Income effect of Integrated Crop Management (ICM) among rice farmers in Indonesia

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Abstract. The growth of Indonesian population, which is predicted to increase about 0.99% in the next 20 years, requires efforts to increase rice production. In line with efforts to increase rice production, the Indonesian government through the Agency for Agricultural Research and Development has advocated a system called Integrated Crop Management (ICM). One component of ICM's most prominent technology and proven to increase productivity is the way of planting the rice, which is called the *Legowo 2:1* planting system. This research aims to assess the factors that affect the adoption of *Legowo 2:1* planting system and the impact of adoption to the farmers' income in district of Pangkajene Kepulauan, South Sulawesi, Indonesia. The type of the data is cross-sectional household level data with 120 respondents. The methodology used to assess the determinants of adoption is Logit Model, while to assess the income effect of adoption is Propensity Score Matching. The results found that age and level of education are determined to be the factors that highly influence the adoption decision, and farmers who adopt the planting system have a higher opportunity of income increase than those who do not adopt.
Key Words: Integrated Crop Management, *Legowo 2:1* planting system, Logit Model, Propensity Score Matching, income.

Introduction. Rice as the staple food in Indonesia is consumed by nearly 90% of the population. The growth of Indonesian population, which is predicted to increase about 0.99% in the next 20 years, requires efforts to increase rice production. Therefore, the Indonesian government targets a rice surplus of about 10 million tons in the next 5 years (Indonesian National Development Planning Agency 2013). The target would not always be easily achieved because there might be various problems that may lead to production losses. One constrain that has been faced over the years is the technology applied by the farmers is still largely a simple technology. Based on this situation, the integrated planting system could be the easiest technology that can be fixed and adopted by farmers.

Using technologies not in the accordance of the recommendation could decrease the productivity. Decreasing productivity can lower people's income, especially farmers. The decline in income would have a negative impact on the socio-economic conditions of farmers. Dontsop Nguezet et al (2011) have found that agricultural technologies that boost productivity can bring some positive impacts to farm households such as increasing incomes, lessen poverty, and ensure food security in developing countries. Crop productivity is determined by the interaction between varieties, growing environment and its management. In line with efforts to increase rice production, the Indonesian government through the Agency for Agricultural Research and Development has advocated a system called Integrated Crop Management (ICM) in 2008. ICM includes the use of high yielding varieties and quality seed, ways of planting in terms of time and pattern, weed control, fertilization, pest and disease control, water management, and post-harvest management (Indonesian Agency for Agricultural Research and Development 2013).

One component of ICM's most prominent technology and proven to increase productivity is the way of planting the rice, which is called the *Legowo 2:1* planting system. This system is a rice planting method that has multiple rows (mostly two or four) and interspersed with an empty row, for instance spacing of (25 x 25) cm between clumps in a row; 12.5 cm spacing inside the row; and 50 cm as the distance between two

rows or written as (25 x 12.5 x 50 cm). The way this system can improve plant population per acre, improve the process of photosynthesis, make the plant more fertile due to the evenly absorption of nutrients for each crop, and improve the growth of rice seedlings work much better rather than planting the rice with tiles system (20 x 20 cm) (Indonesian Agency for Agricultural Research and Development 2013). Although this planting system can improve productivity and ease farmers in management, Subekti et al (2015) concluded that one of the things that might make some farmers reluctant to adopt this cropping system is because it requires more labor in terms of tillage and planting. For further insight, the picture of the *Legowo 2:1* planting system can be seen in Figure 1.

Figure 1. *Legowo* 2:1 planting system in the rice field (original).

ICM in South Sulawesi was firstly introduced in 2008 in two districts, which are Bantaeng and Pangkajene Kepulauan. It was introduced by a collaboration of government researchers from different fields of agricultural knowledge. The research was conducted for five years (ended in 2013). Since 2013, there was no more evaluation of whether the farmers are still benefiting from adopting the technology or not, and whether the percentage of the benefit was increasing or reducing. Also, there was no more updated information about the number of farmers who adopt it. So, it is necessary to do a field study to get the actual data and information.

Based on the aforementioned description above, this study aims to: 1) assess the factors that affect the adoption rate of ICM to rice farmers in the District of Pangkajene Kepulauan, South Sulawesi; 2) analyze the impact of adoption of ICM to the income of the rice farmers in the District of Pangkajene, South Sulawesi.

Material and Method. This study used primary data with a structured questionnaire (see Annex 1). The data is cross-sectional household level data that was collected from July to August 2015 in the district of Pangkajene Kepulauan. In the district, three sub-districts were selected for collecting the data. Those three sub-districts are Pangkajene, Minasa Te'ne, and Bungoro. In each sub-districts, 40 respondents were selected purposively, where some respondents practiced *Legowo 2:1* planting system while others do not apply it. In total, there were 120 respondents that were interviewed. Farmers were categorized as adopters if they have adopted *Legowo 2:1* planting system for at least one season prior to 2015. The reason was because there were no changes in the yield and income yet if they just adopt the system in the last season. Information

gathered in the field including the farm characteristic such as farm size; farmer's socio-economic characteristics such as income, age, educational background, main job, and so on; yield, on-farm income, off-farm income, agricultural expenditures, household expenditures; ownership of endowments; and other information that were necessary for the study.

Statistical analysis

Logit Model. Logit model, or also called as logistic regression is commonly used when the respondent is faced with two choices, which in this case is the choice whether to adopt the new technology or not. Logistic regression is a statistical analysis method to describe the relationships between the dependent variables that has at least two or more categories with the independent variables that has binary categories (Hosmer & Lemeshow 1989). The response variable (adoption) has two probabilites, where 1 is for the adopters and 0 for the non-adopters. Moreover, Awotide et al (2012) stated that the probability of a farmer to adopt the technology reaches 0 when the explanatory variable gets smaller, and it goes to 1 when the explanatory variable gets larger. Systematically, the differential of the logistic probability model is written below:

$$\text{Ln}\frac{Pi}{1-Pi} = \alpha + \Sigma\beta iXi + \Sigma\gamma kDki + ei \quad (1)$$

where:

Pi = farmer's adoption opportunity (1 if farmer is an adopter; 0 if non-adopter);

$\frac{Pi}{1-Pi}$ = odds ratio (risks);

Xi = independent variable;

Dki = dummy variable;

βi, γk = regression coefficients;

α = intercept;

e = error.

In this study, the logit model is further used as the method to estimate the propensity scores, which will be the method to assess the impact of adopting *Legowo 2:1* planting system on the income of the rice farmers. As Guo & Fraser (2010) stated that logistic regression is necessary to derive the propensity scores.

Propensity Score Matching. Guo & Fraser (2010) described that propensity score matching (PSM) is a method that is used to estimate an average treatment effect (ATE) and average treatment effect on the treated (ATT). This method is commonly used to control the bias due to a purposively selection method of the samples, or due to the appearance of confounding variables. The idea of this method is to match the similarities of the covariates between the treatment group (adopters) and the control group (non-adopters) that are expected to affect the income as the outcome of interest of this study. Because there are different dimensions in the independent variables, it will be complicated to match those figures one by one. To make the matching procedure easier, we first need to derive a propensity score for each sample, where the balancing score is between 0-1.

As stated above, the aim of using this method is to estimate the ATE and ATT. First of all, let Y_{1i} and Y_{2i} express the potential income for adopters and non-adopters. Then the ATE or the impact of the adoption to the i^{th} individual is written as:

$$\Delta = Y_{1i} - Y_{2i} \quad (2)$$

where:

Y_{1i} = the income of i^{th} individual from the treatment group;

Y_{2i} = the income of i^{th} individual from the control group.

But as we are not able to calculate the treatment effect for each unit, then the average treatment effect on the treated (ATT) is needed. The ATT is estimated as follows:

$$\tau = E(Y_{1i} - Y_{2i} \mid G_i = 1)$$
$$= E[E\,Y_{1i} - Y_{2i} \mid G_i = 1, P(X)]$$
$$= E[E(Y_{1i} \mid G_i = 1, P(X)) - E(Y_{2i} \mid G_i = 0, P(X))] \quad (3)$$

where:

G_i = dummy variable (G_i = 1 for the i^{th} individual who adopt *Legowo 2:1* planting system, and G_i = 0 if not adopting);

$Y_i = Y_{2i} + G_i (Y_{1i} - Y_{2i})$ = indicator of adoption that is actually received by i^{th} individual;

X = the set of characteristics before treatment.

Adopted from Asfaw & Shiferaw (2010), the estimation of the propensity score can finally be written as:

$$P(X) = P(G_i = 1 \mid X) \quad (4)$$

With the assumptions of:

a) The incomes are independent of the adoption of X variables, then $E(Y_{2i} \mid G = 1, P(X)) = E(Y_{2i} \mid G = 0, P(X))$, and
b) The propensity scores is ranging from 0 to 1, or also can be written as $0 < P(X) < 1$. To assure that each adopter has a counterpart from the non-adopter, there is a positive probability that each individual is adopting (G = 1) or not adopting (G = 0).

Results and Discussion

Factors that affect the adoption of Legowo 2:1 planting system to farmers. The determinants of the adoption of *Legowo 2:1* planting system to rice farmers in the research area were evaluated using a Logit model in STATA. There are seven variables that were evaluated in affecting the adoption of *Legowo 2:1* planting system to the respondents. In addition, a marginal effect was calculated as the partial derivatives of the logistic regression. The marginal effects are used to see how much is the predicted change in the probability of adopting *Legowo 2:1* planting system for one unit of change in an independent variable. Furthermore, the results of the binary logistic regression are presented in the Table 1.

Table 1

Determinants of adoption of *Legowo 2:1* planting system

Variable	*Coefficient*	*Standard error*	*P > |z|*	*Marginal effect*
Age	0.0527**	0.0205	0.010	0.0132 (0.0051)
Education	0.6801***	0.2290	0.003	0.1700 (0.0572)
Household member	0.1173	0.1199	0.328	0.0293 (0.0299)
Farm size	0.6093	0.4125	0.140	0.1522 (0.1031)
Ownerships of land	0.1564	0.2944	0.595	0.0391 (0.0736)
Main job	0.3900	0.4402	0.376	0.0972 (0.1090)
Off-farm income	-0.0505	0.0777	0.516	-0.0126 (0.0194)
Constant	-5.8529	1.7294	0.001	
N	120			
LR Chi^2 (7)	21.34			
Prob > Chi^2	0.0033			
Log likelihood	-72.4932			
Pseudo R^2	0.1283			

Note: Marginal effect was evaluated at the means of each data for continuous variables. In addition, for dummy variables, a value of 0 is used if the mean was less than 0.5 and a value of 1 if the mean is greater than or equals to 0.5. Number in parentheses is the standard error of marginal effect. ** Significant at 5% ($p < 0.05$); *** significant at 1% ($p < 0.01$). Source: author's elaboration from field survey data.

Table 1 shows that there are two factors that are significant in affecting the adoption of *Legowo 2:1* planting system to rice farmers in the research area; those are age and level of education. The likelihood ratio of chi-squared of 21.34 with a p-value 0.003 implies that the whole model is statistically significant. The value of Pseudo R-squared gives an

interpretation that 13% of the different decisions of the rice farmers to adopt *Legowo 2:1* planting system can be explained by the explanatory variables.

The coefficient for age is 0.05, with 5% level of significant. The level of significant proves that age affects the decision of the farmers to adopt *Legowo 2:1* planting system. Because the coefficient of age is positive, it means that the older farmers are more likely to adopt *Legowo 2:1* planting system than the younger ones. The interpretation of the marginal effect with 0.013 is that as the farmer gets older by one year, the probability of them to adopt the technology is increasing by 1.3%. The reason behind this is related to the number of years of the experience in farming, where the older and the more experienced farmers are more likely to receive a new technology. This fact is contradictive with the findings of Banerjee et al (2008), which stated that the probability of adoption to younger farmers is higher than the older ones. Agreed to this finding, Castle et al (2016) also stated that the increasing age of farmers does not guarantee them to adopt a new technology.

The level of education shows a very significant result in affecting the adoption of *Legowo 2:1* planting system to the farmers. The positive sign of the coefficient means that the more educated farmers are more possibly to adopt the technology. The marginal effect that give a figure of 0.17 suggests that every increase in one unit of the level of education of the farmers, they are 17% more likely to adopt *Legowo 2:1* planting system. This phenomenon can be explained because the adoption decision of a farmer is highly affected by the level of education and perception on the technology. Similar to this, Chi & Yamada (2002) have found that the level of education is one of the triggers of the adoption of new technology to farmers because it is related to their perception and mindset. The more educated farmers are sometimes risk taker and more open minded to receive a new technology.

Beside the two factors that were mentioned above, without considering the significance level, there are other factors that were found to be affecting the adoption of *Legowo 2:1* planting system to farmers. It can be seen from the positive sign of the coefficients. Those factors are number of household member, farm size, ownerships of land, and main occupation. On the other hand, there was one factor that proved to be not influencing the adoption of *Legowo 2:1* planting system to farmers because the sign of the coefficient is negative. This factor is the off-farm income. The reason makes sense because it can be said that the farmers would adopt the technology if their off-farm income was decreasing.

Income effect of the adoption of Legowo 2:1 planting system to farmers. This sub-section provides the results of the Propensity Score Matching analysis of income effect from adopting *Legowo 2:1* planting system as one component of the ICM to rice farmers. Income is one way to measure the welfare of a family. To make the matching procedure easier, all the independent variables were matched and weigh to a certain score, which is between 0-1. After getting the propensity score for each sample, the matching algorithm can then be done. The estimation of the average treatment effect on the treated shows different figures of income. Further insight can be seen in Table 2.

Table 2

Estimation of impact analysis of adoption of *Legowo 2:1* planting system on farmer's income

Matching algorithm	*n treated*	*n control*	*ATT*	*Standard error*
Nearest-Neighbor	61	27	8,830,000**	5,320,000
Radius	61	51	12,700,000***	5,500,000
Kernel	61	51	9,810,000**	7,240,000
Stratification	61	51	9,050,000***	2,490,000

Note: Bootstrapped standard errors with 5 replications. **Significant at 5%, *** significant at 1%. Source: author's elaboration from field survey data.

The Table 2 presents the treatment effect (ATT) of the adoption of *Legowo 2:1* planting system to the respondents. First of all, the analysis found that the smallest estimated

propensity score is 0.21, and the largest is 0.9. Those scores then matched with four different methods (nearest neighbor, radius, kernel, and stratification matching method). The results show that all the matching algorithms are statistically significant. Moreover, the matching algorithms tell that the average effect of adopting the system could raise the annual on-farm income of the adopters for about 9,000,000 to 11,000,000 rupiah. This implies that farmers who apply *Legowo 2:1* planting system earn more money from on-farm activities than those who do not apply it. Similarly, a study regarding ICM in corn production in Indonesia which was done by Kariyasa (2014) have reported that farmers who adopt ICM had the opportunity of income increase for about 70 percent.

Conclusions. Integrating several components of agricultural technology in rice plantation is expected to increase productivity, production efficiency, and increase farm income. One most prominent components of Integrated Crop Management that proved to increase rice productivity is *Legowo 2:1* planting system. The adoption of *Legowo 2:1* planting system in Pangkajene Kepulauan is strongly influenced by the age and the level of education of farmers. Rice farmers who have adopted the planting system had a higher opportunity of income increase than those who did not adopt it.

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Annex 1

QUESTIONNAIRE

INCOME EFFECT OF INTEGRATED CROP MANAGEMENT (ICM) AMONG RICE FARMERS IN INDONESIA

Repondent's Name :
Sub-District :
District : Pangkajene and Kepulauan
Province : South Sulawesi

Enumerator :aaaaxxxaaaaaaaaaaaaaa
Date :aaaafffaaaaagaaaaaaaaa
Questionnaire Code Number :aaaaafaaffffaa

AGRIBUSINESS AND RURAL DEVELOPMENT ECONOMICS
SUSTAINABLE INTERNATIONAL AGRICULTURE
GEORG-AUGUST UNIVERSITÄT GÖTTINGEN

I. FARMER'S PERSONAL IDENTITY

1. Name :
2. Age (years old) :
3. Off-farm job :
4. Educational background :
   a. No school
   b. Primary school
   c. Junior high school
   d. Senior high school
   e. Bachelor
5. Number of family members : Person
6. Number of family members that involved in farming : Person
7. Farm size : …….. (Ha)
8. Ownerships of land
   a. Owner
   b. Cultivators
9. Ownership of endowments : a) ……
   b) ……
   c) ……
   d) ……

II. FARMER'S PERCEPTION ON *LEGOWO 2:1* PLANTING SYSTEM

* For this section, if the farmer does not adopt *Legowo 2:1* planting system, ask them the reason. Please fill in the dots below:

……
……

* For those who adopt Legowo 2:1 planting system, please proceed to fill in the following questions:

1. Since when did you plant rice with *Legowo 2:1* planting system?
   ……
2. From who did you get the information on how to plant rice with *Legowo 2:1* planting system?
   a. Agricultural extension
   b. Researchers
   c. Neighbors
   d. Leader of farmer group
   e. Family
   f. Others
3. What causes you to be interested in applying *Legowo 2:1* planting system?
   a. Management reasons
      1) Easy to weed
      2) Easy to eradicate pests and diseases
      3) Easy for planting
      4) Easy to harvest
   b. The reason for its production potential is higher
      1) Good crop fertilizing response
      2) Productive tillers are good (about 13-17 buds per clump)
      3) Low pest and disease attacks
      4) Production of grain per panicle has a uniform shape
   c. The reason of the quality of the production
      1) Contains more grain
      2) Yield of grain is higher than previous system
      3) Less fall off during harvest
4. Production and Production costs
   a. Production (Dry grain harvest) = …… Kg/harvest
      = …… Sack (convert to kg)

b. Production costs

8) Seeds …….. kg, @ Rp ……. Total (Rp) …….

9) Fertilizers

Urea : ……. Kg, @ Rp ……. Total (Rp) …….

Ponska : ……. Kg, @ Rp ……. Total (Rp) …….

TSP : ……. Kg, @ Rp ……. Total (Rp) …….

KCl : ……. Kg, @ Rp ……. Total (Rp) …….

ZA : ……. Kg, @ Rp ……. Total (Rp) …….

10) Insecticides / Fungicides :

- ……..……: ……. kg, @ Rp …… Total (Rp) …….
- ……..……: ……. gram, @ Rp …… Total (Rp) ……
- ……..……: ……. ml, @ Rp …… Total (Rp) …….

11) The cost of processing the nursery land

- Number of days worked till ready to plant : ……..... day
- Labor from family member : ..... Person, salary/day (Rp) .....
- Labor from non-family member : ..... Person, salary/day (Rp).....
- Other information (children / adult)…….....

12) Planting

Number of days worked for planting : ..... day

- Labor from family member : ..... Person, salary/day (Rp) .....
- Labor from non-family member : ..... Person, salary/day (Rp).....
- Other information (children / adult)…….....

13) Weeding

Number of days worked : ..... day

- Labor from family member : ..... Person, salary/day (Rp) .....
- Labor from non-family member : ..... Person, salary/day (Rp).....
- Other information (children / adult)…….....

7) Fertilization

Number of days worked : ..... day

- Labor from family member : ..... Person, salary/day (Rp) .....
- Labor from non-family member : ..... Person, salary/day (Rp).....
- Other information (children / adult)…….....

8) Pests and diseases control

Number of days worked : ..... day

- Labor from family member : ..... Person, salary/day (Rp) .....
- Labor from non-family member : ..... Person, salary/day (Rp).....
- Other information (children / adult)…….....

9) Harvest

Number of days worked : ..... day

- Labor from family member : ..... Person, salary/day (Rp) .....
- Labor from non-family member : ..... Person, salary/day (Rp).....
- Other way to pay labor's salary
  - Cash paid/person/day (Rp) ……..
  - Paid with barter
    - 10 sacks paid with 1 sack
      * Please note down the total kg/sack then convert to Rupiah.
      ……..
    - Other payment method ……..

III. FARMER'S FAMILY WELFARE

1. On-farm income : (Rp) ……
2. Off-farm income : (Rp) ……
3. Expenditures
   a. For school (Rp) ……
   b. Monthly needs
      1) Child spending money for daily school (Rp) ……..
      2) Expenditures for eating (Rp) ……..
      3) Electricity (Rp) ……..

4) Water (Rp) ……..
5) Fuel for vehicle (Rp) ……..
6) Debt (Rp) ……..
7) …… (Rp) ……..
8) …… (Rp) ……..
9) …… (Rp) ……..
10) …… (Rp) ……..

c. To marry off the children (Rp) ……..
d. Saved for subsequent working capital (Rp) ……..
e. Saved for Hajj (Rp) ……..
f. Saved for Umrah (Rp) ……..
g. Renovating the house (Rp) ……..
h. Other purpose of savings (Rp) ……..

4. After you adopt *Legowo 2:1* planting system, do you feel many household needs that can be fulfilled and you feel more prosperous? Please give one example.

……
……
……
……
……
……