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Improvement of Suboptimal Land Productivity Approach by Land and Plant Management

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ABSTRACT

Assessment for increasing productivity of suboptimal land with using three kinds of organic fertilizer and six rice varieties had been conducted in the Debowae village, Waeapo district, Buru regency at 2011. Purpose of the assessment were to determine the effect of three types organic fertilizer and the use of six Inpara varieties to growth and productivity of rice in sub-optimal land. Study used a split plot design with three replications (farmers as replicates), where the main plot was three types of organic fertilizers (livestock manure, granular organic, and petroganic), while the subplot was 6 varieties Inpara (Inpara 1, Inpara 2, Inpara 3, Inpara 4, Inpara 5, and Indragiri). The soil types at the study site based on soil classification were Endoaquepts with soil fertility status was low. The study results showed that the use of organic manure combined with inorganic fertilizers, both from livestock manure, while granular organic and petrogranic, gave an average crop growth and yield better than the results obtained by farmers outside of the study. Average petroganic fertilizer had a better growth and higher crop yields compared to other organic fertilizers. The six varieties of rice swamps that were examined (Inpara 1, Inpara 2, Inpara 3, Inpara 4, Inpara 5, and Indragiri) had the average growth and better yields than rice varieties used by farmers outside of the study (2.75 Mg ha^{-1}). Varieties Inpara 4, Indragiri, Inpara 1 and Inpara 2 had average yield above 7 Mg ha^{-1}, while Inpara 3 and Inpara 5 average above 4 Mg ha^{-1}. Combination of granular organic fertilizer with Inpara 4 variety and petroganic with Indragiri variety had the best results (8.37 and 8.02 Mg ha^{-1}), while the lowest yield (4.48 Mg ha^{-1}) was reached at combination of livestock manure with Inpara 5 variety.

***Keywords**:* Adaptive varieties, land and plant management, organic fertilizers, suboptimal land

INTRODUCTION

Sustainability of the production system and deterioration of land and water resources is an important issue that needs serious attention and treatment in agricultural development (Shah and Strong *cited by* Sumarno 2006). The main target of Ministry of Agriculture was provision of food and sustainable self-sufficiency in rice production targetting 74 million tons of rice in 2012 and surplus of 10 million tonnes in 2014 (Indonesian Agency for Agricultural Research and Development 2011). Sumarno (2006) added that in the future, efforts to increase rice production under challenge at form of the limited ability of land and varieties in increasing productivity, land degradation, water resources, increase of pests and diseases, as well as rate of population growth is still quite high. Furthermore Las *et al*. (2006) stated that conversion of irrigated land into non-agricultural land is also a threat to revitalization of agriculture.

The results of research experts estimate that Indonesia will be a deficit of 9.67 million tonnes of rice in 2020, while fertile rice fields are converted to non-agricultural use or non-food production, which was 1.63 million ha in period of 1981 - 1999 and the 1999-2002 reached 225,338 ha per year (Alihamsyah 2005). One alternative to solving the problem is utilization of suboptimal land and available technology.

Based on data from the International Rice Research Institute (IRRI), rice is the staple food of about 2.7 billion people, or nearly half of the world's population. It needs continue to increasing in the line with population increase, especially in Asian countries. By 2015, even the world of rice consumers is expected to increase to 4 billion people. To meet the growing needs of the world rice production is projected to be increased by 68% from 1989 production of 473 million tonnes to 781 million tonnes in 2020 (IRRI 1990). In Asia, more than 75%

of the rice supplied from 79 million hectares of irrigated rice (Bouman 2001), so that food security in Asia now and in the future depends on the system of irrigated rice land. Furthermore, for 97% of total world rice production is consumed at the location near the production area, because only about 3% are traded in the world market (Greenland 1997). The above facts are to convince the need to keep seeking the sustainability of rice production systems.

On limited land resources availability, agriculture as a livelihood and economic activity is going to deal with things that are contradictory, *i.e* the adequacy of production as the basis for food security with environmental quality, conservation and sustainability of agriculture to the lives of generations forward. Increasing of productivity is not only directed at the optimal land (irrigated rice), but also on land such as suboptimal rainfed areas, dry land, and wetlands.

Sub-optimal land has great potential to be used as a strategic option for the development of future agricultural production areas, particularly to offset shrinking arable land and an increase in demand for production, including food security and agribusiness development (Alihamsyah 2002). The results of research and experience showed that with proper management and in accordance with the characteristics of the land and through the application of science and technology that is correct, then the sub-optimal land belonging to marginal lands with low natural fertility levels can be used as a productive agricultural area (Ismail *et al*. 1993).

Sub-optimal land development for agriculture is generally faced with several problems, including high soil acidity and toxicity of Fe and Al as well as deficiency of nutrients N, P, K, Ca and Mg. Therefore, improvements to the condition of the soil chemistry such as the addition of organic matter, N, P, and K, and lime. In addition to improve chemical properties, it is also needed to do the selection of varieties that are tolerant to the environmental condition of the land, in order to obtain specific varieties.

In Waeapo plain, Buru, sub-optimal land for rice based on distribution maps unit of land is estimated at about 5791.31 ha scattered in various physiographic (Susanto 2010). Sub-optimal land spread on the embankment of the river meanders physiographic, swamp the back, lower part of the river terraces, alluvial depression, plain fluvio marine, freshwater and peat topogen (Figure 1).

According Achmadi and Las (2010), sub-optimal land is used for agriculture in Indonesia just a small part, and even then not optimal. By applying technologies cultivated land scaping and land management and integrated agricultural commodities, sub-optimal land can be as one of the main sources of growth in agribusiness and supporting national food security. Adnyana *et al*. (2005) stated that the technology suboptimal land management can be done through amelioration, balanced fertilization, tillage and water management. According Kaderi (2004) nutrient availability is low in suboptimal land and it can be improved through the addition of organic materials. Application of organic materials as fertilizers, in addition are intended to supply nutrients, it can also suppress Al and Fe so it will not poison the plants (Tisdale *et al*. 1985). Pirngadi and Makarim (2006) stated that the use of organic fertilizers as much as 2 Mg ha^{-1} in combination with inorganic fertilizers to rice cultivation in the integrated crop management (ICM) in sub-optimal land, such as rainfed were able to deliver grain yield of 6.01 Mg ha^{-1}, an increase of approximately 77.8% compared to no use of organic fertilizer with non ICM cultivation. Pirngadi and Pane (2004) also reported that the use of organic materials as much as 5 Mg ha^{-1} and 100 kg KCl ha^{-1} were capable of producing grain amounted to 5.99 to 6.61 Mg ha^{-1} of grain.

Selection of suitable varieties in suboptimal land are also an appropriate technology to be implemented in accordance with the conditions and the typology of land. Contributions varieties on yield improvement were quite high, especially when it was combined with a balanced fertilizer in rice cultivation technology with application of ICM.

The purpose of this study was to determine effect the use of three organic fertilizers and six Inpara varieties on the productivity of rice in suboptimal land in Buru regency.

MATERIALS AND METHODS

Time and Location Assessment

Assessment was done in rice production centers in the plains Waeapo Buru, Debowae village at 2011. The location was chosen with consideration that the productivity of rice in suboptimal land was low, *i.e* less than 2 Mg ha^{-1}, farmers was responsive to technology innovation, and still rarely placed assessment activities.

Studies were arranged in a split plot design, where organic fertilizers were placed as main plots and varieties as sub plots. Main plots consisted of 3 types of organic fertilizers, *i.e* livestock manure (PO-1), granular organic (PO-2), and petroganic (PO-3), while the sub plots consists of six varieties, *i.e*

Inpara 1 (VU-1), Inpara 2 (VU-2), Inpara 3 (VU 3), Inpara 4 (VU-4), Inpara 5 (VU-5), and Indragiri (VU-6). Dosages of organic fertilizer used were livestock manure 3 Mg ha^{-1}, granular organic and petroganic fertilizer, each 1 Mg ha^{-1}. Each treatment was replicated 3 times (farmers as replicates). Dosages of inorganic fertilizers based on soil analysis results for P and K with Paddy Soil Test Kit (PSTK), while nitrogen based on Leaf Color Chart (LCC). Inorganic fertilizer used was NPK Phonska with the appropriate dosage as a conversion from single fertilizer. Others components of rice cultivation technologies were done with ICM technology.

Data collection was conducted through desk study (secondary data), interviews to farmers and Agriculture Field Officer (primary data), and data from assessment (primary data). Observed data included the physical and chemical properties of soil, soil type, farming system/rice cultivation by farmers, plant growth data and yields, and other supporting data. Growth and yield data were tabulated and then analyzed statistically using the SAS system. To see the differences between the treatments the Duncan test were used. Crop yield data on the study would be compared with the data obtained by farmers outside the study (non-farmer cooperators).

RESULTS AND DISCUSSION

Characteristics of Region

Wetland potential at Debowae village was about 605 ha with average productivity of 4.1 Mg ha^{-1}. Varieties wich were planted by many farmers were Cigeulis, Ciherang, Mekongga, Inpari 9, Conde and Cibogo. Innovation ICM technology had been implemented in the Debowae village, the component technology widely adopted was the use of high yielding varieties, however used fertilizer was still very limited with low dose, *i.e* 100-150 kg of Phonska NPK and 100 kg urea per ha. The use of organic fertilizer, as well as the return of composted rice straw had never been done by farmers. One of the obstacles faced by farmers was the difficulty in getting the bio-activator materials for composting rice straw. Generally, farmers still burned rice straw, although indirectly fraction hay farmers had returned it to the ground with the top cut harvest systems.

From the rice fields area in the Debowae village, approximately 10 ha was a problematic area that was in the middle of a stretch of other land, so the land was often attached by pests and diseases if it was not managed. Most of the land can not be processed by hand tractor, especially in the rainy season because the soil was muddy and quite deep. According to information obtained from local farmers, farming expenses incurred higher than earned income, though farmers still cultivated their land. Commonly used fertilizers were Phonska NPK 100-150 kg and urea 50-100 kg per ha, while organic fertilizers did not using. Average yield obtained by farmers in sub-optimal land remained low at 1-2 Mg ha^{-1}, where in the raining season the average was 1 Mg ha^{-1}, and in the dry season was 2 Mg ha^{-1}.

Soil and Nutrient Status

Soil type in the study based on the land classification is Endoaquepts. Endoaquepts are soils formed from clay and sand sediment material (alluvium), whose development is influenced by soil water. Soil color is grayish until gray in ground layer. Distributions Endoaquepts are gray layer found in alluvial and aluvio-marin, hampered drainage, soil color gray to young gray. It consists of two subgroups, *i.e* Fluvaquentic Endoaquepts and Typic Endoaquepts (Soil Survey Staff 1998). According to Susanto (2011), physiographic study locations were marsh on the back with the flat shape of the region, and alluvium parent material. This broad soil type was in the marsh plain physiographic rear Waeapo with approximately 626.51 ha (Figure 1 and Table 1). Swamp river meanders behind the lower part of the flat is located in a flood plain behind the embankment of the river and usually flooded, and composed of fine material, spread to the south of Boiling Water or river bottom Waeapo.

Results of soil samples analysis using a marshland test kit showed that relatively low levels of N, moderate P, low K, and soil pH was very acid (3 - 4). Based on the preliminary data it showed that the main limiting factor on sub-optimal land was high of soil acidity, so that the limiting factor for the availability of other nutrients, particularly phosphorus. In soils that have a high soil acidity, Fe and Mn are the element that are toxic to plants. Elements of P will allegedly bind by Fe or Al making it will unavailable to plants. It is also seen that the levels of P in the soil is classified as moderate.

Dosage of fertilizer recommendations based on the nutrient status were 300 kg urea, 100 kg SP-36, 125 kg KCl + 2.5 tons straw ha^{-1} or 300 kg urea, 100 kg SP-36, and 150 kg KCl ha^{-1} (without straw) and limestone ($CaCO_3$) as much as 2 Mg ha^{-1}. If the compound fertilizers were used, the recommendation dosage were 250 kg NPK 10-10-10 + 175 kg urea ha^{-1} + 50 kg KCl ha^{-1}. NPK fertilizer was given at once by the age of 1-2 weeks after planting and urea split in two to three times, *i.e* each third section at the time of planting, age 2-3 weeks after planting (WAP) and ages 4-5 WAP or each half at age 3-5 and 6-7 WAP.

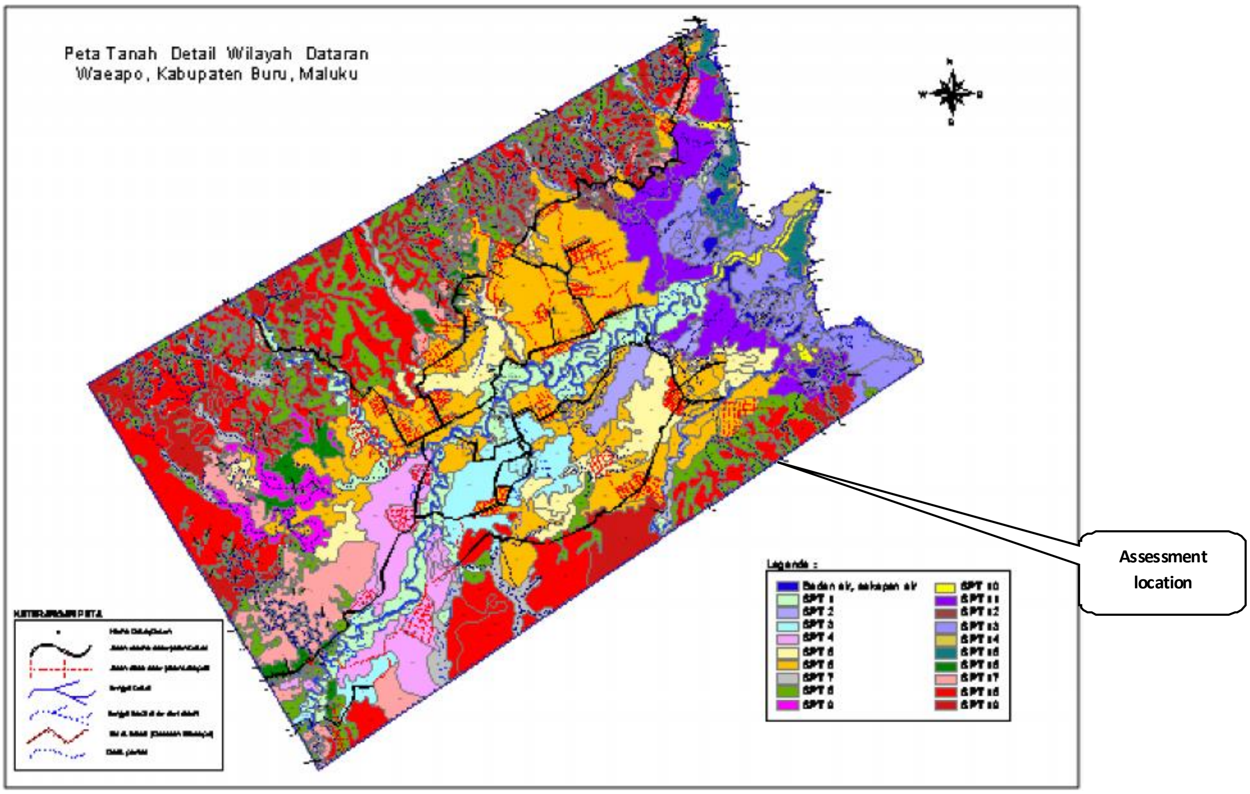

Figure 1. Soil map detailed (scale of 1 : 25,000) of Waeapo District, Buru Regency, Maluku.

Table 1. Prediction of sub-optimal land area (Fluvaquentic endoaquepts , peat/acid sulfate, sulfic fluvaquents, alluvial depression) that have the potential to have made lowland or limited basis of lowland). Allegedly has a very high content of Fe thus inhibiting the growth of rice.

SMU	Fisiography	Wide SMU (ha)	Sub-optimal land	Remarks
0	Lake/depretion precipitated	384.62	-	Water conservation region
1	The embankment of the river meanders	3,738.88	1,402.08	37.5% of the total area (F)
2	***Back swamp***	***626.51***	***626.51***	***Total areal***
3	Terrace of upper river	2,100.61	-	Productive lowland
4	Terrace of lower river	2,821.11	1,410.55	50% of total area (F)
5	Alluvial plains	3,073.60	-	Productive lowland
6	Alluvial plains	10,833.44	-	Productive lowland
7	Line flow	2,290.16	-	Water conservation region
8	Alluvial-Colluvial	7,285.32	-	Water conservation region
9	Depretion of alluvial	1,033.80	1,033.80	Total area
10	Estuaries along the estuarine plains	376.85	-	Water conservation region
11	Palin of fluvio marine	2,986.39	1,119.90	37.5% of the total area (F)
12	Peat of topogen freshwater	198.47	198.47	Total area
13	Peat of topogen tidal	3,247.71	-	Water conservation region
14	Coastal and mud sand	521.91	-	Water conservation region
15	Peat of topogen tidal	762.03	-	Water conservation region
16	Plain of tectonic	968.86	-	N-lowland
17	Plain of tectonic	3,445.18	-	N-lowland
18	Plain of tectonic	9,893.06	-	N-lowland
19	The hills of tectonic	4,877.05	-	N-lowland
	Total Area	61,465.57	5,791.31	

Source : Susanto (2010)

Results of soil samples analysis in soil laboratorium of Center for Research and Development Soil and Agroclimate Bogor, it was known that soil texture was a silty clay, soil pH H_2O WAS acidic (4.0), organic-C was low, total N was very low, available P was very high, and K available was medium, but P Bray-1 was very low, bases were very low to medium, CEC, and base saturated (BS) was medium (Table 2). From the soil samples analysis it was known that soil fertility status was low.

Relatively acidic soil acidity, low organic C, low exchangeable bases, and low CEC were a limiting factor of growth and yields of plant. In addition to the use of adaptive varieties, the use of balanced fertilizers (organic and inorganic fertilizers), and water management with a wet dry system are one of the key in the sub-optimal land, such as wetlands.

Drying by removing water out of the plot is not recommended, because it will cause nutrients N, K, Ca, and Mg will carry out the plot and will exacerbate the occurrence of iron poisoning. In the state of field capacity, the composition of water and oxygen in the soil is relatively balanced. Penetration of sufficient oxygen from the air will create the rooting environment is always in a state of oxidative and iron is in the form of insoluble Fe^{3+} and it is not harmful to plants.

The most rapid inundation was begun after 21 days old plants with a water height of 5-7 cm until the plants aged 45-50 days. Furthermore, lowland was dried again for 7-10 days so the plot was in a state of field capacity. Such circumstances will accelerate the decline in the levels of Fe^{2+} to Fe^{3+} in the soil so they no longer cause poisoning. Drying was done by closing the entrance door water and allowed to dry land by it self and not by water washing or throwing out the plot of rice field. After the plant 55 days old, land was flooded again to 10 days before harvest. In the troubled lands it required state of oxidation-reduction through intermittent irrigation water management.

Climate and Rainfall

Based on rainfall data from monitoring stations of Savana Jaya, Namlea, and Waetina, the study

Table 2. Results of analysis soil sample of sub-optimal land in Debowae village, Waeapo district, Buru Regency.

Description	Method	Unit	Value	Criteria
Soil Texture	Pipet			Silty Clay
- Sand		%	9.00	
- Silt		%	65.00	
- Clay		%	26.00	
pH :	Extract 1.5			
- H_2O			4.60	Acid
- KCl			4.00	
C	Walkley & Black	%	1.18	Low
N	Kjeldahl	%	0.09	Very Low
C/N			13.00	Medium
P_2O_5	HCl 25%	mg 100 g^{-1}	87.00	Very High
K_2O	HCl 25%	mg 100 g^{-1}	33.00	Medium
P_2O_5	Bray-1	ppm	5.00	Very Low
K_2O	Morgan	ppm	56.00	Very High
Exchangable of cations :				
- Ca	NH_4-Acetat 1*N*, pH 7	cmol kg^{-1}	2.87	Low
- Mg	NH_4-Acetat 1*N*, pH 7	cmol kg^{-1}	0.70	Low
- K	NH_4-Acetat 1*N*, pH 7	cmol kg^{-1}	0.06	Very Low
- Na	NH_4-Acetat 1*N*, pH 7	cmol kg^{-1}	0.54	Medium
Total	NH_4-Acetat 1*N*, pH 7	cmol kg^{-1}	4.17	
CEC	NH_4-Acetat 1*N*, pH 7	cmol kg^{-1}	7.63	Low
BS	NH_4-Acetat 1*N*, pH 7	%	55.00	Medium

Source: Laboratorium of Center for Research and Development Soil and Agroclimate Bogor (2011) area was classified as Awa climate type according to Koppen classification (Schmit and Ferguson 1951). Awa climate type is a climate type that has a tropical rain with an average temperature of the coldest month is more than 18^o C and the average temperature of the hottest month is more than 22^o C, there are one or more months with rainfall less than 60 mm and annual rainfall average is less than 2.500 mm.

Rainfall and the annual rainfall average were 1.419 mm at Savana Jaya station during 127 days of rain, 1.324 mm at Namlea station during 136 days of rain, and 5.048 mm at Waetina station for 106 days. Based on data from Savana Jaya and Namlea station, wet months according to Oldeman criteria (> 200 mm per month) were occurred during 2 to 3 months, *i.e* between the months of December to February, and the dry months (< 100 mm per month) for 5 to 6 months were occurred between July and November. Therefore, the second regions was agro-climatic zones E3. In Waetina and the area surrounding, wet months were occured for 8 to 9 months, i.e between November and July, and the dry months between 1 to 2 months were occurred in August and September, so the local agro-climatic zones was B1.

Based on the calculation of the Q ratio, which is the average number of dry months (< 60 mm) divided by the average wet months (> 100 mm) multiplied by 100%, the study area according to Schmit and Ferguson (1951) land a rain type A in Waetina station, and C climate in Savana Jaya station, namely the transition rain type tropical to rainy season with the value Q ratio ranged between 0 - 14.3% and 33.3 - 60%.

Laimeheriwa *et al*. (2002) reported that based on the analysis of data for 37 years of climatological stations in Mako, then this region has an average of 1.871 mm of rainfall; temperature of 26.5Ú C; potential evapotranspiration (PET) 1.562 mm; climate type D2 according Oldeman, Aw (Koppen), and B (Schmidt and Ferguson); period of the dry season from July to November; period of the rainy season from December to June; peak rainfall in the March to June and 9 month growth period (December to August).

Hydrology and Water Resources

Hydrological state of a region is strongly influenced by the state of precipitation, relief, soil conditions, shape and number of rivers and tidal state. Research areas where the topography has a gradient between flat and hilly areas have height difference is quite large with a relatively close distance, so that the strength of the water flow is quite large. This condition may lead to the occurrence of coarse sediment in the river bed material and sediment occur in subordinate areas (low land).

On Waeapo plains there are a large rivers of Waeapo with several tributaries, namely Waegeran, Waetina, Waelo, Waeleman, Waebloi, and Waemiten flowing from the Southwest to the Northeast and empties into the Gulf Kayeli - Banda Sea. Other sizeable river which empties into the sea is Waelata, Waetele, and Waesanleko. Dendritic pattern of stream flow is at the upstream and downstream of the meandering pattern of the river .

Irrigation area on the Waeapo plains is source of irrigation water for paddy field area with a potential area of 17.364 ha and development area of 13.339 ha (Regional Office of Public Works Prov. Moluccas *cited by* Susanto 2011; Susanto *et al*. 2005). This potential can be increased if accompanied by greater water efficiency irrigation technology for example, intermittent irrigation system, the use of resistant varieties for water stress, and added soil organic matter to increase water holding capacity. While based on discharge data on average monthly water (m^3 per second) of seven major rivers namely Waesanleko, Waetele, Waemiten, Waeapo, Waelo and Waelata show much more greater potential. Assuming that 1 ha of paddy fields require 1 liter of water per second (Tarigan and Sinukaban 2001), then if the total of seven river water is used for irrigation water over the rice fields, it can irrigate about 90.266 ha of land (Directorate of Irrigation *cited by* Susanto 2011).

Plant Growth and Yield

Results of variance analysis showed that the influence of the main plot (organic fertilizer) on the growth and yield components in general did not have a significant influence, unless the component panicle length, number of grains per panicle, number of filled grains per panicle, and number of unfilled grains per panicle. While the sub plot (varieties) significantly affected all components of growth and yield. Interaction between organic matter and varieties had a significant influenced on all components of growth and yield, except for the parameters of plant height at harvest, yield of tile and yield of dry grain per ha.

Effect of Organic Fertilizer

Results of Duncan test at the level of 5%, the growth and yield components showed that application of organic fertilizer from petroganic (PO-3) by 1 Mg ha^{-1} provided better growth and higher yields compared to other sources of organic fertilizer which were livestock manure (PO-1) and granular organic fertilizer (PO-2), as shown in Table 3.

Organic fertilizers had a significant effect only on the components of panicle length, number of grains per panicle and the number of unfilled grains per panicle, whereas the components of other plant growth and yield were not significantly different. However, there was a tendency that the use of petroganic fertilizer (PO-3) on average gave better growth and yields, following by granular organic fertilizer (PO-2) and livestock manure (PO-1). This was presumably related to the organic C content of the third organic fertilizer which was based on the fertilizers analysis, livestock manures had the lowest organic C (8.78 %).

The use of petroganic fertilizer (PO-3) had gives the average plant height, number of filled grains, and the yield of tile per plot and yield per ha higher than the use of livestock manure (PO-1) and granular organic fertilizer (PO-2), however, it showed no significantly difference. While granular organic fertilizer had the average number of productive tillers and the highest weight of 1000 seeds, although it was not significantly difference from the treatments of livestock manure and petroganic fertilizer.

The highest panicle length was obtained in the treatment of PO-3 and significantly difference from the PO-1 and PO-2, so did the number of grain per panicle and the number of empty grains per panicle which the highest was obtained at PO-3 and PO-1 and it was significantly difference, but not difference with PO-2. This is presumably because PO-3 (petroganic fertilizer) had a higher C-organic content (12.5%) compared to the other two types of organic fertilizers, the PO-1 (livestock manure) and PO-2 (granular organic), respectively 8.78% and 12.0%. Livestock manure has not met the minimum technical requirements of organic fertilizer for organic C content of at least > 12%, C/N ratio of 15-26, and P_2O_5 < 6%.

Effect of Varieties

Sixth swamp rice varieties studied have a significant influence on all the components of growth and yield. Varieties of Inpara 4 (VU-4) had the highest an average number of grain per panicle, filled grain number per panicle, and grain yield, followed by Indragiri (VU-6), Inpara 1 (VU-1), Inpara 2 (VU-2), and Inpara 5 (VU-5), while the lowest grain yield was on Inpara 3 (VU-3). The six varieties studied had the average yield within the range of the average yield, and also the potential yield of these varieties had been achieved, but varieties Inpara 5 results were below the yield potential that could reach 7.2 Mg ha^{-1}, except Inpara 5 variety that had results below of its yield potential.

The highest plant height at harvest was obtained on Inpara 2, and by Duncan test 5% had significantly difference from other varieties, except to Inpara 3 variety. Otherwise, variety that had the lowest plant height was obtained on Inpara 4 and significantly difference from the other varieties (Table 3). This is consistent with the description of the varieties which showed that from the 6th swamp rice varieties studied, Inpara 4 had the lowest plant height.

Table 3. Average growth and yield components of rice at sub-optimal land from three farmers.

Treatments	Plant Height (cm)	Number of productive tillers/clump	Length of panicle (cm)	Number of grains/ panicle	Number of filled grains/ panicle	Number of unfilled grains /panicle	Weight of 1,000 seeds (g)	Yield of tile/ plot (kg)	Yield (kg DGH ha^{-1})
Main Plot (Organic Fertilizer):									
PO-1	108.00 a	16.50 a	23.58 b	135.52 b	93.27 a	42.25 b	27.62 a	4.11 a	6.58 a
PO-2	108.43 a	17.15 a	23.53 b	138.04 ab	90.13 a	47.94 ab	27.90 a	4.18 a	6.69 a
PO-3	110.57 a	16.94 a	24.09 a	145.46 a	95.09 a	50.37 a	27.64 a	4.22 a	6.75 a
Sub Plot (Inpara Varieties):									
VU-1	109.04 b	18.78 a	22.67 b	145.36 b	93.84 a	51.52 a	30.20 a	4.65 a	7.44 a
VU-2	116.04 a	16.63 ab	24.40 a	141.78 b	91.68 a	50.10 a	29.65 ab	4.44 a	7.10 a
VU-3	115.00 a	12.45 b	24.76 a	146.81 b	96.07 a	50.74 a	27.44 b	3.04 b	4.87b
VU-4	98.44 d	19.45 a	23.13 b	163.68 a	104.60 a	59.15 a	20.60 d	4.97 a	7.95 a
VU-5	105.00 c	16.30 ab	24.34 a	93.85 c	74.32 b	19.53 b	27.14 c	3.08 b	4.92 b
VU-6	110.48 b	17.59 a	23.10 b	146.56 b	96.46 a	50.10 a	31.28 a	4.84 a	7.75 a

Remarks : The average number followed by the same letter are not significantly different at the 0.05 level of Duncan's Test. (PO-1: Livestock Manure 3 Mg ha^{-1}; PO-2: Granular Organic 1 Mg ha^{-1}; PO-3: Petroganic 1 Mg ha^{-1}. VU-1: Inpara 1; VU-2: Inpara 2; VU-3: Inpara 3; VU-4: Inpara 4; VU-5: Inpara 5; VU-6: Indragiri)

Number of productive tillers per panicles showed that Inpara 4 variety had the highest number of tillers and it was not significantly difference from other varieties, except to Inpara 3 by Duncan's test 5%. Otherwise, variety that had the lowest number of productive tillers per panicles obtained in Inpara 3 and no significantly difference with Inpara 2 and Inpara 5 varieties (Table 3). These results are also in accordance with the description of the variety, which showed that the Inpara 4 variety had the highest number of productive tillers per panicles compared with other varieties.

Variety that provided the highest panicle length was obtained on Inpara 3, and Duncan's test 5% showed that no significant by difference with other varieties, except the Inpara 4 and Indragiri varieties. Variety which had the lowest panicle length was Indragiri variety and no significantly difference with Inpara 4 variety (Table 3).

Number of grains per panicle was mostly obtained on Inpara 4 vairety, and Duncan's test 5% showed significant differences with other varieties. Otherwise, Inpara 5 variety had the lowest number of grains per panicle, while four varieties (Inpara 1, Inpara 2, Inpara 3, and Indragiri) had no significantly difference, as shown in Table 3.

The number of filled grain per panicle was mostly obtained on Inpara 4, and Duncan's test 5% showed that no significantly difference with other varieties, except the Inpara 5 variety. Otherwise, Inpara 5 variety had the lowest number of filled grain per panicle, and significantly difference with other varieties (Table 3).

The highest number unfilled grains per panicle was obtained on Inpara 4, and Duncan's test 5% showed that no significantly differences with the other varieties, except to Inpara 5. Variety that had a lowest number of unfilled grains per panicle was on Inpara 5 variety (Table 3). The percentages of empty grains per panicle of all six varieties studied were ranged from 20.80 to 36.14%. Inpara 4 variety also had the highest percentage of unfilled grains (36.14%), followed by Inpara 1 (35.44%), Inpara 2 (35.34%), Inpara 3 (34.56%), Indragiri (34.18%), and the lowest was Inpara 5 (20.80%). The percentages of unfilled grains were quite high because of the attacks of sundep and blasts in plants due to high rainfall, especially in the afternoon.

Indragiri variety had the highest an average weight of 1,000 seeds of dry grain harvest, followed by Inpara 1, Inpara 2, Inpara 3, and Inpara 5, while the lowest was obtained on Inpara 4 variety. This is consistent with the description of each variety studied, which shows that Inpara 4 had the lowest weight of 1,000 seeds (Suprihatno *et al*. 2010). While the highest grain yield was obtained on Inpara 4 varieties, that was 7.95 Mg DGH ha^{-1}, followed by Indragiri, Inpara 1, Inpara 2, and the lowest was obtained on Inpara 3 and Inpara 5, each 4.87 Mg DGH and 4.92 Mg DGH ha^{-1} respectively (Table 3).

Interaction Effect of Fertilizer vs Varieties

Interaction betwen organic fertilizers and varieties on growth and yield component on sub-obtimal land is shown in Table 4. Combination treatment PO-3 VU-1, *i.e* petroganic fertilizer and Inpara 1 variety had the highest average number of productive tillers per clump (23.89 tillers), followed by combination treatments of PO-1 VU-4 (21.45 tillers), PO-2 VU-6 (19.11 tillers), PO-2 VU-4 (19.00 tillers), while the lowest was in PO-1 VU-3 (11.67 tillers). Combination between PO-3 and VU-2 treatment on average provided the highest panicle length (25.01 cm), followed by treatment of PO-3 VU-3 (24.92 cm), PO-2 VU-3 (24.63 cm), PO-3 VU-5 (24.50 cm), while panicle length lowest obtained at combined treatment PO-2 VU-1 (22.05 cm) (Table 4).

The highest number of grain per panicle was obtained in combination treatment of PO-2 VU-4 (178.44 points), followed by PO-3 VU-4 (158.44 points), PO-3 VU-1 (161.70 points), and the lowest was on PO-1 VU-5 (92.11 points). The highest number of filled grain per panicle was obtained in combination treatment of PO-2 VU-4 (117.64 points), following by PO-3 VU-6 (108.30 points), PO-1 VU-4 (105.85 points), PO-1 VU-2 (103.33 points), PO-3 VU-1 (102.07 points), and the lowest was PO-1 VU-5 (72.07 points), while the number of empty grains per panicle mostly were obtained in the combined treatment of PO-3 VU-4 (68.15 points), followed by PO-2 VU-4 (61.00 points), PO-2 VU-2 (60.56 points), PO-3 VU-1 (59.63 points), PO-3 VU-3 (56.59 grains), and the lowest was PO-3 VU-5 (19.11 points) (Table 4).

The highest grain weight of 1,000 seeds (average water content of 14-16%) was obtained in the combination treatment of PO-3 VU-6 (32.63 g), followed by PO-1 VU-2 (31.94 g), PO-2 VU-1 (30.94 g), PO-1 VU-1 (30.42 g), PO-1 VU-6 (30.06 g), PO-3 VU-1 (29.22 g), and the lowest were PO-1 VU-4 and PO-2 VU-4 (20.60 g). The combination of organic fertilizer treatments and varieties that had the highest average grain yields were treatment of PO-2 VU- 4 (8.37 Mg ha^{-1}) and PO-3 VU-6 (8.02 Mg ha^{-1}), while the lower yields were PO-1 VU-3 (4.53 Mg ha^{-1}), PO-1 VU-5 (4.80 Mg ha^{-1}), PO-3 VU-3 (4.85 Mg ha^{-1}), and PO-2 VU-5 (4.91 Mg ha^{-1}), as shown in Table 4.

Growth and yields crop by application of organic fertilizers (both from livestock manure or organic fertilizer) and the use of superior varieties for sub-optimal land, had the higher average

Table 4. Interaction between organic fertilizer and varieties to the average number of productive tillers clump^{-1}, panicle length, number of grains panicle^{-1}, number of filled grains panicle^{-1}, number of unfilled grains panicle^{-1}, weight of 1,000 seeds, tile yield, and yield ha^{-1}.

Treatment	VU-1	VU-2	VU-3	VU-4	VU-5	VU-6	Mean
…………………. Number of productive tillers clump ………………….							
PO-1	15.45	16.67	11.67	21.45	16.78	17.00	16.50
PO-2	17.00	17.22	12.56	19.00	18.00	19.11	17.15
PO-3	23.89	16.00	13.11	17.88	14.11	16.67	16.94
Mean	18.78	16.63	12.45	19.45	16.30	17.59	
………………...……..… Panicle Length (cm) ……..…….….………………..							
PO-1	22.90	24.44	24.74	22.37	24.07	22.95	23.58
PO-2	22.05	23.74	24.63	23.76	24.42	22.58	23.53
PO-3	23.07	25.01	24.92	23.27	24.50	23.76	24.09
Mean	22.67	24.40	24.76	23.13	24.34	23.10	
………………..…………. Number of grains panicle^{-1} …………………….							
PO-1	142.37	145.00	137.18	154.15	92.11	142.29	135.52
PO-2	132.00	136.78	148.29	178.44	94.30	138.40	138.04
PO-3	161.70	143.55	154.96	158.44	95.15	158.97	145.46
Mean	145.36	141.78	146.81	163.68	93.85	146.56	
………………………. Number of filled grains panicle^{-1} …………………….							
PO-1	95.22	103.33	88.48	105.85	72.07	94.63	93.27
PO-2	84.22	76.22	101.37	117.64	74.85	86.44	90.13
PO-3	102.07	95.48	98.37	90.30	76.04	108.30	95.09
Mean	93.84	91.68	96.07	104.60	74.32	96.46	
…………………… Number of unfilled grains panicle^{-1} …………………...							
PO-1	47.15	41.67	48.70	48.30	20.04	47.66	42.25
PO-2	47.78	60.56	46.92	61.00	19.45	51.96	47.94
PO-3	59.63	48.07	56.59	68.14	19.11	50.67	50.37
Mean	51.52	50.10	50.74	59.15	19.53	50.10	
…………………………… Weight of 1,000 seeds (g) ……………..……………							
PO-1	30.42	31.94	26.65	20.60	26.04	30.06	27.62
PO-2	30.94	29.10	27.11	20.60	28.51	31.15	27.90
PO-3	29.22	27.92	28.56	20.61	26.88	32.63	27.64
Mean	30.20	29.65	27.44	20.60	27.14	31.28	
…………………………… Tile Yield (kg) ……………..……………							
PO-1	4.68	4.64	2.83	4.77	3.00	4.76	4.11
PO-2	4.63	4.12	3.27	5.23	3.07	4.76	4.18
PO-3	4.64	4.54	3.03	4.90	3.17	5.01	4.22
Mean	4.65	4.44	3.04	4.97	3.08	4.84	
…………………………. Yield DGH Ha^{-1} (Mg) ……………..……………							
PO-1	7.48	7.43	4.53	7.63	4.80	7.61	6.58
PO-2	7.40	6.60	5.23	8.37	4.91	7.62	6.69
PO-3	7.42	7.27	4.85	7.84	5.07	8.02	6.75
Mean	7.44	7.10	4.87	7.95	4.92	7.75	

Remarks: PO-1: Livestock Manure 3 Mg ha^{-1}; PO-2: Granules Organic 1 Mg ha^{-1}; PO-3: Petroganic 1 Mg ha^{-1}.
VU-1: Inpara 1; VU-2: Inpara 2; VU-3: Inpara 3; VU-4: Inpara 4; VU-5: Inpara 5; VU-6: Indragiri.

compared to the yields which were obtained by non-cooperator farmer in around of assessment location (Table 5).

The best Fertilizer dose was 50 kg urea and 100 kg Phonska NPK (without organic fertilizer). Average grain yields which were obtained by farmers outside the study on the planting season. 2011 was 2.60 Mg - 2.90 Mg DGH ha^{-1} (average 2.75 Mg DGH ha^{-1}) were higher than the average yields of the previous year (1 Mg - 2 Mg DGH ha^{-1}),

Table 5. Average of growth and yield of rice which reach of farmers outside study on Direct Planting and Transplanting, 2011

Planting systems	Plant Height (cm)	Number of productive tillers/clump	Length of panicle (cm)	Number of grains panicle^{-1}	Number of filled grains panicle^{-1}	Number of empty grains panicle^{-1}	Weight of 1,000 seeds (g)	Yield of tile plot^{-1} (kg)
Direct planting	92.67	7.33	22.87	112.22	79.11	33.11	25.93	2.60
Transplanting	98.00	11.00	23.72	145.11	85.56	59.56	26.03	2.90
Mean	95.33	9.17	23.29	128.67	82.33	46.33	25.98	2.75

Remarks : - Ciherang and Cigeulis varieties

but the yields were still lower than the average yield which was obtained in the study (4.87 Mg - 7.95 Mg DGH ha^{-1}). This is presumably one to the improvement of plant growth environmental because application of organic and inorganic fertilizers, as well as varieties which were an adaptive variety for sub-optimal land.

According Junita *et al*. (2002), organic fertilizers contained many macro elements such as Ca, Mg, and S, but the quick and tangible effect of organic fertilizer on plant growth was the addition of N, P, and K. Organic fertilizers can also form complexes with Al and Fe so that P nutrients are more available to the plant (Nursyamsi *et al*. 1995). Furthermore Sufardi (2001) described that the acid pH, the high solubility of heavy metals that are toxic to plants, such as Al, Fe, and Mn being increased, where the heavy metals can bind other elements that are needed by plants as an element of P. Manure application is able to suppress the Al-dd and increases soil pH, which is also followed by an increase of P available to plants (Barchia *et al*. 2007).

Organic fertilizer which was combined by inorganic fertilizers and the use of suitable varieties for sub- optimal land resolved issues of sub-optimal land in plain Waeapo, especially in Debowae villages and in some centers of rice production in Moluccas. Varieties Indragiri, Inpara 4, Inpara 1, and Inpara 2 are varieties that have good adaptation in sub-optimal land, and opportunity to be developed, while varieties Inpara 5 and Inpara 3 were taken into consideration because the yields were low, although the yields were still above average yield which were obtained by farmers in the vicinity of the study or before the previous yield. Similarly, petroganic fertilizer is the first choice, but the granular organic fertilizer and the cattle manure fertilizer can also be another option because the results did not significantly difference.

CONCLUSIONS

The use of three types of organic fertilizers and six varieties on suboptimal land, provided a higher average yields (4.53 Mg - 8.37 Mg DGH ha^{-1}) compared to the yields which were obtained by farmers outside the study (2.75 DGH ha^{-1}) or rice previous yield before (1-2 Mg DGH ha^{-1}).

The use of organic fertilizers which were combined by inorganic fertilizer had an average yields over 6 t DGH ha^{-1}, the petroganic had a higher average rice yield (6.75 Mg DGH ha^{-1}) compared to granules organic (6.69 Mg DGH ha^{-1}) and livestock manure (6.58 Mg DGH ha^{-1}).

The six varieties of sub-optimal land (Inpara 1, Inpara 2, Inpara 3, Inpara 4, Inpara 5, and Indragiri) had the yields of 4.87 Mg - 7.95 Mg DGH ha^{-1}. Variety of Inpara 4 had the highest yield (7.95 Mg DGH ha^{-1}), while Inpara 3 was the lowest (4.87 Mg DGH ha^{-1})

Combination of granules organic with Inpara 4 variety, and petroganic with Indragiri variety had the best yields (8.37 Mg and 8.02 Mg DGH ha^{-1}), whereas the lowest yields (4.48 Mg DGH ha^{-1}) were obtained in a combination of livestock manure with Inpara 5 variety.

The use of organic fertilizer combined with inorganic fertilizers, and the use of suitable varieties for sub- optimal land was able to overcome the problem of suboptimal land in Waeapo plains, especially in Debowae villages. Varieties of Indragiri, Inpara 4, Inpara 1, and Inpara 2 had a good adaptation in sub-optimal land and it was likely to be studied and developed in other locations.

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