at the same time with productive tillers observation activity on November 23rd, 2015.

l. Yield production

Rice potential production was counted based on the estimation method of yield production within sixm^{2}plot area. Production from this sampling area was measured in kg and the result was converted to production per hectare area into tones /ha. Rice was harvested between November 18th and November 29th, 2015.

m. Harvest Index (HI)

Harvest Index (HI) was formulated as a fraction between the grain yields over total above-ground biomass (Yang, 2010). Ten plant samples were used for this purpose. Dry mass was analyzed at the laboratory of Brawijaya University that was located at Jatikerto Agrotechnopark, Malang residence after harvesting time finished.

$$HI = \frac{Dry\ mass\ of\ grain\ yield}{Dry\ mass\ of\ above\ ground\ part}$$

n. Crop Damage

Beside agronomic traits, crop damage which might be caused by diseases, pests, ducks, and fish activity was identified in two week basis to define the plant critical points when the damage could result in yield losses. Starting at nine weeks after planting (WAP), the last identification was on 13 WAP. According to Natawigena in 1989, the formula to count crop damage is defined as:

$$I = \frac{a}{a+b} x\ 100\%$$

I : Intensity of damage (%)

a : Number of damage’s tiller

b : Number of non-damage’s tiller

Other traits

o. Monitoring diseases incidence

Rice disease symptoms were scored twice: at the halfway point (October 5th) and before harvest (November, 20th). Infection percentage was estimated using visual methods.

$$DI = (\sum(n.v))/N.Z$$

DI = Disease intensity

n = number of plant attacked

v = Index value for rice leaf disease

N = Total number of plants

Z = Highest score Index value for rice leaf disease

p. Protein content of each sub plot was analyzed after harvesting time at Brawijaya University laboratory. There were 18 samples available and the analysis was finished at December 28th, 2015.

Figure 9: Observations in the field: (a) plant height measurement, (b) tiller numbers calculation, (c) first heading remark

q. Cooking test

The cooking test was conducted on December 3rd, 2015 to determine local stakeholders' favorite genotypes. Rice from each sub plot was cooked separately under the same treatment. Thus, there were18 samples had been tested. There were 26 stakeholders who were farmers, Brawijaya University students, Wageningen University student, agriculture extension agents, and agriculture service officers were asked to do the tasting test. Hedonic test with five liking scales (1=dislike very much, 2=dislike, 3=like slightly, 4=like and 5 =like very much) was conducted. Then, each of participants was asked to rank the rice taste based on aroma, appearance, stickiness, texture, and taste.

Figure 10: Cooking test

2.6. Data analysis

Analysis of variance (Anova) was used to determine the effect of each treatment and interaction between genotypes x cultivation systems (G x M interaction). Additive Main Effects and Multiplicative Interaction (AMMI) analysis were used to get further explanation about the interaction (G x M). Through AMMI analysis we could transform the main variables which correlated with other main variables into a new variable which was not correlated anymore. This new variable was named Principal Component (PC). Thus, it can be used to explain the portion size of Sum of Square (SS) of that interaction. Furthermore, there were two models of AMMI used in this study that were AMM1 and AMMI2. The AMMI1 graphs present biplot between average mean and PC1, whether AMMI 2 graphs reveal biplot between PC1 and PC2 (Matjik & Sumertajaya, 2002). Using AMMI1, plant stability can be approached using PC1. While for AMMI2, approaches through AMMI Stability Value (ASV) using formula as:

$$\text{ASV} = \sqrt{\frac{PC1\,ss}{PC2\,ss}(PC1) + (PC2)^2}$$

PC1 = Principal Component 1 score

PC2 = Principal Component 2 score

$PC1_{SS}$ = Sum of Square for PC1

$PC2_{SS}$ = Sum of Square for PC2

Moreover, Genotype-Genotype Environment (GGE) biplot was used as well (Yan *et al*., 2003). GGE model refers to the major influence of genotype (G) and genotype*environment (G*E) interaction effects. Thus, both analyses can be used as complementary for each other *(Samonte et al., 2005)*. Environment (E) in this term was used to represent cultivation system (M). All of the data analysis was processed using Statistical Analysis System (SAS) portable version 9.1.3 and Microsoft excel.

3. Results and Discussion

The results will be presented for eachspecific research objective. The morphological traits are presented in Table 2. Furthermore, Anova was done to determine the influences of genotypes (G), cultivation systems (M), and G*M interaction to genotypes performance (Table 3). If G*M interaction was significant, the sum of square was split through AMMI analysis which resulted in three PC’s (Table 4).

3.1. Morphological trait

Table 2. Performance of 6 genotypes at 3 cultivation systems

Genothype	Cultivation System	Leaf Blade Hair			Ligule			Flag leaf	Panicle		Culm	Grain Endosperm	
		Presence	pubescence	Location	Presence	Shape	Color	Attitude	Branches attitude	Expression	Habbit	Shape	Color
G1	Con.	√	Intermediate	Both	√	3	Colorless	Semi-erect	Semi-erect	Drooping	Erect	Medium	Dark brown
	Org.	√	Intermediate	Both	√	3	Colorless	Semi-erect	Semi-erect	Drooping	Erect	Medium	Dark brown
	Com.	√	Intermediate	Both	√	3	Colorless	Semi-erect	Semi-erect	Drooping	Erect	Medium	Dark brown
G2	Con.	√	Intermediate	Both	√	3	Colorless	Horizontal	Semi-erect	Drooping	Erect	Spindle shape	Light red
	Org.	√	Intermediate	Both	√	3	Colorless	Horizontal	Semi-erect	Drooping	Erect	Spindle shape	Light red
	Com.	√	Intermediate	Both	√	3	Colorless	Horizontal	Semi-erect	Drooping	Erect	Spindle shape	Light red
G3	Con.	√	Intermediate	Both	√	3	Colorless	Semi-erect	Semi-erect	Drooping	Semi-erect	Spindle shape	Red
	Org.	√	Intermediate	Both	√	3	Colorless	Semi-erect	Semi-erect	Drooping	Semi-erect	Spindle shape	Red
	Com.	√	Intermediate	Both	√	3	Colorless	Semi-erect	Semi-erect	Drooping	Erect	Spindle shape	Red
G4	Con.	√	Intermediate	Both	√	3	Colorless	Semi-erect	Semi-erect	Drooping	Erect	Medium	Milky white
	Org.	√	Intermediate	Both	√	3	Colorless	Semi-erect	Semi-erect	Drooping	Erect	Medium	Milky white
	Com.	√	Intermediate	Both	√	3	Colorless	Semi-erect	Semi-erect	Drooping	Erect	Medium	Milky white
G5	Con.	-	Glabrous	-	√	3	Colorless	Semi-erect	Erect-semi erect	Drooping	Erect	Medium	White
	Org.	-	Glabrous	-	√	3	Colorless	Semi-erect	Erect-semi erect	Drooping	Erect	Medium	White
	Com.	-	Glabrous	-	√	3	Colorless	Semi-erect	Erect-semi erect	Drooping	Erect	Medium	White
G6	Con.	√	Intermediate	Under	√	3	Colorless	Erect	Erect	Drooping	Erect	Medium	White
	Org.	√	Intermediate	Under	√	3	Colorless	Erect	Erect	Drooping	Erect	Medium	White
	Com.	√	Intermediate	Under	√	3	Colorless	Erect	Erect	Drooping	Erect	Medium	White

G1=black rice; G2=red rice 1; G3=red rice 2; G4=sticky rice; G5=menthikwangi; G6=ciherang

Evaluation of the genotype performances was done for 12 traits. Overall, all of the genotypes showed persistent performance over the three different cultivation systems, except for G3 for the culm habit. Their culm was erect in the complex cultivation system, while in the other systems it was semi-erect culm. For leaf blade hair, G1,G2, G3 ,and G4, all had an intermediate pubescence at both leaf blade surfaces. But, it was fewer for G5 and G6. For the ligule and panicle, the expression was the same for all of the genotypes. Interestingly, G6 which is known as a commercial cultivar showed its erect performance of the flag leaf and panicle branches. Furthermore, grain endosperm characteristic was different between genotypes, except for G5 and G6 which had the same shape and color. Moreover, the grain color was different between genotypes, but was not influenced by the cultivation system.

Generally, there were no genotypic differences between the cultivation systems for ligule, leaf blade hair, panicle, and grain endosperm. Diversity in morphologic trait between intra or inter species is influenced by genetic factor (Suhartini, 2010). Mostly, the coloration of grain pericarp is regulated by genotype component (Furukawa *et al.*, 2007). Pericarp color is determined by a combination of two genes (Rc and Rd), in which *RcRd* results in red grain, *Rcrd* results in brown grain, and the other combination would be expressed as white grain color. These morphological differences could be used to determine relationship between genotypes due to the similarity of the determinant gene(Kinoshita, 1984). In this study, the relationship between genotype might be identified based on the pericarp color. It means that G2 and G3 might have closer relationship than G2 and G5. Meanwhile, the erectness of G3 culm in complex cultivation system might have a correlation with the nitrogen availability. Furthermore, the mixed cropping system provides an extra advantage in reducing the N-losses rate from the cultivation field (Lantinga, 2004).

3. 2. Anova and AMMI analysis

Table 3. Mean square value for 6 rice genotypes in 3 cultivation systems

Source	df	Tiller Numbers		Damage Tillers			Plant Height	Flowering Time		Leaf length	Panicle Numbers	1000 grains weight	HI	Harvest Time	Yield
		All	Prod.	I	II	III		First	50%						
Genotype (G)	5	36.43**	5.51**	0.06	0.36*	0.8	1119**	27.27**	33.42**	41.12*	11.25**	29.28**	0.26	128.07**	2.03**
Cultivation method (M)	2	214.74**	87.82**	0.28*	2.00**	8.31**	1236**	9.41	38.39**	285.82**	100.59**	3.13	0.01	3.91	42.16**
GxM	10	2.94	2.18*	0.05	0.18	0.81	38*	3.27	8.54**	17.38	2.95	9.74**	0.23	4.69*	1.75**
Error	53	3.36	1	0.05	0.14	0.56	15	3.87	2.71	12.05	1.49	1.94	0.14	1.7	0.39

SS = Sum of Square, MS = Mean Square, df= degree of freedom; G x M = Genotypes x cultivation system interaction
I, II and III refers to observation number 1,2 and 3
*, ** significant at level of 0.05 and 0.01, respectively

Table 4. PC1 score and stability rank for genotypes

Plant height			50% flowering		Productive tillers		Harvest Time		1000 Grains weigth		Yield	
GEN	MEAN	PC1	MEAN	PC1	MEAN	PC1	MEAN	PC1	YLD	PC1	MEAN	PC1
G1	99.2	-0.16	84.6	0.90	13.3	-0.12	109.3	0.78	30.5	1.97	6.5	0.94
G2	126.1	-2.06	86.3	-1.49	12.3	0.38	112.7	-1.35	29.9	-1.21	5.7	-0.42
G3	95.3	0.95	81.8	0.60	12.3	-0.91	109.3	-0.50	29.0	-0.43	5.7	-0.89
G4	105.9	0.03	82.6	0.22	11.6	0.23	104.9	1.03	25.6	-0.35	6.1	0.24
G5	108.9	-0.95	85.4	-0.79	13.7	0.95	109.2	-0.02	27.6	0.04	6.9	0.35
G6	99.0	2.19	82.0	0.57	13.0	-0.53	102.1	0.06	26.9	-0.02	5.9	-0.22

GEN = genotypes, MEAN = mean value, PC1 = Principal components 1
G1=black rice; G2=red rice 1; G3=red rice 2; G4=sticky rice; G5=menthik wangi; G6=ciherang

Table 3 presents the combined Anova result for 14 observed traits of 6 genotypes in the three cultivation systems. Various trait performances due to genotypes were presented in this study, except for HI and crop damage at the first and third observation. The cultivation system also played a role in the expression of the ten different traits, although it didn't influence significantly during the first flowering time, the 1000 grains weight, HI, and harvest time. Furthermore, the genotypic variation between different cultivation systems were significant for productive tiller numbers, plant height, 50% heading time, harvest time, and yield.

Furthermore, AMMI1 can also expose the stability performance of a genotype. Performance stability of a genotype can be identified through PC1 absolute score. Genotypes with low PC1 absolute score have a higher stability than genotypes or cultivation system with higher score (Gauch & Zobel, 1996). There were differences among the genotypes; some performed as the most stable genotypes, such as G4 for plant height and 50% heading time trait, G1 for productive tillers and G5 for the harvest time trait. Generally, the genotype G4 performance was stable for plant height, 50% heading time, productive tillers, and yield trait (Table 4).

Table 5. The mean square value for 100 grains weight and yield traits for AMMI model

Source	df	1000 grains weight				Yield			
		SS	MS	Contribution to		SS	MS	Contribution to	
				Total SS (%)	GxM (%)			Total SS (%)	GxM (%)
GxM	10	97.45	9.74**	27.76		17.46	1.75**	13.89	
PC1	6	74.58	12.43**		76.53	13.17	2.20**		75.44
PC2	4	22.87	5.72*		23.47	4.29	1.07*		24.55
PC3	2	0	0		0	0	0		0
Error	53	58.33	1.94	16.61		11.56	0.39	9.20	

SS = Sum of Square, MS = Mean Square, df= degree of freedom; G x M = Genotypes x cultivation system interaction; PC1 = Principal components 1; PC2 = Principal components 2; PC3 = Principal components 3
*, ** significant at level of 0.05 and 0,01, respectively

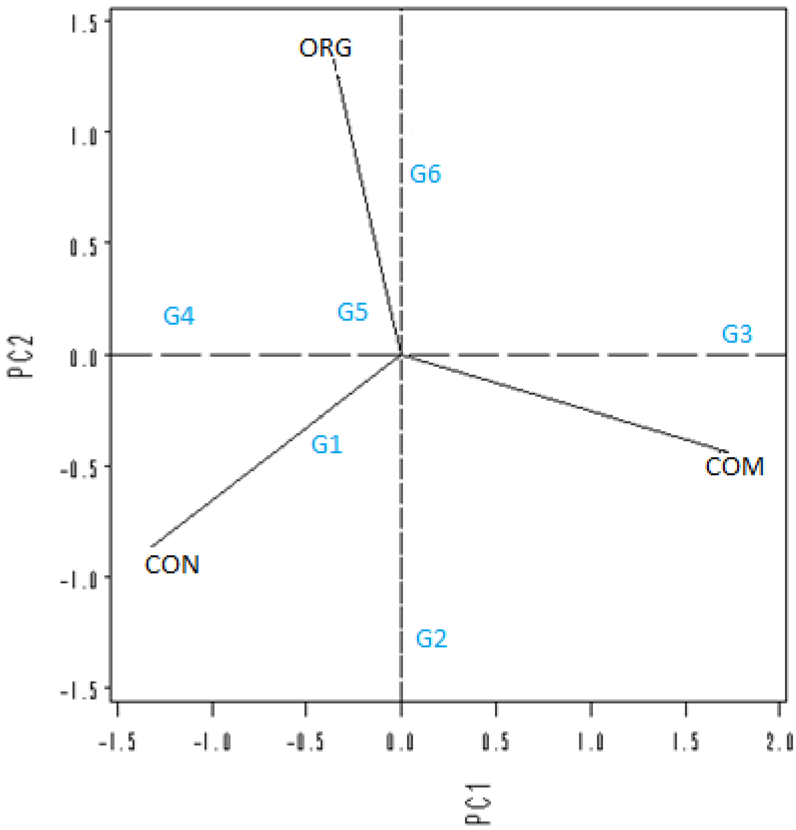
Table 5 is an Anova for AMMI models on 1000 grains weight and yieldwhere the sources of summary for GxMwas derived into PC'S. Totally, the variation between genotypes by environment for 1000 grains weight and yield contributed 27.76% and 13.89% to the total phenotype variation. Further, the interaction between genotypes and cultivation systems was captured very well by the first and second PC. Thus, AMMI model 2 was run since PC1 and PC2 was significant at P=0.01 and P= 0.05 (Gauch Jr, 1992).

Table 6. Genotypes stability rank based on AMMI Stability Values (ASV)

Genotype	1000 grains weight				Rank	Yield				Rank
	Mean	PC1	PC2	ASV		Mean	PC1	PC2	ASV	
G1	29.04	-0.43	-0.31	0.83	2	6.54	0.94	0.37	1.68	6
G2	27.62	0.04	-1.25	1.25	4	5.76	-0.44	0.04	0.77	3
G3	30.52	1.97	0.10	3.56	5	5.66	-0.89	0.51	1.64	5
G4	29.93	-1.21	0.23	2.19	6	6.09	0.25	0.18	0.47	1
G5	25.59	-0.35	0.24	0.67	1	6.87	0.36	-0.28	0.68	2
G6	26.92	-0.02	0.99	0.99	3	5.91	-0.21	-0.83	0.91	4

PC1 = Principal components 1; PC2 = Principal components 2; ASV = AMMI Stability Value; Mean = Mean yield value
G1=black rice; G2=red rice 1; G3=red rice 2; G4=sticky rice; G5=menthik wangi; G6=ciherang

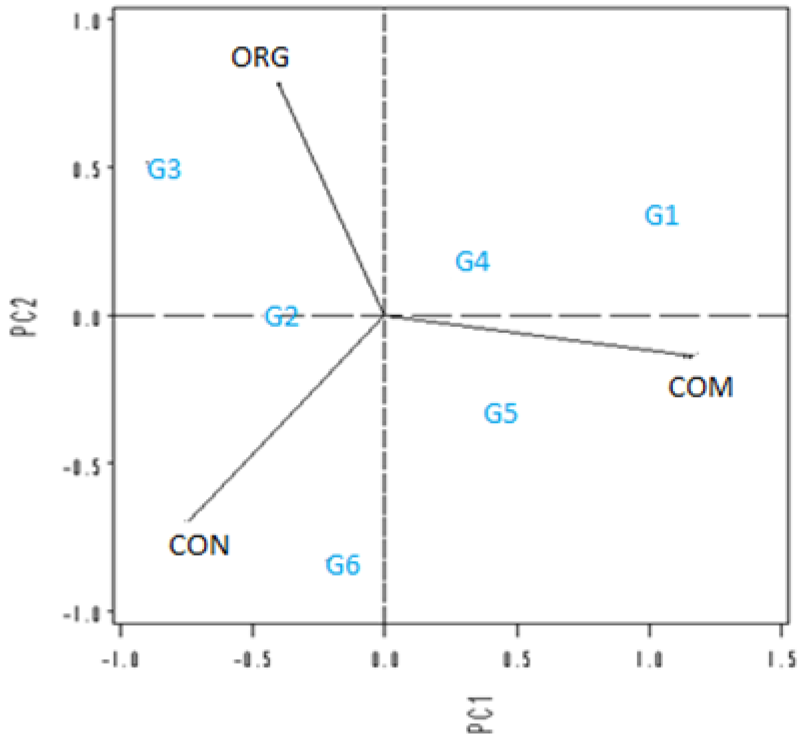
In the Table 6, the genotype stability over cultivation systems was ranked based on ASV score since this value score had a positive correlation with the interaction between genotypexcultivation systems. Thus, the genotype G5 was determined as the most stable genotype with respect to size of grains in the different cultivation systems. While for the yield, the genotype G4 was identified as the most stable one.Although it did not produce the highest yield. The genotype G5 had the highest yield in this study, but ranked second for its stability.



G1=black rice; G2=red rice 1; G3=red rice 2; G4=sticky rice; G5=menthik wangi; G6=ciherang

Figure 11: AMMI2 biplot for 1000 grains weight trait

For 1000 grain weight, PC1 and PC2 had a 76.53% and 23.47% contribution to the genotypic variation under different cultivation systems. Their total mean squares were 11 times larger as compared to the mean square value for error component. The genotypes G4 and G5were well adapted to organic (Org.) cultivation system, since they were located at quadrant four of the AMMI biplot. While for the genotypes G1 and G2, each of them waswell adapted under conventional (Con.) cultivation system and complex (Com.) cultivation system(Figure 11).



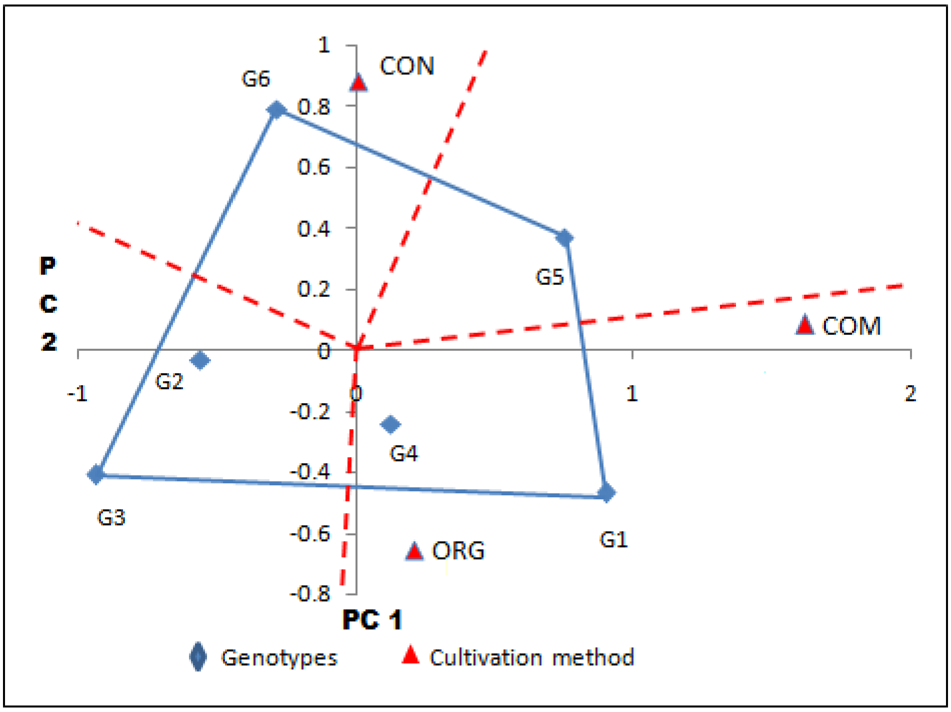
G1=black rice; G2=red rice 1; G3=red rice 2; G4=sticky rice; G5=menthik wangi; G6=ciherang

Figure 12: AMMI2 biplot for yield trait

Furthermore, the genotype*cultivation system interaction could account for 13.89% of the total yield variation, which 75.44% of it wascontributed by PC1 and PC2 for the rest value. In the specific adaptation term, there were the genotypes G6 that performed well at conventional (Con.) cultivation system, G3 at organic (Org.) cultivation system, and G5 at complex (Com.) cultivation system (Figure 12).

3. 3. GGE Biplot

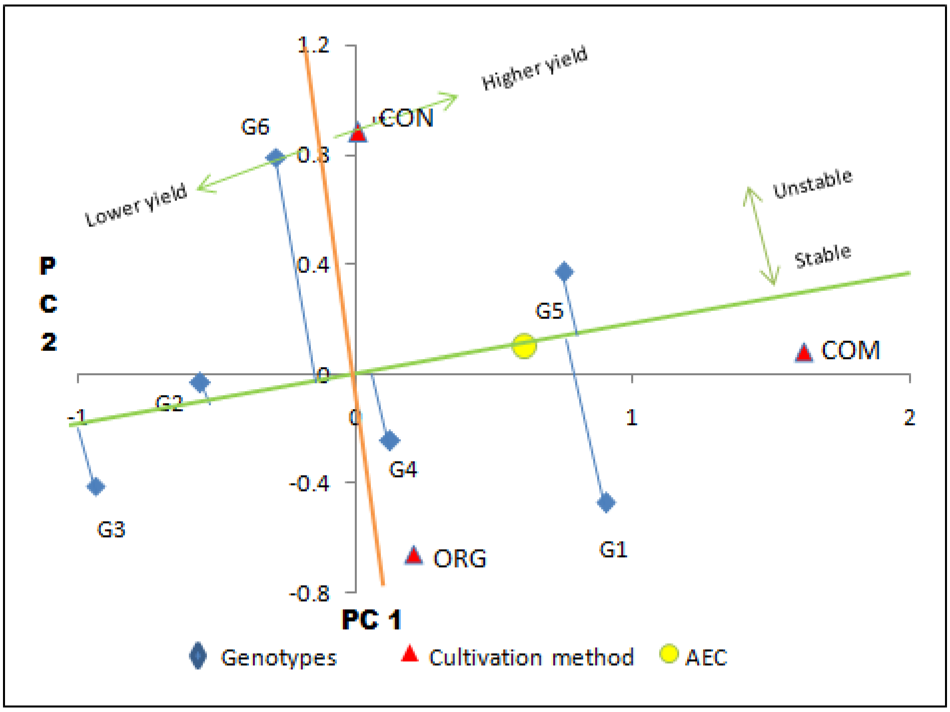
To identify which the best adapted genotype for yield production in an environment, GGE analyses were run as well. This system was useful to explain the variation of trait means value that was due to GGE factor (Yan & Kang, 2002).



G1=black rice; G2=red rice 1; G3=red rice 2; G4=sticky rice; G5=menthik wangi; G6=ciherang

Figure 13: GGE biplot for the best genotypes under 3 cultivation systems

A GGE polygon graph could reveal relative performance of each genotype at a certain cultivation system condition. Through a “which-won-where” pattern which means that genotypes with a position on the corner of a polygon could be identified as the best genotypes for its sector (Yan and Kang, 2003). Each sector was separated with a line which wasformed from biplot origin point and perpendicular to each side of the polygon. Sector containing a cultivation system point is called a mega-environment (Figure 13). In organic (Org.) and complex (Com.) cultivation systems, there wasthe genotype G1 which performed as the best adapted genotype, followed by G4. While for the conventional (Con.) system, the G6 performed well for its yield production.



G1=black rice; G2=red rice 1; G3=red rice 2; G4=sticky rice; G5=menthik wangi; G6=ciherang

Figure 14: GGE biplot with AEC

Included in GGE graphs, there are Average Environment Coordination (AEC) views as well. These AEC formed from AEC abscissa that pass biplot origin and AEC point and AEC ordinate which is perpendicular to the abscissa and also passes origin point of the biplot (Yan *et al.*, 2007). AEC abscissa was used as the reference to determine the genotype stability. When a genotype is closer to this line, it means that it has a higher stability compared to another genotype which is located further from that line. On the other hand, AEC ordinate line separates the genotypes that have a higher mean value than the average mean of the performance and other genotypes with a lower value. These higher mean genotypes are located at the right side of the line (figure 14). In this graph, G2 had the closest location with the AEC line that means it was the most stable genotype, although its production was lower than the average mean. On the other hand, genotypes G1 and G6 were located far away from the AEC line that means both of them do not perform stable over different cultivation systems.

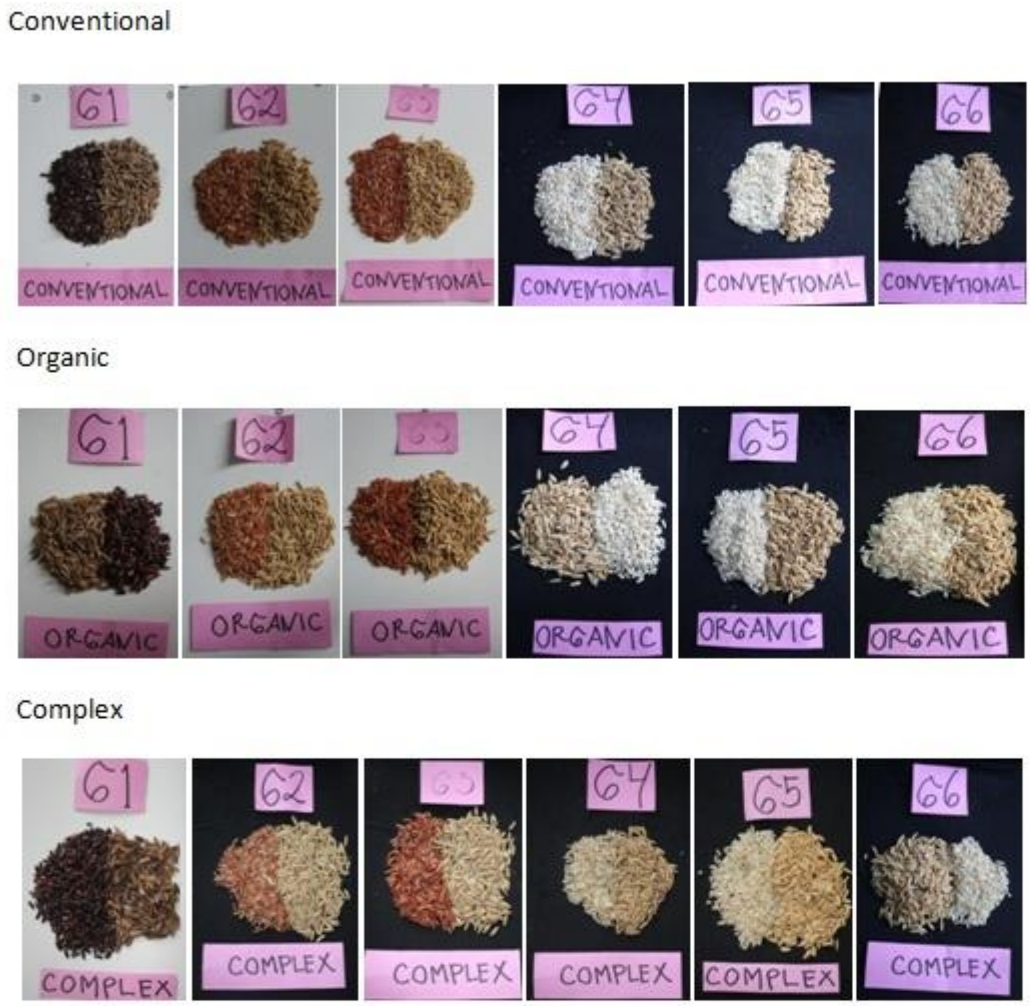


Figure 15. Rice grains production

3. 4. Analysis for stability and adaptability over the cultivation system based on AMMI and GGE

Table 7.Classification genotypes stability and adaptability over the cultivation system based on yield trait using AMMI and GGE

Cultivation method	Genotype																		Mean average
	G1			G2			G3			G4			G5			G6			
	Mean	AMMI	GGE	Mean	AMMI	GGE	Mean	AMMI	GGE	Mean	AMMI	GGE	Mean	AMMI	GGE	Mean	AMMI	GGE	
Con.	7.36	x	x	7.82	x	Stable	7.74	x	x	7.54	Stable	x	8.57	x	x	8.42	√	√	7.91
Org.	5.54	x	√	5.07	x		5.56	√	x	5.23		√	5.58	x	x	4.41	x	x	5.23
Com.	6.72	x	√	4.38	x		3.69	x	x	5.49		√	6.46	√	x	4.91	x	x	5.28
Average	6.54			5.76			5.66			6.09			6.87			5.91			**6.14**

√ = well adapted , x = not adapted
G1=black rice; G2=red rice 1; G3=red rice 2; G4=sticky rice; G5=menthik wangi;G6=ciherang

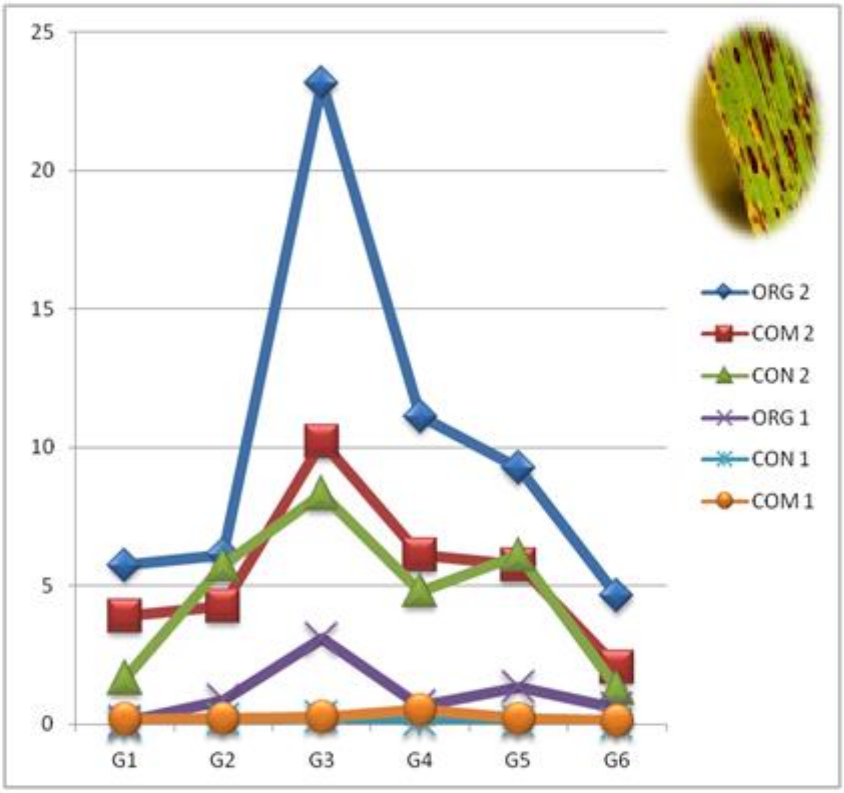
In a MET study, the interaction between genotype and environment plays an important role in determining genotypes stability performance. Higher interaction leads to dynamic stability or in other words similar with specific adaptation. Contrariwise, there is a static stability which is characterized by its constant performance under various environments (H. Becker & Leon, 1988). Combined with the high yield result, both stability types would result in new candidates of potential stable or specific environment genotypes (Tarakanovas & Ruzgas, 2006). Using AMMI and GGE systems, genotypes red rice 1 and sticky rice confirmed that they could adapt at a wide range area. Furthermore, sticky rice genotype provided a higher yield, even more if it is compared to Ciherang cultivar.

AMMI and GGE provided different results for genotypes adaptability and stability except for specific genotypeswithconventional cultivation. Using both analysis systems, Ciherang was identified as the best adapted genotype for conventional system. Due to the fact that Ciherang was bred under conventional condition, this genotype did not perform well under organic condition. It may only be adapted under a narrow environment range, mainly for those that depend on high external input from the farmer. The fact that conventional breeders do not take plant traits into account which affect its independence from external should become a concern (Lammerts van Bueren & Myers, 2012). Specifically, different genotypes show its specific adaptation under different cultivation system.

The G1 performed as the best genotype which could grow well under both organic systems. G3 is a potential genotype for organic monoculture, G5 is a potential genotype for complex system, and G1 for both organic systems. Becausegenotype G2 and G4 have a wider adaptation, they have an opportunity to be developed as well. Itis a big opportunity since rice grains with black and red color do nothave that much attention to be developed in Indonesia. In fact, only one new cultivar for red rice was released among 190 new cultivars which were released by Indonesian Center of Rice Research (ICRR) (Suprihatno & Padi, 2010). In a cooking test trial, this new cultivar named Aek Sibundong was favored by respondents in Central Java, East Java, Bali, and Nusa Tenggara Baratbetter than their common rice (Indrasari & Adnyana, 2007).

Overall, the mean average for both organic cultivation systems is lower compared to the conventional systems. The higher water level in complex plot treatment at early stages of rice growth might explain the results. As we wanted to keep a high fish fingerling survival when they just released at early rice growth stage, unconciously we add more water in complex plot than in conventional plot to make fish easily adapt to the new environment. The higher water level inhibited tillers production at the tillering stage (Thakur *et al*.,2011). Therefore, the number of tillers are lower than in conventional plots which lead to lower grain yield. According to Uma Khumairoh in 2011, water level can be increased when rice passed tillering stage to panicle initiation onward. At this phase, rice has produced tillers maximally and with higher water level, fish can continuously swim within rice plants and eating rotten tillers which only allow productive tillers remained and continue to develop grain. On the other hand, the water management in this complex system was quite different with former research of Uma Khumairoh in year 2011. In her experiment, the water level was kept in two cm height for one month after transplantation time. In this recent complex system, the water source mainly was obtained from the irrigation system. Due to the fact that there were fish in the system, rainfall rate was low, and watering shift was low (once in five days), the farmer tried to keep the water in the complex system at a higher level.

Therefore, in ideal situation, the higher number of productive tiller in complex rice system will result on the higher grain yield. Another explanation is might be related with goat manure decomposition process which is slower compared to other kinds of organic fertilizers. The hard texture of goat manure could become the main reason for this. This kind of manure need to be destructed physically before it was applied to the field (Wijayanti, 2013). Thus, green manure or compost are better option as fertilizers in organic production at first cycle. In line with the former research that indicated organic farming needs a long transition period. Transition period is needed to repair soil in term of chemical, physical and biological condition. Several studies revealed that crop production under organic cultivation resulted in a lower yield compared to a conventional (Neera *et al.*, 1999; Padel, 2001).



G1=black rice; G2=red rice 1; G3=red rice 2; G4=sticky rice; G5=menthikwangi; G6=ciherang

Figure 16: Disease intensity for brown leaf spot of six genotypes in three cultivation systems

3. 6. Disease intensity

During this study, brown leaf spot attack was identified in the field. This disease could have caused yield losses up to 5% (Savary et al., 2000). Low nitrogen supply has a big influence to the severity of the disease (Chattopadhyay & Dickson, 1960). The differences in the disease severity might have a relation with the genotype sensitivity to nitrogen availability. Through evaluation twice, genotype G3 showed its higher susceptibility to this disease compared to the other genotypes. This genotype gave a significant response to the nitrogen deficiency in the soil by performing an-erect culm and a high severity for brown leaf disease attack.

Further evaluation showed that all of the genotypes tended to show a higher disease intensity at the second time point. Genotype G1 and G6 performed a low incidence of brown spot symptoms (Figure 16). Between two organic systems, the complex system provided better support for the genotypes to defend against thebrown leaf attack. By using local rice genotypes in a complex agro-ecosystem, there was a positive influence on the rice nutrient availability and a symptom reduction of six different pest attacks (Khumairoh et al., 2012).

3. 7. Protein content

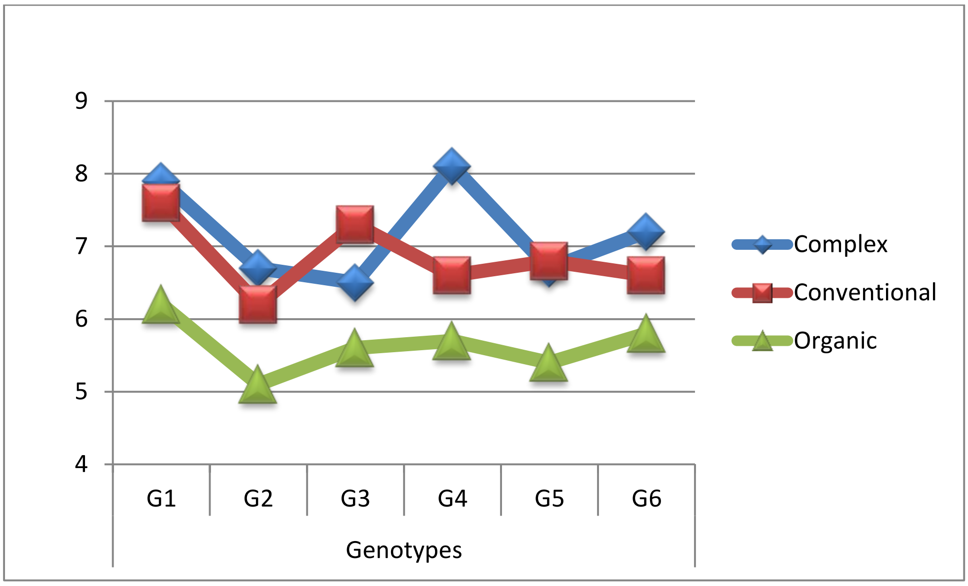


Figure 17: Protein content of six genotypes in three cultivation systems

With an average protein content of 7.2%, the complex system proved its ability to reach a higher grain protein content compared to the other two cultivation systems (Appendix 1). Genotype G1 performed the highest protein content among the genotypes. Genotype G4 obtained 8.1% protein content under complex cultivation system, which was the best value between 18 samples. On the other hand, average protein content for genotype G2 was the lowest (6.03%) and in combination with organic systems resulted in 5.12% protein content which was the lowest value among all samples as well.

3. 8. Cooking test result

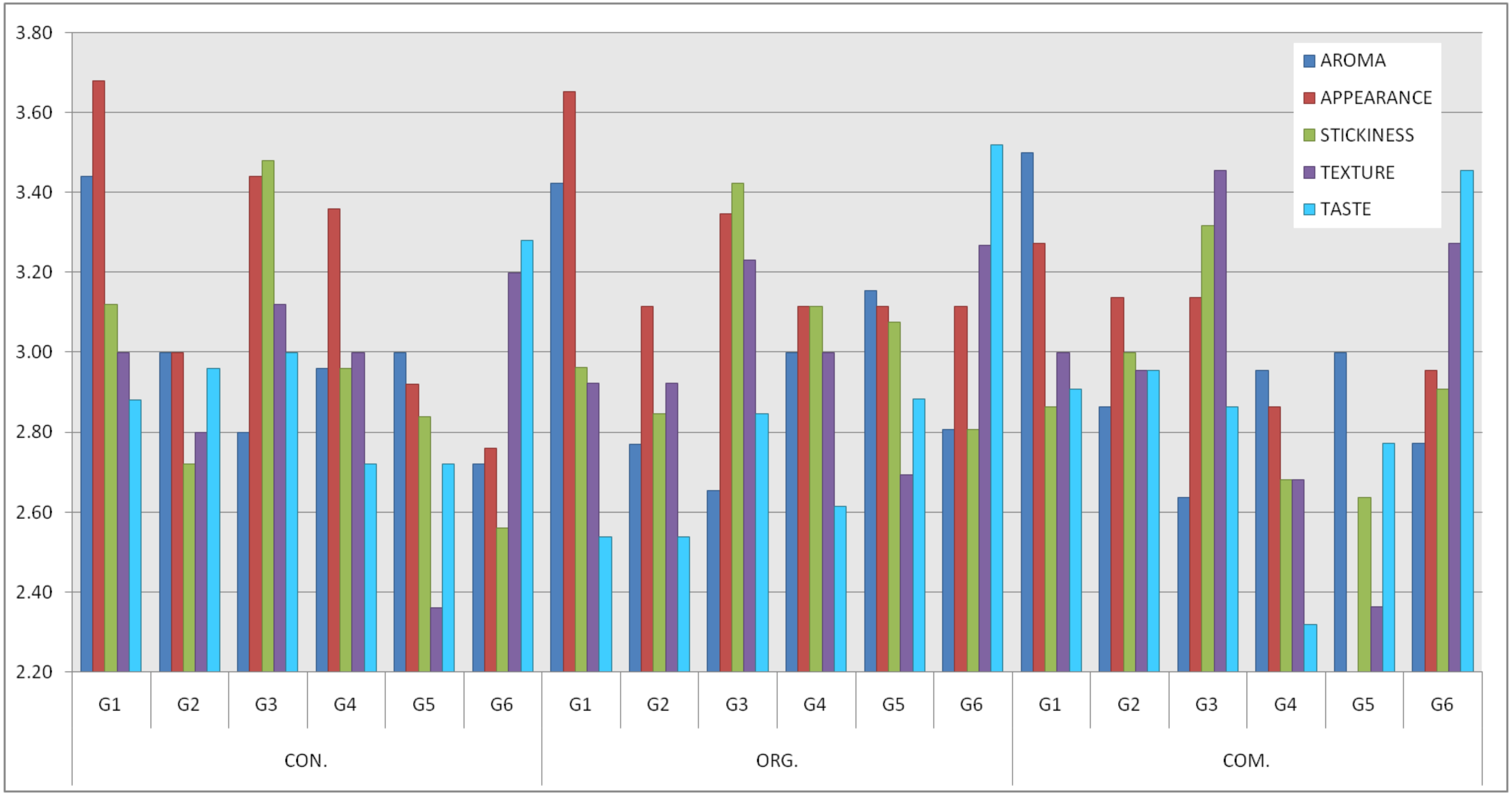


Figure 18. Cooking test result for six genotypes grain on three cultivation systems

During the cooking test observation, the panelists were asked to write down their preference liking for the aroma, appearance, stickiness, and taste criteria of six rice genotypes that were grown under three different cultivation systems. Average mean for each aspect was described in Figure 17. Different rice genotypes had different characteristics that attracted panelists to appreciate them i.e. G6 under monoculture organic for its taste, G1 under conventional condition waschosen for its appearance, G3 under conventional condition for its stickiness, and G3 under complex cultivation for its texture.

Rice grain with higher protein content might have a harder texture. Protein has a characteristic to inhibit water absorption and swelling process of starch granules. Thus, starch gelatinization could not be optimized (Ishima et al., 1974). Interestingly, this black rice was chosen also for its aroma more than menthik wangi. The majority of black rice has a specific aroma. There are 36 out of 56 accessions containing 2-Acetyl-1-pyrroline (2-AP), a major compound that presents commonly in aromatic rice (Bounphanousay *et al.*, 2008).

3. 9. Trait of importance

Evaluation on agronomic traits is essential for plant breeding development. By recognizing the agronomic traitsthat correlated with yield quality and quantity, undesirable traits could be avoided (Grist, 1986; Garcia *et al*., 1998). In this study, the flag leaf could be used as an example. The erect flag leaf wasmore desirable than the horizontal one due to the higher sunlight intercept. This trait might have a positive correlation with the high yield (Chang & Li, 1991; Dewi *et al*., 2009). Regarding that, genotype G2 is not a recommended genotype for further improvement due to its horizontal flag leaf and relatively low average yield crop. The fact that this genotype has a long growing cycle and tall performance would be useful as an additional consideration to reject this cultivar.

The grain color and protein content havean importance in selection as well. In this study, the genotype G1 is a promising genotype for further improvement due to its high protein content. Rice grain with a purple pericarp like black rice also contains a high protein value (Villareal & Juliano, 1989). In addition, the colored rice also has a positive correlation with antioxidant properties (Hu *et al.*, 2003). This antioxidant can prevent diabetes mellitus and cancerdisease (Laight, Carrier, & Änggård, 2000). Thus, grain color of rice could be used as a determinant trait for selecting rice for a healthier ways of life.

3.10. Conclusion and recommendation

With the exception of genotype G3 which showed an erect culm in the complex system, the morphological performance was similar under the three cultivation systems. Genotypic variation due to different cultivation system was depicted by productive tiller numbers, plant height, 50% heading time, harvest time, and yield.

Furthermore, the genotypes G2 and G3 resulted in stable yield production over different cultivation systems. On the other hand, there were some varieties that performed as a prospective genotype for each of the cultivation systems. In this study, G6 seemed adapted to the conventional system; G1, G3, and G4 performed best under the monoculture organic system; G1 and G5 performed best in the complex system.

Moreover, flag leaf and grain endosperm color could be noticed as an important trait for genotype selection in rice. Using grain color traits as the consideration, G1 has an added value for further improvement. Furthermore, using the flag leaf slope trait, genotype G2 is not recommended for that. The genotype G3 had a unique characteristic for its sensitivity to nitrogen content in the soil that might be related to its sensitivity to leaf brown spot.

Additionally, the conventional and organic system provided different results with respect to the genotype performances. Although the organic system result was not equal to conventional result, the complex system indicated that it had an added value as compared to organic monoculture. On average, it provided better disease resistance and grain protein content (Table 7). Genotypes G1, G4, G5, and G6 under complex cultivation system also performed better yield production compared to organic system.

Finally, the fact that this experiment was conducted as a first cycle of a transition period from conventional to organic cultivation cannot be ignored. Longer time is needed to provide enough time for soil to increase the biological activity with the intention of regaining their natural fertility. Thus, an advanced study over season and year is needed. Equal water amount and level should be maintained in all treatments while taking fish survival into account. A quick decomposed organic matter need to be applied for a better yield at the first cycle.

References

Agriculture Ministry of Indonesia (AMI) . (2014). Peraturan Menteri Pertanian Republik Indonesia nomor 130/Permentan/SR.130/11/2014 tentang kebutuhan dan Harga Eceran Tertinggi (HET) pupuk bersubsidi untuk sektor pertanian tahun anggaran 2015. Retrieved 14 October, 2015, from http://psp.pertanian.go.id/assets/file/2014/Permentan_Kebutuhan_dan_HET_2015.pdf

Agriculture Ministry of Indonesia (AMI).(2011). *Permentan No. 87/Permentan/SR.130/12/2011 tentangKebutuhandanHargaEceranTertinggi (HET) PupukBersubsidiuntukSektorPertanian 2012*. Jakarta, Indonesia: Indonesian Agriculture Ministry Retrieved from https://kriswidiatmoko.files.wordpress.com/2012/11/permentan-87-2011-utk-2012.pdf.

Becker, H., & Leon, J. (1988). Stability analysis in plant breeding. *Plant breeding, 101*(1), 1-23.

Becker, K., & Frei, M. (2004). Improving the nutrient availability in rice—Biotechnology or biodiversity. *Agric. Rural Devel, 11*, 64-65.

Bounphanousay, C., Jaisil, P., Sanitchon, J., Fitzgerald, M., & Hamilton, N. S. (2008). Chemical and molecular characterization of fragrance in black glutinous rice from Lao PDR. *Asian Journal of Plant Sciences, 7*, 1-7.

Budiman, B., Arisoesiloningsih, E., & Edi Wibowo, R. B. (2012). Growth adaptation of two Indonesian black rice origin NTT cultivating In organic paddy field, Malang-East Java. *Journal of Tropical Life Science, 2*(3), 77-80.

Chang, T.-T., & Li, C.-C. (1991). Genetics and Breeding. In B. S. Luh (Ed.), *Rice: Volume I. Production/Volume II. Utilization* (pp. 23-101). Boston, MA: Springer US.

Chattopadhyay, S., & Dickson, J. (1960). Relation of nitrogen to disease development in rice seedlings infected with Helminthosporium oryzae. *Phytopathology, 50*, 434-438.

Chen, P.-N., Kuo, W.-H., Chiang, C.-L., Chiou, H.-L., Hsieh, Y.-S., & Chu, S.-C. (2006). Black rice anthocyanins inhibit cancer cells invasion via repressions of MMPs and u-PA expression. *Chemico-biological interactions, 163*(3), 218-229.

Cox, S. (2009). Crop domestication and the first plant breeders. *and farmer participation*, 1.

Cruz, C. R. D. (1992). *Rice-fish research and development in Asia* (Vol. 24): WorldFish.

Darwis, S. (1992). POTENSI SIRIH (Piper betle L.) SEBAGAI TANAMAN OBAT. *Warta Tumbuhan Obat Indonesia, 1*(1 Jan).

Dewi, I. S., Trilaksana, A. C., Koesoemaningtyas, T., & Purwoko, B. S. (2009). Karakterisasi Galur Haploid Ganda Hasil Kultur Antera Padi. *Buletin Plasma Nutfah, 15*(1), 1-12.

EPA. (2015). Organic farming. Retrieved 9 April, 2015, from http://www.epa.gov/agriculture/torg.html.

FAO, I., & IFDC, I. (2002). PPI. 2002. *Fertilizer use by crop. Fifth Edition. FAO Rome*.

Fontaine, L., Rolland, B., & Bernicot, M.-H. (2008, 18-20 June). *Contribution to organic breeding programmes of wheat variety testing in organic farming in France.* Paper presented at the 2nd Conference of the International Society of Organic Agriculture Research, Modena, Italy.

Furukawa, T., Maekawa, M., Oki, T., Suda, I., Iida, S., Shimada, H.,Kadowaki, K. i. (2007). The Rc and Rd genes are involved in proanthocyanidin synthesis in rice pericarp. *The Plant Journal, 49*(1), 91-102.

Garcia, E., Jamilena, M., Alvarez, J., Arnedo, T., Oliver, J., & Lozano, R. (1998). Genetic relationships among melon breeding lines revealed by RAPD markers and agronomic traits. *Theoretical and Applied Genetics, 96*(6-7), 878-885.

Gauch, H., & Zobel, R. (1996). AMMI analysis of yield trials. In 'Genotype by environment interaction'.(Eds MS Kang, HG Gauch) pp. 85–122: CRC Press: Boca Raton, FL.

Gauch Jr, H. (1992). *Statistical analysis of regional yield trials: AMMI analysis of factorial designs*: Elsevier Science Publishers.

Grist, D. (1986). Rice: Tropical Agricultural Series: London: Macmillan.

Hartatik, W., & Widowati, L. (2006). *Pupuk kandang*. Retrieved from http://balittanah.litbang.pertanian.go.id/ind/dokumentasi/lainnya/04pupuk%20kandang.pdf

Hu, C., Zawistowski, J., Ling, W., & Kitts, D. D. (2003). Black rice (Oryza sativa L. indica) pigmented fraction suppresses both reactive oxygen species and nitric oxide in chemical and biological model systems. *Journal of Agricultural and Food Chemistry, 51*(18), 5271-5277.

Ichikawa, H., Ichiyanagi, T., Xu, B., Yoshii, Y., Nakajima, M., & Konishi, T. (2001). Antioxidant activity of anthocyanin extract from purple black rice. *Journal of Medicinal Food, 4*(4), 211-218.

Indonesia Organic Association(AOI). (2011). Statistik Pertanian Organik Indonesia 2011. *Bogor (ID): AOI*.

Indonesian Agency for Agricultural Reasearch and Development (IAARD). (2015). Deskripsi varietas Ciherang. Retrieved 11 April, from http://www.litbang.pertanian. go.id/varietas/one/130/

International Fertilizer Industry Association (IFA). (2014). Fertilizer Outlook 2014-2018. Retrieved 14 April, 2015, from http://www.google.nl/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCEQFjAA&url=http%3A%2F%2Fwww.fertilizer.org%2Fen%2Fimages%2FLibrary_Downloads%2F2014_ifa_sydney_summary.pdf&ei=M-8sVbCOAsL4aqb9gOAL&usg=AFQjCNGk_2No-4PcmJxxMXXw0WO_qI1S0Q&sig2=byaloLWy5KFckHbH6jF03g&bvm=bv.90790515,d

International Rice Research Institute (IRRI). (2016). World rice statistics online query facility. Retrieved 11 January 2016, 2016

Indrasari, S. D., & Adnyana, M. O. (2007). Preferensi konsumen terhadap beras merah sebagai sumber pangan fungsional. *Buletin Iptek Tanaman Pangan, 2*(2).

Ishima, T., Taira, H., Yoshikawa, S., & Mikoshiba, K. (1974). Effect of nitrogenous fertilizer application and protein content in milled rice on olganoleptic quality of cooked rice. *Report of National Food Research Institute (Japan)*.

Kariyasa, K. (2005). Sistem integrasi tanaman ternak dalam perspektif reorientasi kebijakan subsidi pupuk dan peningkatan pendapatan petani. *Jurnal Analisis Kebijakan Pertanian, 3*(1), 68-80.

Kastono, D. (2005). Tanggapan pertumbuhan dan hasil kedelai hitam terhadap penggunaan pupuk organik dan biopestisida gulma siam (Chromolaena odorata). *Ilmu pertanian, 12*(2), 103-116.

Khumairoh, U., Groot, J. C., & Lantinga, E. A. (2012). Complex agro-ecosystems for food security in a changing climate. *Ecology and evolution, 2*(7), 1696-1704.

Khumairoh, U. (2011). *Effects of duck, fish, and azolla fully integration into an organic rice system in Malang, Indonesia.* (Master thesis), Wageningen University, Wageningen.

Kinoshita, T. (1984). Gene analysis and linkage map. *Developments in crop science*.

Laight, D., Carrier, M., & Änggård, E. (2000). Antioxidants, diabetes and endothelial dysfunction. *Cardiovascular research, 47*(3), 457-464.

Lammerts van Bueren, E., Jones, S. S., Tamm, L., Murphy, K. M., Myers, J. R., Leifert, C., & Messmer, M. (2011). The need to breed crop varieties suitable for organic farming, using wheat, tomato and broccoli as examples: a review. *NJAS-Wageningen Journal of Life Sciences, 58*(3), 193-205.

Lammerts van Bueren, E. T., & Myers, J. R. (2012). *Organic crop breeding*: Wiley Online Library.

IAFP. (2016). Kebutuhan pupuk urea thn 2006 - 2015. Retrieved 10 March 2016, from http://www.appi.or.id/?statistic.

Lantinga, E. A., Oomen, G. J., & Schiere, J. B. (2004). Nitrogen efficiency in mixed farming systems. *Journal of Crop Improvement, 12*(1-2), 437-455.

Lobell, D. B., Cassman, K. G., & Field, C. B. (2009). Crop yield gaps: their importance, magnitudes, and causes. *Annual Review of Environment and Resources, 34*(1), 179.

Martani. (2015). Mentik Wangi & Mentik Susu. from ttp://martani.co/portfolio/mentik-wangi-mentik-susu

Matjik, A., & Sumertajaya, I. (2002). Perancangan percobaan dengan Aplikasi SAS dan Minitab, Jilid I. Bogor: IPB Press.

Mayrowani, H. (2012). *Pengembangan pertanian organik di Indonesia.* Paper presented at the Forum Penelitian Agro Ekonomi.

Mutiarawati, T. (2006). Kendala dan Peluang Dalam Produksi Pertanian Organik di Indonesia. *Makalah Ilmiah Fakultas Pertanian Universitas Padjadjaran Bandung*.

Natawigena. (1989). *Pestisida dan Kegunaannya*. Bandung: CV Armico.

Nauta, W., Groen, A., Roep, D., Veerkamp, R., & Baars, T. (2003). *Vision of breeding for organic agriculture.* Paper presented at the Supplement to the workshop report.

Neera, P., Katano, M., & Hasegawa, T. (1999). Comparison of rice yield after various years of cultivation by natural farming. *Plant production science, 2*(1), 58-64.

Padel, S. (2001). Conversion to organic farming: a typical example of the diffusion of an innovation? *Sociologia ruralis, 41*(1), 40-61.

Pandin, M. R. L. (2008). Potret industri pupuk Indonesia *Economic Review* (Vol. 214). Jakarta, Indonesia.

Salgado, J. M., de Oliveira, A. G. C., Mansi, D. N., Donado-Pestana, C. M., Bastos, C. R., & Marcondes, F. K. (2010). The role of black rice (Oryza sativa L.) in the control of hypercholesterolemia in rats. *Journal of Medicinal Food, 13*(6), 1355-1362.

Samonte, S. O. P., Wilson, L. T., McClung, A. M., & Medley, J. C. (2005). Targeting cultivars onto rice growing environments using AMMI and SREG GGE biplot analyses. *Crop Science, 45*(6), 2414-2424.

Sariubang, M., & Nurhayu, A. (2005). *Integrasi usahatani tanaman padi–sapi potong berwawasan pertanian organik.* Paper presented at the Pros. Seminar Nasional Teknologi Peternakan dan Veteriner. Bogor.

Sasa, J. J., & Syahromi, O. (2006). Sistem Minapadi dalam Perspektif Produktivitas Lahan, Pendapatan, dan Lingkungan. *Jurnal Pertanian Tanaman Pangan, 25*(2).

Savary, S., Willocquet, L., Elazegui, F. A., Teng, P. S., Van Du, P., Zhu, D., . . . Singh, H. (2000). Rice pest constraints in tropical Asia: characterization of injury profiles in relation to production situations. *Plant Disease, 84*(3), 341-356.

Statistic's Indonesia (SI). (2015). Capita Weekly Average Consumption of Several Food Items, 2007-2014 Retrieved 20 January, 2015, from http://www.bps.go.id/linkTabelStatis/view/id/950#accordion-daftar-subjek3

Statistic Trenggalek Regency(STR), S. T. R. (2013). *Trenggalek in number*. Trenggalek, Indonesia: Retrieved from http://trenggalekkab.bps.go.id/ linkTabelStatis /view/id/11.

Sudarmo, S. (2005). *Teknologi Tepat Guna PESTISIDA NABATI, Pembuatan dan Pemanfaatannya*: Kanisius.

Suhartini, T. (2010). Keragaman Karakter Morfologis Plasma Nutfah Spesies Padi Liar (Oryza spp.). *Buletin Plasma Nutfah, 1*, 17-28.

Sumarno. (2006). Periodisasi Musim Tanam Padi Sebagai Landasan Manajemen Produksi Beras Nasional. Retrieved 20 August, 2015, from http://www.litbang.pertanian.go.id/artikel/one/106/

Suprihatno, B., & Padi, B. B. P. T. (2010). *Deskripsi varietas padi*: Balai Besar Penelitian Tanaman Padi, Badan Penelitian dan Pengembangan Pertanian, Departemen Pertanian.

Susilowati, E. Y. (2006). Identifikasi nikotin dari daun tembakau (Nicotiana tabacum) kering dan uji efektivitas ekstrak daun tembakau sebagai insektisida penggerek batang padi (Scirpophaga innonata). *Universitas Negeri Semarang*.

Sutanto, R. (2002). *Penerapan Pertanian Organik: pemasyarakatan dan pengembangannya*: Kanisius.

Taofik, M., Yuianti, E., Barizi, A., & Hayati, E. (2010). Isolasi dan identifikasi senyawa aktif ekstrak air daun paitan (Tithonia diversifolia) sebagai bahan insektisida botani untuk pengendalian hama tungau Eriophydae. *Alchemi, 2*(1), 104-157.

Tarakanovas, P., & Ruzgas, V. (2006). Additive main effect and multiplicative interaction analysis of grain yield of wheat varieties in Lithuania. *Agronomy research, 4*(1), 91-98.

Thakur, A. K., Rath, S., Patil, D. U., & Kumar, A. (2011). Effects on rice plant morphology and physiology of water and associated management practices of the system of rice intensification and their implications for crop performance. Paddy and Water Environment, 9(1), 13-24.

United State Departement of Agriculture (USDA). (2012). Indonesia rice. Retrieved 14 April, 2015, from http://www.pecad.fas.usda.gov/highlights/2012/03/Indonesia_rice_Mar2012/

Villareal, C. P., & Juliano, B. O. (1989). Variability in contents of thiamine and riboflavin in brown rice, crude oil in brown rice and bran-polish, and silicon in hull of IR rices. *Plant Foods for Human Nutrition, 39*(3), 287-297.

Wijayanti, E. (2013). *Pengaruh Pemberian Pupuk Kotoran Ayam Dan Kotoran Kambing Terhadap Produktivitas Cabai Rawit (Capsicum frustescens L.).* Universitas Muhammadiyah Surakarta.

Wissuwa, M., Mazzola, M., & Picard, C. (2009). Novel approaches in plant breeding for rhizosphere-related traits. *Plant and Soil, 321*(1-2), 409-430.

Yan, W., & Kang, M. S. (2002). *GGE biplot analysis: A graphical tool for breeders, geneticists, and agronomists*: CRC press.

Yan, W., Kang, M. S., Ma, B., Woods, S., & Cornelius, P. L. (2007). GGE biplot vs. AMMI analysis of genotype-by-environment data. *Crop Science, 47*(2), 643-653.

Zeigler, R. S. (2011). Indonesia reaps rewards from cooperation in rice research. from
http://irri.org/blogs/bob-s-blog/indonesia-reaps-rewards-from-cooperation-in-rice-research

Apendix 1

Mean value

1. Total tiller numbers (tillers/plant)

Genotype	Cultivation method								
	Conventional			Organic			Complex		
G1	26	26	21	17	17	17	25	14	14
G2	20	22	18	17	15	16	21	13	12
G3	25	21	20	17	15	15	18	13	12
G4	20	17	15	13	14	10	14	12	12
G5	27	22	19	22	16	18	22	15	14
G6	23	23	23	21	13	15	18	12	13

2. Productive tiller numbers

Genotype	Cultivation method								
	Conventional			Organic			Complex		
G1	16	17	15	11	12	13	12	12	12
G2	14	15	13	11	10	12	13	11	10
G3	16	15	14	11	11	14	10	9	10
G4	14	15	13	10	10	9	12	9	11
G5	15	17	13	13	11	14	14	14	12
G6	16	16	17	12	10	12	11	10	12

3. Crop damage I

Genotype	Cultivation method								
	Conventional			Organic			Complex		
G1	1.72	8.64	6.95	5.52	9.13	6.22	5.84	9.43	8.00
G2	2.06	7.78	10.71	5.54	8.30	7.56	3.15	7.90	9.85
G3	4.18	9.48	5.11	13.62	13.63	7.14	3.26	5.98	6.96
G4	2.56	1.80	3.96	8.70	7.07	8.95	12.55	1.44	2.48
G5	3.97	9.63	2.76	5.32	14.36	8.91	3.13	4.46	9.47
G6	1.27	2.88	2.76	14.06	6.65	10.70	7.89	2.52	8.12

4. Crop damage II

Genotype	Cultivation method								
	Conventional			Organic			Complex		
G1	5.89	4.84	8.33	8.78	8.89	10.28	8.89	8.99	12.35
G2	6.60	6.51	8.86	13.70	12.83	10.36	7.46	10.71	15.48
G3	6.28	5.19	8.13	15.24	8.48	10.64	4.60	9.98	8.47
G4	8.02	4.09	6.60	7.30	10.29	14.55	7.53	9.09	4.03
G5	12.67	6.10	8.03	9.81	15.07	15.49	4.51	8.00	8.98
G6	5.63	6.41	6.97	12.33	11.40	15.51	8.07	9.87	10.24

5. Crop damage III

Genotype	Cultivation method								
	Conventional			Organic			Complex		
G1	10.91	19.32	22.07	18.82	13.07	22.27	13.44	20.66	20.63
G2	16.14	27.82	34.45	10.49	6.62	19.84	13.60	24.48	23.84
G3	19.91	34.20	35.59	5.89	11.61	9.08	21.98	29.93	15.12
G4	14.70	19.24	21.98	14.44	20.72	14.29	15.84	14.87	12.44
G5	16.31	17.74	28.18	18.18	9.40	9.65	13.77	12.28	16.14
G6	28.87	20.14	9.66	14.11	5.32	10.80	16.62	14.17	8.65

6. Plant Height

Genotype	Cultivation method								
	Conventional			Organic			Complex		
G1	102	113	111	89	95	90	95	94	105
G2	137	142	139	109	106	126	128	121	126
G3	101	102	106	91	90	92	92	91	92
G4	114	113	118	93	99	104	104	104	104
G5	117	121	123	99	95	105	107	108	105
G6	101	104	102	98	89	102	101	92	102

7. First heading time (days after sowing)

Genotype	Cultivation method								
	Conventional			Organic			Complex		
G1	76	79	77	79	76	77	79	76	74
G2	78	73	80	81	79	80	81	75	80
G3	73	78	74	76	77	76	75	76	77
G4	73	75	77	76	75	74	74	75	72
G5	73	75	74	80	79	75	78	75	77
G6	73	71	75	71	75	74	75	75	74

8. 50% heading time

Genotype	Cultivation method								
	Conventional			Organic			Complex		
G1	84	86	85	84	86	85	84	85	82
G2	84	79	84	88	89	90	88	87	88
G3	79	83	80	81	80	82	83	85	83
G4	80	82	82	81	83	85	83	83	84
G5	83	82	83	86	87	89	86	86	87
G6	84	79	79	81	82	80	81	87	85

9. Leaf length

Genotype	Cultivation method								
	Conventional			Organic			Complex		
G1	36	40	34	27	33	21	32	32	26
G2	35	40	38	31	24	23	31	33	26
G3	29	28	24	26	29	20	34	31	21
G4	30	40	32	28	40	21	32	38	24
G5	36	34	32	26	23	21	37	32	24
G6	32	35	26	29	20	17	35	33	19

10. Panicle numbers

Genotype	Cultivation method								
	Conventional			Organic			Complex		
G1	18	19	16	13	13	13	15	12	12
G2	15	15	13	13	10	13	13	11	10
G3	18	18	15	13	11	13	11	9	11
G4	13	15	15	9	11	8	11	11	12
G5	16	18	15	13	13	15	15	15	12
G6	15	18	18	13	11	12	12	10	12

11. 1000 grains weight

Genotype	Cultivation method								
	Conventional			Organic			Complex		
G1	29	31	31	27	28	30	29	30	27
G2	28	29	30	25	26	26	27	30	28
G3	26	31	27	30	29	29	34	34	32
G4	30	32	33	28	29	33	30	28	26
G5	27	26	26	27	24	26	25	25	25
G6	26	27	26	27	27	29	27	30	23

12. HI

Genotype	Cultivation method								
	Conventional			Organic			Complex		
G1	0.19	0.11	0.19	0.20	0.13	0.14	0.22	0.23	0.19
G2	0.12	0.16	0.17	0.13	0.12	0.14	0.11	0.16	0.17
G3	0.17	0.16	0.15	0.22	0.15	0.13	0.13	0.12	0.14
G4	0.12	0.17	0.14	0.23	0.16	0.17	0.13	0.12	0.19
G5	0.17	0.14	0.12	0.17	0.21	0.16	0.17	0.22	0.14
G6	0.14	0.17	0.16	0.16	0.12	0.11	0.11	0.13	0.18

13. Harvest time

Genotype	Cultivation method								
	Conventional			Organic			Complex		
G1	108	110	112	112	110	107	108	107	110
G2	110	108	112	114	114	114	114	114	114
G3	108	109	107	110	110	110	110	110	110
G4	106	106	106	104	104	104	104	106	104
G5	107	109	110	108	110	109	109	109	112
G6	101	103	101	101	103	103	103	103	101

14. Yield

CONV			ORG			COMP		
6.86	7.50	7.71	5.05	6.36	5.23	7.14	6.77	6.26
8.00	7.88	7.58	5.39	4.30	5.52	4.86	4.18	4.10
8.25	7.14	7.81	6.21	4.43	6.05	3.57	3.51	3.99
7.20	7.07	8.36	5.10	5.68	4.90	6.24	5.13	5.10
7.89	9.20	8.61	6.36	5.47	4.92	7.05	6.42	5.92
8.52	7.89	8.83	5.33	3.75	4.15	4.27	4.62	5.85

15. Protein content

Cultivation system	**Genotypes**						**Average**
	G1	**G2**	**G3**	**G4**	**G5**	**G6**	
Conventional	7.6	6.2	7.3	6.6	6.8	6.6	6.9
Organic	6.2	5.1	5.6	5.7	5.4	5.8	5.7
Complex	7.9	6.7	6.5	8.1	6.7	7.2	**7.2**
Average	**7.3**	6.0	6.5	6.8	6.3	6.5	6.6