Rice productivity on tidal swampland in the agricultural assistance area program in Barito Kuala Regency South Kalimantan

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Abstract. Food needs that continue to increase rapidly along with population growth and the conversion of optimal paddy fields to non-agricultural land make sub-optimal land an alternative rice-producing land. One of the sub-optimal land being developed for use as a source of rice production is tidal land. The purpose of this research is to improve the productivity and feasibility of rice farming by supervising double row technology in tidal land in Barito Kuala Regency. The performance of rice the new superior varieties of Inpara 2, inpara 8, inpari 32, inpari 40 and inpari 42 in the tidal swampland in the 2018 dry season are quite good. How to plant with super double row planting increases productivity by 43% compared to ordinary planting. The highest productivity with super double row is Inpara 2 variety (5.83 t / ha), then inpari 42 (5.19 t /ha), Inpara 8 (4.78 t/ha), Inpari 40 (4.23 t/ha), Inpara 3 (3.85 t /ha) and Inpari 32 (2.54 t/ha). The planting method with super double row gives an RC ratio of 2.07 and a R/C ratio of 1.07. Whereas the R/C ratio planting of the farmer way is 1.60. And the MBCR (marginal benefit-cost ratio) super double row 2.41. This shows that rice farming using super double row provides benefits and worth applying.

1. Introduction
One of the alternative to fulfil the needs of food is with the utilization of the sub-optimal field like tidal swampland, that many found in South Kalimantan. In South Kalimantan, tidal swampland has 188,908 ha and 113,998 ha located in Barito Kuala district [1]. Around 77.21 % has already been used for agricultural land. That land has potentially developed to be rice production land.

Some biggest problems that have been faced if tidal swampland fields becoming crops land is the water regulation still not good enough, low level of soil fertility, very low pH, and high content of pyrite. This condition has made soil productivity and the crops become low. The most important thing in managing swampland is water management. The function of water management is not just to decrease or increase the availability of water surface, but also to decrease the soil acidity, to prevent the oxidized pyrite layer, and to wash the toxic substances that accumulate in the plants rooting zone [2,3,4].

There are three approach that can be done to develop tidal swampland to become agricultural land; (1) applying land technology management that are water regulation, soil, nutrient and ameliorant ingredients, (2) using plant and tolerant varieties to land condition and farmer preferences, and (3) mix of both. The first approach is a bit expensive and difficult because it needs additional power, tools
and cost but produce well. Meanwhile, the second approach is rather easy and cheap. The third approach is the best alternative because not just it fixed the quality and land productivity but also gives the optimal result [5].

Double row system is an engineering technology to obtained plants population more than 160,000 ha⁻¹. Super double row technology is a rice field cultivation technology based on double row plating 2:1. Besides using the double row system 2:1, important component from super double row technology are: 1) the new paddy’s superior varieties potentially high result; 2) biodecomposer that gave together when soil cultivation (second plough); 3) organic fertiliser applied through seed treatment and balance fertilization based on soil test kits for tidal swampland (PUTR); 4) controlling plant pests using vegetable pesticides and inorganic pesticides based on threshold of control, and 5) agricultural tools and machinery [6]. The purpose of this paper is to increase the productivity with super double row technology and feasibility of farming in tidal swamp field in Barito Kuala district.

2. Materials and Methods

The assessment was done on 4 farmers, in Jejangkit Muara village (tidal swamp type B overflow), Barito Kuala district in the dry season (July-Nov) 2018. Treatment given are varieties and planting way:

A. Inpara 2 squared planting system (existing)
B. Inpara 2 super double row planting system
C. Inpara 3 super double row planting system
D. Inpara 8 super double row planting system
E. Inpari 32 super double row planting system
F. Inpari 40 super double row planting system
G. Inpari 42 super double row planting system

Assessment using random group layout with 4 replications (=4 farmers). Every treatment on field area around 0.20 ha, field total is 5.6 ha. The use of Inpari varieties was meant to understand the varieties adaptation to tidal swamp field that was given lime (2 t/ha) and biological microbes.

Seeds planted on seedling age 21-25 DAS (day after seedling), 2-3 stem each hole. Farmer way: squared planting system (25 x 25 cm), lime given 500 kg/ha, fertilize dosage each hectare 150 urea and 250 ponska, and fertilizer is given twice (7 and 35 DAP, Days After Plating).

Super double row technology that is being used are: double row planting (25 x 10-15 cm) x 50 cm; lime given 2000 kg/ha; microbes given that function to quicken the organic matter decomposition (Biodecomposer), and microbes that function as biological fertiliser, seed treatment; balance fertilization, with fertilization 100 kg urea ha⁻¹+400 kg ponska ha⁻¹, and given three times (7, 35 and 50 DAP).

Observation variables include yield component and yield crops that is plant height, the maximum number of tillers, panicle number, panicle length, the amount of grain each panicle, the weight of 1000 seeds, productivity. The data obtained were analyzed using variance and Different Real Honest test with level 5%. Input data and output in farming collected to analyze the financial fairness to production cost. The farming income that calculated is return and cost ratio (R/C), benefit and cost ratio (B/C) and Marginal Benefit-Cost Ratio (MBCR) to knowing the level of farming fairness introduction compared to conventional farming.

3. Result and Discussion

3.1. Land fertility conditions of location

The result of soil analyzed in the laboratory can be seen in Table 1, showing that the soil in assessment location is very acid, with soil Fe contained is very high (240.6 ppm). On flooded land condition, in the reduced state, a change of insoluble iron occurred (Fe³⁺) to soluble iron (Fe²⁺) that has been done by reducing microbes Fe [7,8]. High level of soluble Fe can cause paddy gets iron
toxicity. “Reference [9]” found that Fe concentration in solvent $\geq 200$ ppm caused obstruction in the growth of the plant, and 600 ppm concentration caused paddies to died.

Table 1. Results data from laboratory from soil assessment location, 2018

| No. | Description | Score | Category   |
|-----|-------------|-------|------------|
| 1   | pH H$_2$O   | 3.890 | Very Acid  |
| 2   | C-Organic   | 5.090 | %          |
| 3   | N-total     | 0.395 | %          |
| 4   | K exchangeable | 0.343 | cmol/kg    |
| 5   | Na dd       | 0.310 | cmol/kg    |
| 6   | Ca dd       | 3.816 | cmol/kg    |
| 7   | Mg dd       | 2.797 | cmol/kg    |
| 8   | Al dd       | 3.910 | cmol/kg    |
| 9   | H dd        | 0.919 | cmol/kg    |
| 10  | P available | 18.885 | ppm        |
| 11  | Kej Al      | 32.330 | %          |
| 12  | Fe (soil)   | 240.604 | ppm        |
| 13  | texture : Sand:dust:clay | 51.1 : 24.45 : 24.45 | Sandy clay loam |

Assessment location has low fertility, can be seen by the low pH and nutrient content around medium-low. Iron toxicity on plant can be happening if: 1) High concentration Fe$^{2+}$ in soil solvent that caused by strong reducing condition in soil and/or low pH, 2) Low nutrient status and unbalance in soil, 3) Lack of root oxidation and low exclusion power Fe$^{2+}$ by root that is caused by nutrient deficiency P, Ca, Mg or K, 4) Lack root oxidation power (exclusion Fe$^{3+}$) caused by material accumulation that inhibits respiration (H$_2$S, FeS, organic acid), 5) Organic matter application is not yet decomposed, 6) Fe supply continuously from under surface water or lateral seepage from higher place [7,10,11].

3.2. Yield component and crops yield

The growth of paddy that is planted in double row super generally showing the planting growth is better than the farmer’s way. Inpara 8 is higher than the others, and the tillers amount and panicle amount Inpara 40 is higher. Panicle Inpara 3 is longer, meanwhile, the grain amount of Inpara 2 and Inoari 42 is greater. The lowest presentation of empty grain amount is Inpara 2 and Inpara 3 (Table 2).

Planting system of double row 2:1 is alternating planting between two rows of rice plants and one empty row, by paying attention to the array of plants. The benefit of double row planting system 2:1 is making all planting lines to be side plants. The advantage of the side plants is better sunlight reception and better air circulation, nutrient content more equal, and to simplify the plant maintenance [12].

Table 2. Observation of growth and crop yield

| Treatment        | Plant Height | Tiller Number | Panicle Number | Panicle length | Grain Number | % Empty Grain | 1000 grain | Productivity t/ha$^{-1}$ |
|------------------|--------------|---------------|----------------|----------------|--------------|--------------|-----------|--------------------------|
| A. Inpara 2 (existing)) | 89.60 d      | 19.60 b       | 16.60 c        | 24.00 b        | 117.00 d     | 0.72 a        | 24.27 a   | 3.3167 c                 |
| B. Inpara 2      | 108.29 b     | 16.37 c       | 13.46 e        | 24.16 b        | 170.17 a     | 0.37 c        | 26.52 a   | 5.8333 a                 |
| C. Inpara 3      | 97.67 c      | 12.21 d       | 9.79 f         | 28.55 a        | 160.18 b     | 0.34 c        | 25.36 a   | 3.8542 c                 |
| D. Inpara 8      | 115.21 a     | 16.42 c       | 15.00 d        | 23.10 c        | 148.45 c     | 0.50 b        | 26.99 a   | 4.7833 b                 |
| E. Inpares 32    | 94.08 cd     | 18.17 b       | 15.25 d        | 20.67 d        | 148.33 c     | 0.49 b        | 25.54 a   | 2.5396 d                 |
| F. Inpara 40     | 99.50 c      | 22.50 a       | 18.33 a        | 24.67 b        | 160.92 b     | 0.48 b        | 25.48 a   | 4.2333 b                 |
| G. Inpara 42     | 99.08 c      | 19.75 b       | 17.75 b        | 23.50 c        | 174.08 a     | 0.42 bc       | 23.78 b   | 5.1938 ab                |

Information: the different alphabets in the same columns showing the real difference on level 5%
Good growth plants are able to absorb nutrients in a greater amount, the availability of the nutrients in soil effecting to plants activities include the photosynthesis activity, so that plant can increase the growth and production. The higher growth plant produced on higher plants population in one overlay. The higher growth plant does not guarantee the plant productivity also high [13].

Tillers formation influenced by genetic traits and environmental conditions that is appropriate with the plant's growth. Higher plants are using more assimilate to form stem and leaves rather than to form tillers [14]. Tillers amount will be maximum if plants have better genetic traits and environmental conditions that are appropriate with the plant's growth and plants development. also includes the range of planting. because the planting range determined the sun radiation and nutrient competition [15].

Panicle amount is determined by the number of tillers that grown before primordial face [16]. and the possibility of tillers to formed last panicle can’t produce it with fully filled grains so that it is possible to produce empty grains. Stated that the photosynthesis rate on the header is limited to the availability of CO$_2$ around the leaves. Therefore if the amount of plants is higher in one clump, then the leaves position will coincide causing the competition to use CO$_2$ around the leaves [17].

The length of panicle is influenced more by genetic traits. Variety of Inpara 2 farmer’s way is not that different from super double row. The longer the panicle that is formed the more opportunity grains can be collected by panicle. Grains amount on plants with super double row technology is higher than farmer’s way. Grains pithy amount and formed seeds weight in one panicle is very depending on the photosynthesis process from plants during its growth.

Percentage of empty grains cause by environmental factors that are the availability and nutrients balance. and there is stem borer attack on paddy so that it affected the percentage of empty grains (Observation data that attacked by stem borer on paddy shows on Table 4).

### Table 3. Observation of panicle amount that attacked by stem borer

| Treatment       | Replicates to |
|-----------------|---------------|
|                 | 1  | 2  | 3  | 4  |
| A. Inpara 2 (existing) | +++ | +++ | +++ | +++ |
| B. Inpara 2     | ++ | ++ | ++ | ++ |
| C. Inpara 3     | ++ | ++ | ++ | ++ |
| D. Inpara 8     | +++ | +++ | ++ | ++ |
| E. Inpari 32    | +++ | +++ | ++ | ++ |
| F. Inpari 40    | ++ | +++ | +++ | ++ |
| G. Inpari 42    | ++ | +++ | +++ | ++ |

Information: ++++++ = Very High; +++ = High; +++ = Medium; ++ = Low

Weight of 1000 grain on plant depends on the shape and size of seeds. this largely determined by genetic traits. slightly by environmental and photosynthesis result. High and low the weight of seeds depend from whether or not the dry material contained in the seed. Dry material in seed contained from photosynthesis result that is further can be used to fill the seed [18].

Plants productivity with double row super planting increased the production till 43% than with farmer’s way. This caused by the effect of side plants that gave high production and better grains quality, increase the amount of population/clumps plants each hectare. there is empty room for water regulation. increasing the number of sunlight plants received optimally useful in photosynthesis process [19]. Planting range affected the panicle length. grains amount each panicle. and paddy result for each ha. This suspected caused by the effect of double row system. where plants got enough nutrient supply, water and sunlight. Therefore will cause the photosynthesis process to occur optimally. Utilization of empty room on legowo planting system caused the photosynthesis process continuously effective on the generative phase. photosynthesis result is brought more to seeds so the
result of the grain is higher. Moreover, there is an improvement of growth plants environmental with chalk given. the use of decomposer microbes and organic fertiliser. The lime application makes soil nutrient become more available and added the elements of Ca and Mg, decomposer microbes making the organic material on field decomposed quickly so that it’s beneficial for the plants. The organic fertilizer that is given as seed treatment, increasing the plant growth so the growth of plants is faster and can adapt more to unwell environmental.

3.3. Farming Analysis
Financial analysis from input and output data showing, profit that obtained from using super double row technology is higher around Rp 13,593,500 than farmer’s way. Return and cost ratio of super double row technology is 2.07. farmer’s way 1.60. R/C ratio is a comparison between receipt (Return) with business costs, if RC ratio > 1. means farming is profitable. RC ratio 2.07 means every Rp 1 capital that is issued will give income Rp 2.07. Meanwhile, BC ratio is a comparison between profit that obtained by cost issued in one planting period. Value of B/C on super double row technology 1.07, higher than existing 0.60. Means, every Rp 1 capital that is issued will give profit 1.07. Farming rated worthy and give benefit if MBCR (Marginal Benefit-Cost Ratio) score > 1. From the result of MBCR score super double row 2.41. It means super double row technology is worth to use. Super double row farming is more efficient than non super double row farming in input usage. Super double row farming technology rated worthy as it is shown by the higher score of MBCR.

| No | Description | Super double row | Existing |
|----|-------------|-----------------|---------|
| A  | Expenditure/output |                 |         |
|    | 1. Production facilities | 4,780,000 | 2,430,000 |
|    | 2. Labor | 7,875,000 | 6,900,000 |
|    | Total cost | 12,655,000 | 9,330,000 |
| B  | Receipt/input |                 |         |
|    | - Yield 5,833 kg x Rp. 4,500. | 26,248,500 |         |
|    | - Yield 3,317 kg x Rp. 4,500. |             |         |
| C  | Income | 13,593,500 | 5,596,500 |
| D  | R/C Ratio (B/A) | 2.07 | 1.60 |
|    | B/C | 1.07 | 0.60 |
|    | MBCR | 2.41 |        |

4. Conclusion
The performance of rice the new superior varieties of Inpara 2, inpara 8, inpari 32, inpari 40 and inpari 42 in the tidal swampland in the 2018 dry season are quite good. Super double row system increases productivity by 43% compared to ordinary planting. The highest productivity with super double row is Inpara 2 variety (5.83 t ha\(^{-1}\)). then inpari 42 (5.19 t ha\(^{-1}\)). Inpara 8 (4.78 t ha\(^{-1}\)). Inpari 40 (4.23 t ha\(^{-1}\)). Inpara 3 (3.85 t ha\(^{-1}\)) and Inpari 32 (2.54 t ha\(^{-1}\)). The planting method with Super double row gives an R/C ratio of 2.07 and a BC ratio of 1.07. Whereas the RC planting ratio of the farmer way is 1.60. And the MBCR (marginal benefit-cost ratio) super double row 2.41. This shows that rice farming using double row super provides benefits and worth applying.

Acknowledgment
Thank you to the Indonesian Agency for Agricultural Research and Development for funding this research. Special thanks to Mukarji, Sutono, and Suyatno for helping to carry out the research in the field.
References

[1] Biro Pusat Statistik 2016 Luas Lahan Menurut Penggunaannya di Provinsi Kalimantan Selatan 2016. Banjarmasin.

[2] Suryadi FX, Hollanders PHJ, and Susanto RH 2010 Mathematical modeling on the operation of water control structures in a secondary block case study: Delta Saleh. South Sumatra. Host

[3] Fagi AM, Maamun MY, Djamhuri M, Sarwani M and Ar-Riza I 1997 Pengembangan pertanian tanaman pangan berwawasan agribisnis pada lahan rawa sejuta hektar. Hlm.100-108. Dalam. Prosiding Seminar Hasil Penelitian/Pengkajian untuk Mendukung Pengembangan Lahan Rawa/Gambut Sejuta Hektar di Kalimantan Tengah. Balai Pengkajian Teknologi Pertanian Kalimantan Tengah, Pusat Penelitian Sosial Ekonomi Pertanian.

[4] Alihamsyah T, Sarwani M, and Ar-Riza I 2002 Komponen utama teknologi optimalisasi lahan rawa sebagai sumber pertumbuhan produksi padi masa depan. Makalah Utama. Seminar IPTEK Padi. Badan Penelitian dan Pengembangan Pertanian. Sukamandi, 5 Maret 2002.

[5] Alihamsyah T 2002 Optimalisasi Pendayagunaan Lahan Rawa Pasang Surut. In Prosiding Seminar Nasional : Optimalisasi Pendayagunaan Sumberdaya Lahan 6-7 Agustus 2002 Cisarua. Puslitbang Tanah dan Agroklimat.

[6] Badan Litbang Pertanian 2016 Petunjuk Teknis Budi Daya Padi Jajar Legowo. Kementerian Pertanian Jakarta

[7] Audebert A 2006 Iron partitioning as a mechanism for iron toxicity tolerance in low land rice. In. Audebert A., Narteh L. T., Killar D and Bek B (Ed.). Iron Toxicity in Rice-Based System in West Africa. Africa Rice Center (WARDA).

[8] Becker M and AshF 2005 Iron toxicity in rice condition and management concept. Journal of Plant Nutrition and Soil Science 168: 558-573.

[9] Noor A, Iskandar Lubis, Munif Ghalimandhi, Muhammad Achmad Chozin, Khairil Anwar dan Desta Wirnas 2012 Pengaruh Konsentrasi Besi dalam Larutan Hara terhadap Gejala Keracunan Besi dan Pertumbuhan Tanaman Padi The Effect of Iron Concentration in Nutrient Solution to Iron Toxicity Symptoms and Growth of Rice. J. Agron. Indonesia 40 (2) : 91 - 98 (2012)

[10] Dobermann A and Fairhurst T 2000 Rice Nutrient Disorders and Nutrient Management Handbook series Potash and Phosphate Institute (PPI) Potash and Phosphate Institute of Canada (PPIC) and International Rice Institute.

[11] Mehbaran P. Abdol Zadeh A and Reza Sadeghipour H 2008 Iron toxicity in rice (Oryza sativa L.) under different potassium nutrition. Asian J. of Plant Sci. 7:1-9

[12] Mujisihono R and Santosa T 2001 Sistem Budidaya Teknologi Tanam Benih Langsung (TABELA) dan Tanam Jajar Legowo (TAJARWO) Makalah Seminar Perekayasaan Sistem Produksi Komoditas Padi dan Palawija. Diperta Provinsi D.I. Yogyakarta.

[13] Aribawa 2012 Pengaruh sistem tanam terhadap peningkatan produktivitas padi di lahan sawah dataran tinggi beriklim basah Balai Pengkajian Teknologi Pertanian (BPTP) Bali Denpasar. http://pertanian.trunojoyo.ac.id.

[14] Asfaruddin 1997 Evaluasi ketegangan galur-galur padi gogo terhadap keracunan aluminium dan efisiensinya dalam penggunaan kalium. Tesis Program Pascasarjana IPB. Bogor.

[15] Husana Y 2010 Pengaruh Penggunaan Jarak Tanam Terhadap Pertumbuhan dan Produksi Padi Tesis Program Studi Ilmu Pertanian Program Pasca Sarjana. Universitas Tadulako.

[16] Wangiyana W. Laiwan Z. dan Sanisah 2009 Pertumbuhan dan Hasil Tanaman Padi Varietas Ciherang dengan Teknik Budidaya “SRI (system of rice intensification)” pada Berbagai Umur dan Jumlah Bibit per Lubang Tanam. Crop Agro Vol. 2 No. 1. Hal 70-78.

[17] Rosenberg N J 1974 Microclimate The Biological Environment. John Wiley New York.
[18] Masdar 2007 Interaksi jarak tanam dan jumlah bibit per titik tanaman pada sistem intensifikasi padi terhadap pertumbuhan vegetatif tanaman. Jurnal Akta Agrosia. Edisi Khusus (1): 92-98.

[19] Pangerang 2013 Keuntungan dan kelebihan system jarak tanam jajar legowo padi sawah. PPL Kabupaten Maros. Http/pertanian. Trunojoyo.ac.id. Diakses Pada Tanggal 20 Agustus 2016.